Science AT MIT

Summer 2025 | Published twice yearly

RESEARCH HEALS LIVES

Science is fundamental to improving human health

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In December 2024, MIT launched the MIT Health and Life Sciences (HEALS) Collaborative to bring together researchers from across the Institute to deliver health care solutions at scale.

MIT School of Science

TABLE OF CONTENTS

Letter from the Dean

Hello, my dear fellow alumni and friends,

Never would I have imagined that the cover title of our magazine would need to convey a message as directly as "Research Heals Lives." Because of course it does. Scientific inquiry has been the foundation of our prosperity, health, and leadership as a nation in the world. And in this moment, that preeminence is at risk as we at MIT and other leading research universities and institutes are under threat. Federal cuts to research funding and programming will have direct and dire consequences on the global scientific enterprise that has served us at MIT, the nation, and all of humanity.

And yet, our spirit of curiosity and inquiry remains unbounded here at MIT.

In this issue, we take an in-depth look at the recent coalescing of fundamental research in the life sciences. As one of President Sally Kornbluth's primary initiatives, the MIT Health and Life Science (MIT HEALS) Collaborative aims to catalyze discovery, innovation, and impact for human health.

The MIT HEALS Collaborative will pursue ambitious goals seeking to make transformational advances in AI and life science, low-cost diagnostics, neuroscience and mental health, environmental life science, food and agriculture, the future of public health and health care, and women's health.

And all of that begins with fundamental research of the kind only we can do here at MIT School of Science. In addition to reading about the HEALS launch event (see page 4), we've gathered research stories about some of our recently tenured MIT Science faculty who are working in the areas of fundamental life sciences research and potential for impacting human health.

On page 9, you can read our exclusive interview with alumna Nancy Andrews, MD, PhD, the Executive Vice President and Chief Scientific Officer of Boston Children's Hospital, about her MIT journey and the importance of fundamental research as the root of advancing the MIT HEALS mission.

You can also read on page 26 about the new Hood Pediatric Innovation Hub, spurred by the HEALS Collaborative, which aims to break down barriers to pediatric innovation and foster transformative research to improve children's health outcomes.

I am truly excited to see what new collaboration and innovations MIT HEALS brings forward as our researchers apply for seed grants to continue our important research in the life sciences.

And lest you think the issue is entirely focused on life sciences research, turn to page 22 to learn more about how our climate science efforts are proceeding through the newly dedicated Center for Sustainability Science and Strategy (CS3). Those of you who joined our breakfast talk this past April were treated to a lecture by Professor Noelle Eckley Selin, recently inducted into the American Association for the Advancement of Science (AAAS). Through her work as director of CS3, Noelle sees climate science as inherently linked with the sociopolitical organizations and structures that determine how that research is used or implemented.

On page 19, you can read a profile of Jess Speedie, one of eight recipients of the 2025 51 Pegasi b Fellowship provided by the Heising-Simons Foundation. Speedie's work has focused on understanding "cosmic nurseries" and the detection and characterization of the youngest planets in the galaxy.

Like Selin and Speedie, our faculty and their graduate students and postdocs are investigating the answers to fundamental scientific questions, and generating new knowledge to ask the next set of questions. Sometimes these answers lead us to unexpected connections across fields, new frameworks or tools for inquiry, and sometimes, direct applications to areas of immediate interest or concern, such as mitigating the effects of climate change, utilizing AI in new and beneficial ways, and improving human health.

And sometimes? Fundamental scientific research doesn't make these applications known immediately. Sometimes, it might be decades . . . but it is rarely "never." The value of inquiry, curiosity, the seeking out of answers and the creation of knowledge powers prosperity.

We are at a moment in time when funding for research that has produced the greatest scientific enterprise in the world is uncertain at best. We at MIT remain committed to supporting the research programs here, including those you'll read about in this issue of *Science@MIT*, that allow this freedom of scientific inquiry that has led to the most important discoveries the world has yet known.

As always, I hope you will come to campus soon to see, in-person, the contributions that we in the School of Science are making on behalf of us all.

With my very best wishes,

Nergis

Dean Nergis Mavalvala PhD '97

Introducing MIT HEALS, a life sciences initiative to address pressing health challenges

The MIT Health and Life Sciences Collaborative will bring together researchers from across the Institute to deliver health care solutions at scale

Anne Trafton | MIT News

At MIT, collaboration between researchers working in the life sciences and engineering is a frequent occurrence. Under a new initiative, the Institute plans to strengthen and expand those collaborations to take on some of the most pressing health challenges facing the world.

The new MIT Health and Life Sciences Collaborative, or MIT HEALS, will bring together researchers from all over the Institute to find new solutions to challenges in health care. HEALS will draw on MIT's strengths in life sciences and other fields, including artificial intelligence and

■ MIT has a long history of pioneering new fields in the life sciences, as Institute Professor Phillip Sharp noted in his keynote address. *Photo: Jake Belcher*

chemical and biological engineering, to accelerate progress in improving patient care.

"As a source of new knowledge, of new tools and new cures, and of the innovators and the innovations that will shape the future of biomedicine and health care, there is just no place like MIT," MIT president Sally Kornbluth said at a launch event in Kresge Auditorium. "Our goal with MIT HEALS is to help inspire, accelerate, and deliver solutions, at scale, to some of society's most urgent and intractable health challenges."

The launch event served as a day-long review of MIT's historical impact in the life sciences and a preview of what it hopes to accomplish in the future.

"The talent assembled here has produced some truly towering accomplishments. But also — and, I believe, more importantly — you represent a deep well of creative potential for even greater impact," Kornbluth said.

Massachusetts governor Maura Healey, who addressed the filled auditorium, spoke of her excitement about the new initiative, emphasizing that "MIT's leadership and the work that you do are more important than ever."

"One of the things as governor that I really appreciate is the opportunity to see so many of our state's accomplished scientists and bright minds come together, work together, and forge a new commitment to improving human life," Healey said. "It's even more exciting when you think about this convening to think about all the amazing cures and treatments and discoveries that will result from it. I'm proud to say, and I really believe this, this is something that could only happen in Massachusetts. There's no place that has the ecosystem that we have here, and we must fight hard to always protect that and to nurture that."

A history of impact

MIT has a long history of pioneering new fields in the life sciences, as Institute Professor Phillip Sharp noted in his keynote address. Fifty years ago, MIT's Center for Cancer Research was born, headed by Salvador Luria, a molecular biologist and a 1975 Nobel Laureate.

That center helped to lead the revolutions in molecular biology, and later recombinant DNA technology, which have had significant impacts on human health. Research by MIT professor Robert Weinberg and others identifying cancer genes has led the development of targeted drugs for cancer, including Herceptin and Gleevec.

In 2007, the Center for Cancer Research evolved into the Koch Institute for Integrative Cancer Research, whose faculty members are divided evenly between the School of Science and the School of Engineering, and where interdisciplinary collaboration is now the norm.

While MIT has long been a pioneer in this kind of collaborative health research, over the past several years, MIT's visiting committees reported that there was potential to further enhance those collaborations, according to Nergis Mavalvala, dean of MIT's School of Science.

"One of the very strong themes that emerged was that there's an enormous hunger among our colleagues to collaborate more. And not just within their disciplines and within their departments, but across departmental boundaries, across school boundaries, and even with the hospitals and the biotech sector," Mavalvala told MIT News.

To explore whether MIT could be doing more to encourage interdisciplinary research in the life sciences, Mavalvala and Anantha Chandrakasan, dean of the School of Engineering and MIT's chief innovation and strategy officer, appointed a faculty committee called VITALS (Vision to Integrate, Translate and Advance Life Sciences).

That committee was co-chaired by Tyler Jacks, the David H. Koch Professor of Biology at MIT and a member and former director of the Koch Institute, and Kristala Jones Prather, head of MIT's Department of Chemical Engineering.

"We surveyed the faculty, and for many people, the sense was that they could do more if there were improved mechanisms for interaction and collaboration. Not that those don't exist — everybody knows that we have a highly collaborative environment at MIT, but that we could do even more if we had some additional infrastructure in place to facilitate bringing people together, and perhaps providing funding to initiate collaborative projects," Jacks said.

These efforts will build on and expand existing collaborative structures. MIT is already home to a number of institutes that promote collaboration across disciplines, including not only the Koch Institute but also the McGovern Institute for Brain Research, The Picower Institute for Learning and Memory, and the Institute for Medical Engineering and Science.

"We have some great examples of crosscutting work around MIT, but there's still more opportunity to bring together faculty and researchers across the Institute," Chandrakasan said before the launch event. "While there are these great individual pieces, we can amplify those while creating new collaborations."

Supporting science

In her opening remarks, Kornbluth announced several new programs designed to support researchers in the life sciences and help promote connections between faculty at MIT, surrounding institutions and hospitals, and companies in the Kendall Square area.

"I'm really looking forward to HEALS further enlarging the interactions that we have, and I think the possibilities for science, both at a mechanistic level and understanding the complexities of health and the planet, are really great," said Ruth Lehmann, director of the Whitehead Institute for Biomedical Research. *Photo: Jake Belcher*

"A crucial part of MIT HEALS will be finding ways to support, mentor, connect, and foster community for the very best minds, at every stage of their careers," Kornbluth said.

With funding provided by Noubar Afeyan PhD '87 an executive member of the MIT Corporation and founder and CEO of Flagship Pioneering, MIT HEALS will offer fellowships for graduate students interested in exploring new directions in the life sciences.

Another key component of MIT HEALS will be the new Hood Pediatric Innovation Hub, which will focus on development of medical treatments specifically for children. This program, established with a gift from the Charles H. Hood Foundation, will be led by Elazer R. Edelman, a cardiologist and the Edward J. Poitras Professor in Medical Engineering and Science at MIT.

"Currently, the major market incentives are for medical innovations intended for adults — because that's where the money is. As a result, children are all too often treated with medical devices and therapies that don't meet their needs, because they're simply scaled-down versions of the adult models," Kornbluth said.

As another tool to help promising research projects get off the ground, MIT HEALS will include a grant program known as the MIT-MGB Seed Program. This program, which will fund joint research projects between MIT and Massachusetts General Hospital/Brigham and Women's Hospital, is being launched with support from Analog Devices, to establish the Analog Devices, Inc. Fund for Health and Life Sciences.

Additionally, the Biswas Family Foundation is providing funding for postdoctoral fellows, who will receive four-year appointments to pursue collaborative health sciences research. The details of the fellows program will be announced in spring 2025.

"One of the things we have learned through experience is that when we do collaborative work that is cross-disciplinary, the people who are actually crossing disciplinary boundaries and going into multiple labs are students and postdocs," Mavalvala said prior to the launch event. "The trainees, the younger generation, are much more nimble, moving between labs, learning new techniques, and integrating new ideas."

Revolutions

Discussions following the release of the VITALS committee report identified seven potential research areas where new research could have a big impact: AI and life science, low-cost diagnostics, neuroscience and mental health,

> “I’m proud to say, and I really believe this, this is something that could only happen in Massachusetts. There’s no place that has the ecosystem that we have here, and we must fight hard to always protect that and to nurture that.”

environmental life science, food and agriculture, the future of public health and health care, and women’s health. However, Chandrakasan noted that research within HEALS will not be limited to those topics.

“We want this to be a very bottom-up process,” Chandrakasan told MIT News. “While there will be a few areas like AI and life sciences that we will absolutely prioritize, there will be plenty of room for us to be surprised on those innovative, forward-looking directions, and we hope to be surprised.”

At the launch event, faculty members from departments across MIT shared their work during panels that focused on the biosphere, brains, health care, immunology, entrepreneurship, artificial intelligence, translation, and collaboration. In addition, a poster session highlighted over 100 research projects in areas such as diagnostics, women’s health, neuroscience, mental health, and more.

The program, which was developed by Amy Keating, head of the Department of Biology, and Katharina Ribbeck, the Andrew (1956) and Erna Viterbi Professor of Biological Engineering, also included a spoken-word performance by Victory Yinka-Banjo, an MIT senior majoring in computer science and molecular biology. In her performance, called “Systems,” Yinka-Banjo urged the audience to “zoom out,” look at systems in their entirety, and pursue collective action.

“To be at MIT is to contribute to an era of infinite impact. It is to look beyond the microscope, zooming out to embrace the grander scope. To be at MIT is to latch onto hope so that in spite of a global pandemic, we fight and we cope. We fight with science and policy across clinics, academia, and industry for the betterment of our planet, for our rights, for our health,” she said.

In a panel titled “Revolutions,” Douglas Lauffenburger, the Ford Professor of Engineering and one of the founders of MIT’s Department of Biological Engineering, noted that engineers have been innovating in medicine since the 1950s, producing critical advances such as kidney dialysis, prosthetic limbs, and sophisticated medical imaging techniques.

MIT launched its program in biological engineering in 1998, and it became a full-fledged department in 2005. The department was founded based on the concept of developing new approaches to studying biology and developing potential treatments based on the new advances being made in molecular biology and genomics.

“Those two revolutions laid the foundation for a brand new kind of engineering that was not possible before them,” Lauffenburger said.

During that panel, Jacks and Ruth Lehmann, director of the Whitehead Institute for Biomedical Research, outlined several interdisciplinary projects underway at the Koch Institute and the Whitehead Institute. Those projects include using AI to analyze mammogram images and detect cancer earlier, engineering drought-resistant plants, and using CRISPR to identify genes involved in toxoplasmosis infection.

These examples illustrate the potential impact that can occur when “basic science meets translational science,” Lehmann said.

“I’m really looking forward to HEALS further enlarging the interactions that we have, and I think the possibilities for science, both at a mechanistic level and understanding the complexities of health and the planet, are really great,” she said.

The importance of teamwork

To bring together faculty and students with common interests and help spur new collaborations, HEALS plans to host workshops on different health-related topics. A faculty committee is now searching for a director for HEALS, who will coordinate these efforts.

Another important goal of the HEALS initiative, which was the focus of the day’s final panel discussion, is enhancing partnerships with Boston-area hospitals and biotech companies.

"I'm proud to say, and I really believe this, this is something that could only happen in Massachusetts. There's no place that has the ecosystem that we have here, and we must fight hard to always protect that and to nurture that," said Governor Maura Healey. *Photo: Jake Belcher*

"There are many, many different forms of collaboration," said Anne Klibanski, president and CEO of Mass General Brigham. "Part of it is the people. You bring the people together. Part of it is the ideas. But I have found certainly in our system, the way to get the best and the brightest people working together is to give them a problem to solve. You give them a problem to solve, and that's where you get the energy, the passion, and the talent working together."

Robert Langer, the David H. Koch Institute Professor at MIT and a member of the Koch Institute, noted the importance of tackling fundamental challenges without knowing exactly where they will lead. Langer, trained as a chemical engineer, began working in biomedical research in the 1970s, when most of his engineering classmates were going into jobs in the oil industry.

At the time, he worked with Judah Folkman at Boston Children's Hospital on the idea of developing drugs that would starve tumors by cutting off their blood supply. "It took many, many years before those would [reach patients]," he said. "It took Genentech doing great work, building on some of the things we did that would lead to Avastin and many other drugs."

Langer has spent much of his career developing novel strategies for delivering molecules, including messenger RNA, into cells. In 2010, he and Afeyan co-founded Moderna to further develop mRNA technology, which was eventually incorporated into mRNA vaccines for Covid.

"The important thing is to try to figure out what the applications are, which is a team effort," Langer said. "Certainly when we published those papers in 1976, we had obviously no idea that messenger RNA would be important, that Covid would even exist. And so really it ends up being a team effort over the years."

Dr. Nancy Andrews, MIT alumna, doctor, donor, and HEALS advisor

What's next: On the heels of MIT's launch of the Health and Life Sciences initiative

Nancy Andrews, MD, PhD, is the Executive Vice President and Chief Scientific Officer of Boston Children's Hospital.

Dr. Andrews' academic honors include election to the American Academy of Arts and Sciences, the National Academy of Sciences, and the National Academy of Medicine. She is a past president of the American Society of Clinical Investigation, and past Chair of the Board of Directors of the Burroughs Wellcome Fund. She is also a member of the MIT Corporation, the Institute's board of trustees.

To say that Dr. Andrews has some authority on the matter of scientific discovery and leadership would be an understatement.

On December 4, 2024, the MIT community, including Dr. Andrews, gathered to launch the MIT Health and Life Sciences (MIT HEALS) collaborative that supports the convergence of world-class expertise across MIT and industry leaders in biotechnology, pharmaceuticals, and hospitals (including Boston Children's Hospital) — all to catalyze discovery, innovation, and impact for human health.

Dr. Andrew tells us more about her MIT journey and the importance of fundamental research as the root of advancing the MIT HEALS mission.

Your career has exemplified the interface between basic science and clinical advancement and it started with obtaining your PhD in Biology from MIT. How did that foundation influence your path as a leader?

I knew I wanted to be a scientist helping to solving clinical problems from the time I arrived in Boston as a medical student. MIT Biology gave me the opportunity to learn how to do rigorous, fundamental research that had the potential to advance medicine. It was unusual for Harvard MD/PhD students to do their dissertation research at MIT then, but I was fascinated by the breadth and importance of work at the MIT Cancer Center (a precursor to the Koch Institute for Integrative Cancer Research) and in my final year, at the new Whitehead Institute, founded by my PhD advisor, David Baltimore.

During my training, I flipped back and forth between clinical medicine and science. Despite overlapping content, they are very different fields and it was disorienting at first. But I learned to be facile in changing mindset. In my early years on the faculty of Boston Children's Hospital and Harvard Medical School, I established my own research lab and spent 15 to 20 percent of my time seeing children with hematology and oncology problems. As I became more senior, my clinical work became focused, aligning very closely with work in my laboratory. We were interested in hereditary disorders of iron balance, and many of my clinic patients had unusual iron disorders. It was my job to understand what was wrong and address their clinical issues, but it was also an opportunity to develop a deeper understanding of iron biology. The insights gleaned from the clinic complemented our work in the lab and helped us work out details of mammalian iron transport, its regulation, and its perturbation in disease. At the time I was one of only four women physician-scientists who were Howard Hughes Medical Institute (HHMI) investigators, and I was grateful for HHMI's generous support of our research.

My first significant leadership role also mixed science and medicine. At the end of 1999, I became director of the Harvard-MIT MD/PhD Program, overseeing the education of students who, like me, wanted to have a deep understanding of both fields. I knew the weaknesses of

the program because I was an alumna, and I worked with faculty colleagues to make it stronger. Less than four years later, I was tapped to become dean for Basic Sciences and Graduate Studies at Harvard Medical School, with oversight responsibility for the MD/PhD program, the Harvard/MIT Health Sciences and Technology Program, Harvard's medical sciences graduate programs, and the basic science departments based on medical school quadrangle. It was a very fulfilling role, which took advantage of all the training I'd had.

In 2007, my career took a very sharp turn, and I moved to North Carolina to become dean of the Duke University School of Medicine. Once again, my experiences in both medicine and science were valuable. I no longer saw patients, but I continued to have a research laboratory for almost my entire deanship. I became involved in national leadership roles that took advantage of my dual expertise, serving as chair of the board of directors of the Burroughs Wellcome Foundation, on the governing council of the National Academy of Medicine, as chair of the board of directors of the American Academy of Arts and Sciences, and, most relevant here, as a member of the MIT Corporation. I also joined the boards of Novartis, Charles River Laboratories, and Maze Therapeutics. When I stepped down as dean, I had a portfolio of these responsibilities and a few others, which drew upon and amplified my physician-scientist expertise.

Just over three years ago I returned to my professional roots, to serve as executive vice president and chief scientific officer at Boston Children's Hospital, overseeing a large and complex research enterprise. Boston Children's has many physician-scientists on its faculty, in addition to PhD scientists devoted to medical research. My fluency in both medicine and science is a great asset, and I bring deep experience from my prior leadership roles.

As a MD-PhD you have a unique lens on the bench-to-bedside interface, please talk a bit about this dynamic and the importance of fundamental scientific research as a cornerstone of the discoveries that will lead to the health solutions of tomorrow.

It's hard to find a medical advance that is not rooted in fundamental science — I can't think of one. It's not necessary to have both an MD and a PhD to make important contributions, but dual degree training provides a special perspective. Physician-scientists, whether or not they have PhDs, make connections that nonphysicians may not see. They know what questions are clinically interesting and important and may address those questions in their work. But they also make connections between very basic findings and disease processes. For me, that was the most fun part. Medical research thrives when people bring diverse perspectives to solve problems, and physician-scientists often provide the links between those perspectives.

How can the MIT Health and Life Sciences initiative pave the way for the next generation of scientists who will lead in this space?

MIT offers an incredible intellectual landscape for people interested in advancing human health. Every part of MIT is, potentially, quite relevant, and the HEALS initiative builds on the MIT community's openness and attraction to important, practical problems. There have been strong connections between MIT and Boston-area hospitals for decades and HEALS amplifies them in a new and exciting way.

One of the inaugural projects of this initiative features a partnership with Boston Children's Hospital. How does basic science interface with clinical practice at Boston Children's?

Diseases of childhood offer unique insights into human biology because many medical problems that occur early in life result either from genetic predisposition or infectious diseases. That was part of what attracted me to pediatrics to begin with. It means that we have a better chance of understanding how diseases originate and better tools for developing potent therapies. Because research has been a big part of who we are for decades, Boston Children's is a powerhouse for fundamental research and its translation, and a prime setting for clinical trials. We can do a lot on our own, but MIT's strengths complement ours beautifully, and we can do so much more together.

What opportunities do you see on the horizon for more partnerships between HEALS and hospitals?

I think the key will be the people involved. Getting people with different perspectives, different training, different interests together in new ways, to do what MIT does so well — to go after the tough, important problems. Boston Children's is pretty good at that too — both clinically and in our labs — and we make great partners.

As a donor to the Department of Biology at MIT, what are your hopes for the future of scientific research and its impact on our world?

I've tended to give for two causes. First, because I benefitted from an emergency fund for graduate students when I was a student and needed money unexpectedly, I've repaid that fund many times over. And my other giving has almost always been unrestricted. As a long-time administrator, I know how valuable unrestricted gifts are for institutions and their departments, and I fully trust MIT to use my money wisely, for worthwhile purposes. That's even more important right now, when there's tremendous uncertainty about funding for biomedical research in the United States.

Helping the immune system attack tumors

Stefani Spranger is working to discover why some cancers don't respond to immunotherapy, in hopes of making them more vulnerable to it

Anne Trafton | MIT News

"We really want to understand why our immune system fails to recognize cancer," says MIT associate professor Stefani Spranger. *Photo: Gretchen Ertl*

In addition to patrolling the body for foreign invaders, the immune system also hunts down and destroys cells that have become cancerous or precancerous. However, some cancer cells end up evading this surveillance and growing into tumors.

Once established, tumor cells often send out immunosuppressive signals, which leads T cells to become "exhausted" and unable to attack the tumor. In recent years, some cancer immunotherapy drugs have shown great success in rejuvenating those T cells so they can begin attacking tumors again.

While this approach has proven effective against cancers such as melanoma, it doesn't work as well for others, including lung and ovarian cancer. MIT associate professor Stefani Spranger is trying to figure out how those tumors are able to suppress immune responses, in hopes of finding new ways to galvanize T cells into attacking them.

"We really want to understand why our immune system fails to recognize cancer," Spranger says. "And I'm most excited about the really hard-to-treat cancers because I think that's where we can make the biggest leaps."

Her work has led to a better understanding of the factors that control T cell responses to tumors, and raised the possibility of improving those responses through vaccination or treatment with immune-stimulating molecules called cytokines.

"We're working on understanding what exactly the problem is, and then collaborating with engineers to find a good solution," she says.

Jumpstarting T cells

As a student in Germany, where students often have to choose their college major while still in high school, Spranger envisioned going into the pharmaceutical industry

Spranger was drawn to MIT by the collaborative environment of MIT and its Koch Institute for Integrative Cancer Research. "That community is so vibrant, and it's amazing to be a part of it," Spranger says. *Photo: Gretchen Ertl*

and chose to major in biology. At Ludwig Maximilian University of Munich, her course of study began with classical biology subjects such as botany and zoology, and she began to doubt her choice. But, once she began taking courses in cell biology and immunology, her interest was revived and she continued into a biology graduate program at the university.

During a paper discussion class early in her graduate school program, Spranger was assigned to a science paper on a promising new immunotherapy treatment for melanoma. This strategy involves isolating tumor-infiltrating T cells during surgery, growing them into large numbers, and then returning them to the patient. For more than 50 percent of those patients, the tumors were completely eliminated.

"To me, that changed the world," Spranger recalls. "You can take the patient's own immune system, not really do all that much to it, and then the cancer goes away."

Spranger completed her PhD studies in a lab that worked on further developing that approach, known as adoptive T cell transfer therapy. At that point, she still was leaning toward going into pharma, but after finishing her PhD in 2011, her husband, also a biologist, convinced her that they should both apply for postdoc positions in the United States.

They ended up at the University of Chicago, where Spranger worked in a lab that studies how the immune system responds to tumors. There, she discovered that while melanoma is usually very responsive to immunotherapy, there is a small fraction of melanoma patients whose T cells don't respond to the therapy at all. That got her interested in trying to figure out why the immune system doesn't always respond to cancer the way that it should, and in finding ways to jumpstart it.

During her postdoc, Spranger also discovered that she enjoyed mentoring students, which she hadn't done as a graduate student in Germany. That experience drew her away from going into the pharmaceutical industry, in favor of a career in academia.

"I had my first mentoring teaching experience having an undergrad in the lab, and seeing that person grow as a scientist, from barely asking questions to running full experiments and coming up with hypotheses, changed how I approached science and my view of what academia should be for," she says.

Modeling the immune system

When applying for faculty jobs, Spranger was drawn to MIT by the collaborative environment of MIT and its Koch Institute for Integrative Cancer Research, which offered the chance to collaborate with a large community of engineers who work in the field of immunology. "That community is so vibrant, and it's amazing to be a part of it," she says.

Building on the research she had done as a postdoc, Spranger wanted to explore why some tumors respond well to immunotherapy, while others do not. For many of her early studies, she used a mouse model of non-small cell lung cancer. In human patients, the majority of these tumors do not respond well to immunotherapy.

"We build model systems that resemble each of the different subsets of nonresponsive, nonsmall cell lung cancer, and we're trying to really drill down to the mechanism of why the immune system is not appropriately responding," she says.

As part of that work, she has investigated why the immune system behaves differently in different types of tissue. While immunotherapy drugs called checkpoint inhibitors can stimulate a strong T cell response in the skin, they don't do nearly as much in the lung. However, Spranger has shown that T cell responses in the lung can be improved when immune molecules called cytokines are also given along with the checkpoint inhibitor.

Those cytokines work, in part, by activating dendritic cells — a class of immune cells that help to initiate immune responses, including activation of T cells.

"Dendritic cells are the conductor for the orchestra of all the T cells, although they're a very sparse cell population," Spranger says. "They can communicate which type of danger they sense from stressed cells and then instruct the T cells on what they have to do and where they have to go."

Spranger's lab is now beginning to study other types of tumors that don't respond at all to immunotherapy, including ovarian cancer and glioblastoma. Both the brain and the peritoneal cavity appear to suppress T cell responses to tumors, and Spranger hopes to figure out how to overcome that immunosuppression.

"We're specifically focusing on ovarian cancer and glioblastoma, because nothing's working right now for those cancers," she says. "We want to understand what we have to do in those sites to induce a really good antitumor immune response."

Mapping mRNA through its life cycle within a cell

Xiao Wang's studies of how and where RNA is translated could lead to the development of better RNA therapeutics and vaccines

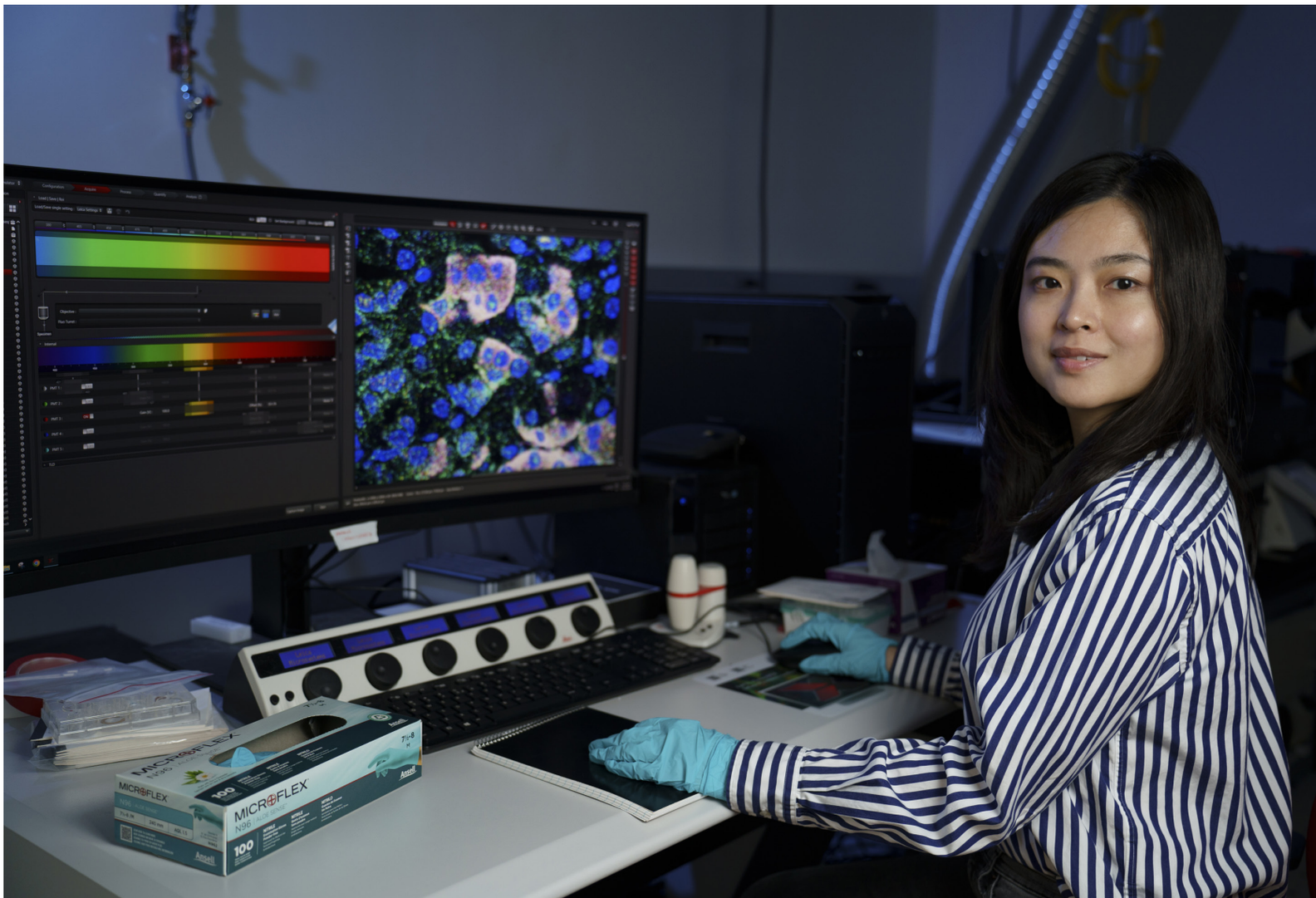
Anne Trafton | MIT News

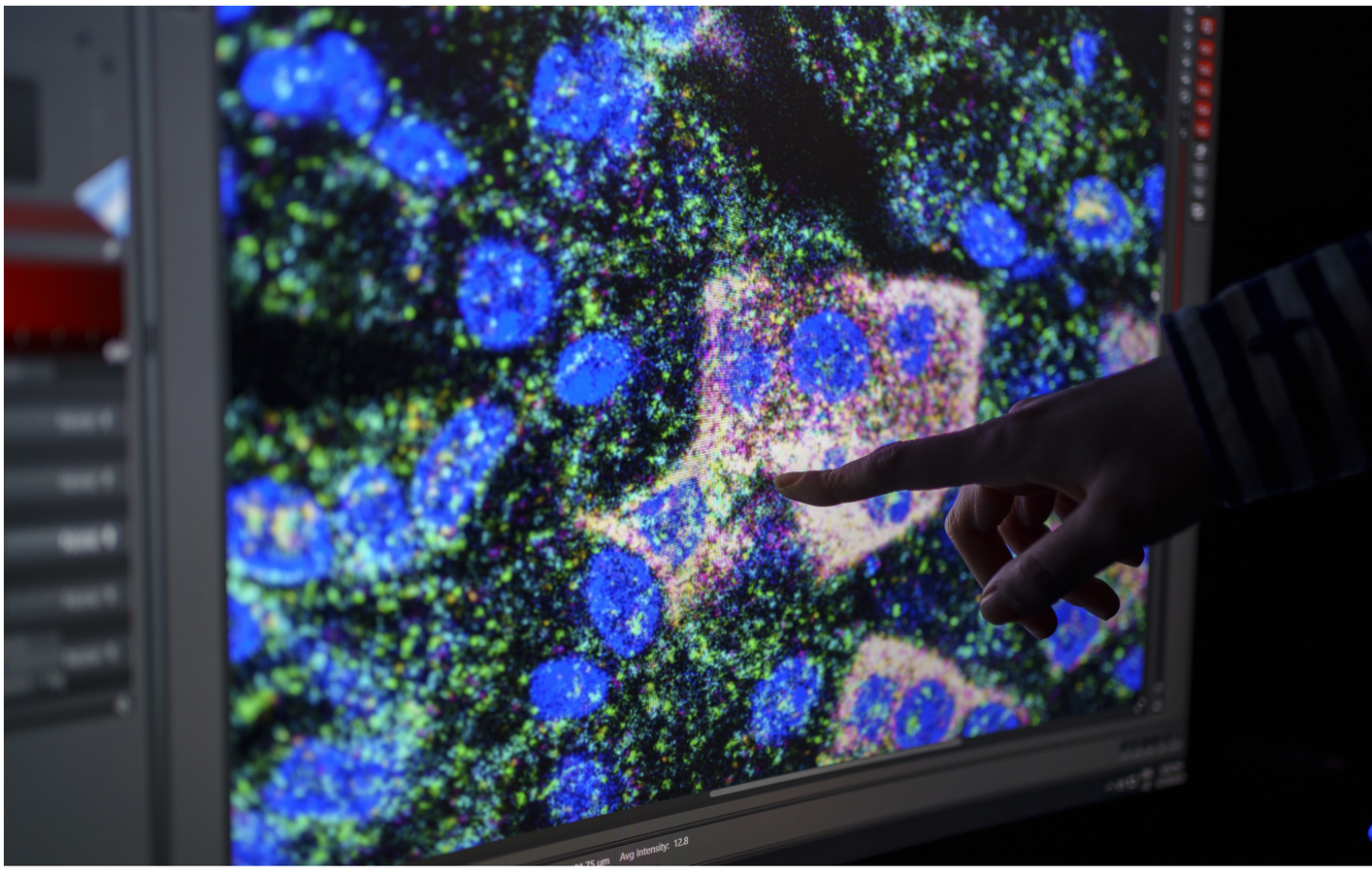
When Xiao Wang applied to faculty jobs, many of the institutions where she interviewed thought her research proposal — to study the life cycle of RNA in cells and how it influences normal development and disease — was too broad.

However, that was not the case when she interviewed at MIT, where her future colleagues embraced her ideas and encouraged her to be even more bold.

"What I'm doing now is even broader, even bolder than what I initially proposed," says Wang, who holds joint appointments in the Department of Chemistry and the Broad Institute of MIT and Harvard. "I got great support from all my colleagues in my department and at Broad so that I could get the resources to conduct what I wanted to do. It's also a demonstration of how brave the students are. There is a really innovative culture and environment here, so the students are not scared by taking on something that might sound weird or unrealistic."

"I really like to do research because every day you have a hypothesis, you have a design, and you make it happen," says MIT associate professor Xiao Wang. *Photo: Jodi Hilton*





"We are trying to develop a tool kit that will let us visualize every step of the RNA life cycle inside cells and tissues," Wang says. *Photo: Jodi Hilton*

Wang's work on RNA brings together students from chemistry, biology, computer science, neuroscience, and other fields. In her lab, research is focused on developing tools that pinpoint where in a given cell different types of messenger RNA are translated into proteins — information that can offer insight into how cells control their fate and what goes wrong in disease, especially in the brain.

"The joint position between MIT Chemistry and the Broad Institute was very attractive to me because I was trained as a chemist, and I would like to teach and recruit students from chemistry. But meanwhile, I also wanted to get exposure to biomedical topics and have collaborators outside chemistry. I can collaborate with biologists, doctors, as well as computational scientists who analyze all these daunting data," she says.

Imaging RNA

Wang began her career at MIT in 2019, just before the Covid-19 pandemic began. Until that point, she hardly knew anyone in the Boston area, but she found a warm welcome.

"I wasn't trained at MIT, and I had never lived in Boston before. At first, I had very small social circles, just with my colleagues and my students, but amazingly, even during the pandemic, I never felt socially isolated. I just felt so plugged in already even though it's a very close, small circle," she says.

Growing up in China, Wang became interested in science in middle school, when she was chosen to participate in China's National Olympiad in math and chemistry. That gave her the chance to learn college-level course material, and she ended up winning a gold medal in the nationwide chemistry competition.

"That exposure was enough to draw me into initially mathematics, but later on more into chemistry. That's how I got interested in a more science-oriented major and then career path," Wang says.

At Peking University, she majored in chemistry and molecular engineering. There, she worked with Professor Jian Pei, who gave her the opportunity to work independently on her own research project.

"I really like to do research because every day you have a hypothesis, you have a design, and you make it happen. It's like playing a video game: You have this roughly daily feedback loop. Sometimes it's a reward, sometimes it's not. I feel it's more interesting than taking a class, so I think that made me decide I should apply for graduate school," she says.

As a graduate student at the University of Chicago, she became interested in RNA while doing a rotation in the lab of Chuan He, a professor of chemistry. He was studying chemical modifications that affect the function

of messenger RNA — the molecules that carry protein-building instructions from DNA to ribosomes, where proteins are assembled.

Wang ended up joining He's lab, where she studied a common mRNA modification known as m6A, which influences how efficiently mRNA is translated into protein and how fast it gets degraded in the cell. She also began to explore how mRNA modifications affect embryonic development. As a model for these studies, she was using zebra fish, which have transparent embryos that develop from fertilized eggs into free-swimming larvae within two days. That got her interested in developing methods that could reveal where different types of RNA were being expressed, by imaging the entire organism.

Such an approach, she soon realized, could also be useful for studying the brain. As a postdoc at Stanford University, she started to develop RNA imaging methods, working with Professor Karl Deisseroth. There are existing techniques for identifying mRNA molecules that are expressed in individual cells, but those don't offer information about exactly where in the cells different types of mRNA are located. She began developing a technique called STARmap that could accomplish this type of "spatial transcriptomics."

Using this technique, researchers first use formaldehyde to crosslink all of the mRNA molecules in place. Then, the tissue is washed with fluorescent DNA probes that are complementary to the target mRNA sequences. These probes can then be imaged and sequenced, revealing the locations of each mRNA sequence within a cell. This allows for the visualization of mRNA molecules that encode thousands of different genes within single cells.

"I was leveraging my background in the chemistry of RNA to develop this RNA-centered brain mapping technology, which allows you to use RNA expression profiles to define brain cell types and also visualize their spatial architecture," Wang says.

Tracking the RNA life cycle

Members of Wang's lab are now working on expanding the capability of the STARmap technique so that it can be used to analyze brain function and brain wiring. They are also developing tools that will allow them to map the entire life cycle of mRNA molecules, from synthesis to translation to degradation, and track how these molecules are transported within a cell during their lifetime.

One of these tools, known as RIBOmap, pinpoints the locations of mRNA molecules as they are being translated at ribosomes. Another tool allows the researchers to measure how quickly mRNA is degraded after being transcribed.

"We are trying to develop a tool kit that will let us visualize every step of the RNA life cycle inside cells and tissues," Wang says. "These are newer generations of tool development centered around these RNA biological questions."

> "Our goal is to create a toolbox and RNA synthesis strategy where we can precisely tune the chemical modification on every particle of RNA."

One of these central questions is how different cell types control their RNA life cycles differently, and how that affects their differentiation. Differences in RNA control may also be a factor in diseases such as Alzheimer's. In a 2023 study, Wang and MIT professor Morgan Sheng used a version of STARmap to discover how cells called microglia become more inflammatory as amyloid-beta plaques form in the brain. Wang's lab is also pursuing studies of how differences in mRNA translation might affect schizophrenia and other neurological disorders.

"The reason we think there will be a lot of interesting biology to discover is because the formation of neural circuits is through synapses, and synapse formation and learning and memory are strongly associated with localized RNA translation, which involves multiple steps including RNA transport and recycling," she says.

In addition to investigating those biological questions, Wang is also working on ways to boost the efficiency of mRNA therapeutics and vaccines by changing their chemical modifications or their topological structure.

"Our goal is to create a toolbox and RNA synthesis strategy where we can precisely tune the chemical modification on every particle of RNA," Wang says. "We want to establish how those modifications will influence how fast mRNA can produce protein, and in which cell types they could be used to more efficiently produce protein."

Modeling complex behavior with a simple organism

Anne Trafton | MIT News

The roundworm *C. elegans* is a simple animal whose nervous system has exactly 302 neurons. Each of the connections between those neurons has been comprehensively mapped, allowing researchers to study how they work together to generate the animal's different behaviors.

Steven Flavell, an MIT associate professor of brain and cognitive sciences and investigator with The Picower Institute for Learning and Memory at MIT and the Howard Hughes Medical Institute, uses the worm as a model to study motivated behaviors such as feeding and navigation, in hopes of shedding light on the fundamental mechanisms that may also determine how similar behaviors are controlled in other animals.

In recent studies, Flavell's lab has uncovered neural mechanisms underlying adaptive changes in the worms' feeding behavior, and his lab has also mapped how the activity of each neuron in the animal's nervous system affects the worms' different behaviors.

> "*C. elegans* has a fairly well-defined, smallish set of behaviors, which makes it attractive for research. You can really measure almost everything that the animal is doing and study it."

Such studies could help researchers gain insight into how brain activity generates behavior in humans. "It is our aim to identify molecular and neural circuit mechanisms that may generalize across organisms," he says, noting that many fundamental biological discoveries, including those related to programmed cell death, microRNA, and RNA interference, were first made in *C. elegans*.

"Our lab has mostly studied motivated state-dependent behaviors, like feeding and navigation. The machinery that's being used to control these states in *C. elegans* — for example, neuromodulators — are actually the same as in humans. These pathways are evolutionarily ancient," he says.

Drawn to the lab

Born in London to an English father and a Dutch mother, Flavell came to the United States in 1982 at the age of 2, when his father became chief scientific officer at Biogen. The family lived in Sudbury, Massachusetts, and his mother worked as a computer programmer and math teacher. His father later became a professor of immunology at Yale University.

Though Flavell grew up in a science family, he thought about majoring in English when he arrived at Oberlin College. A musician as well, Flavell took jazz guitar classes at Oberlin's conservatory, and he also plays the piano and the saxophone. However, taking classes in psychology and physiology led him to discover that the field that most captivated him was neuroscience.

"I was immediately sold on neuroscience. It combined the rigor of the biological sciences with deep questions from psychology," he says.

While in college, Flavell worked on a summer research project related to Alzheimer's disease, in a lab at Case Western Reserve University. He then continued the project, which involved analyzing postmortem Alzheimer's tissue, during his senior year at Oberlin.

"My earliest research revolved around mechanisms of disease. While my research interests have evolved since then, my earliest research experiences were the ones that really got me hooked on working at the bench: running experiments, looking at brand new results, and trying to understand what they mean," he says.

By the end of college, Flavell was a self-described lab rat: "I just love being in the lab." He applied to graduate school and ended up going to Harvard Medical School for a PhD in neuroscience. Working with Michael Greenberg, Flavell studied how sensory experience and resulting neural activity shapes brain development. In particular, he focused on a family of gene regulators called MEF2, which play important roles in neuronal development and synaptic plasticity.

All of that work was done using mouse models, but Flavell transitioned to studying *C. elegans* during a postdoctoral fellowship working with Cori Bargmann at Rockefeller University. He was interested in studying how neural circuits control behavior, which seemed to be more feasible in simpler animal models.

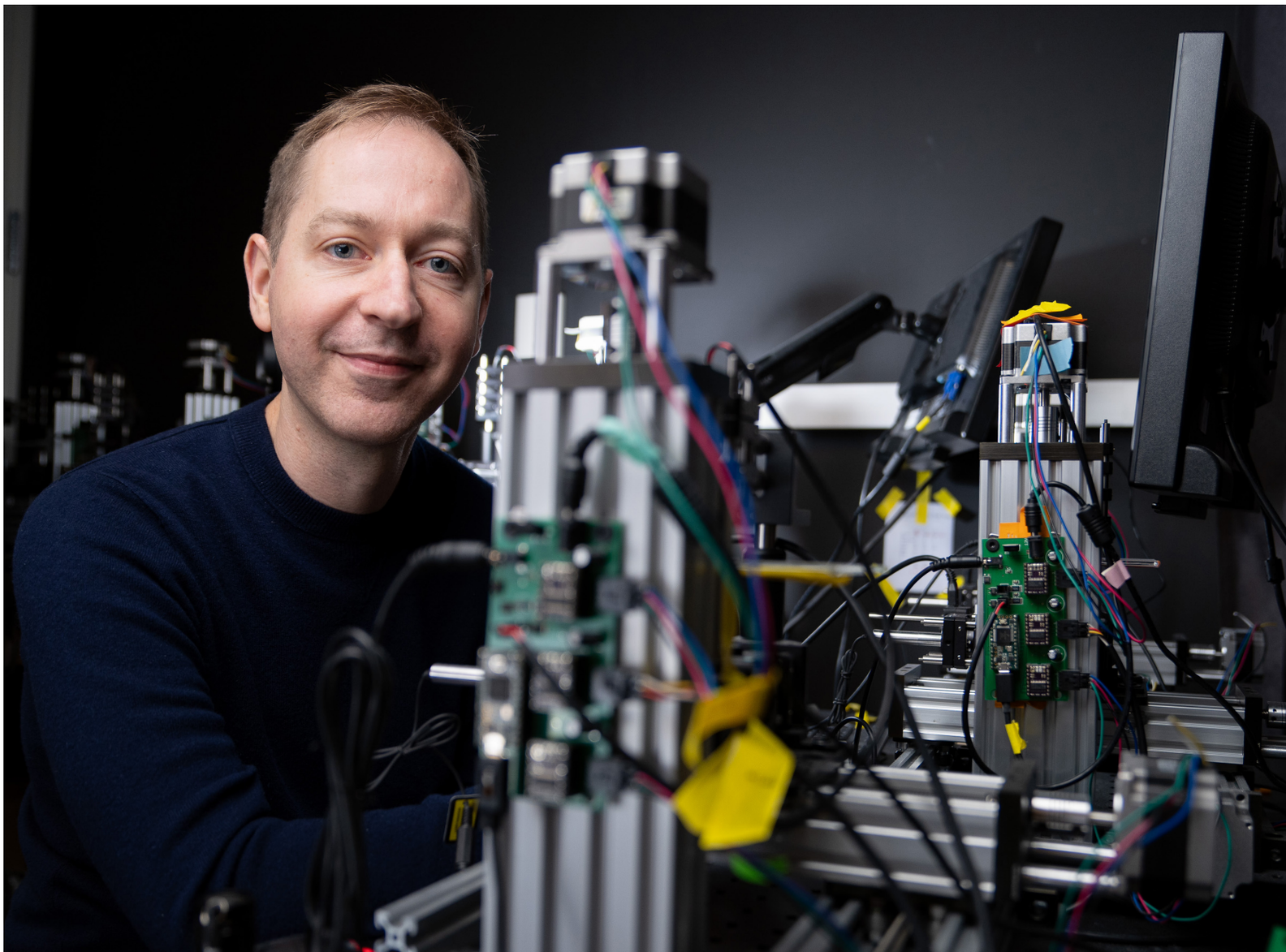
"Studying how neurons across the brain govern behavior felt like it would be nearly intractable in a large brain — to understand all the nuts and bolts of how neurons interact with each other and ultimately generate behavior seemed daunting," he says. "But I quickly became excited about studying this in *C. elegans* because at the time it was still the only animal with a full blueprint of its brain: a map of every brain cell and how they are all wired up together."

That wiring diagram includes about 7,000 synapses in the entire nervous system. By comparison, a single human neuron may form more than 10,000 synapses. "Relative to those larger systems, the *C. elegans* nervous system is mind-bogglingly simple," Flavell says.

Despite their much simpler organization, roundworms can execute complex behaviors such as feeding, locomotion, and egg-laying. They even sleep, form memories, and find suitable mating partners. The neuromodulators and cellular machinery that give rise to those behaviors are similar to those found in humans and other mammals.

"*C. elegans* has a fairly well-defined, smallish set of behaviors, which makes it attractive for research. You can really measure almost everything that the animal is doing and study it," Flavell says.

"Being at MIT has allowed my lab to be much more multidisciplinary than it could have been elsewhere," says Associate Professor Steven Flavell.
Photo: Bryce Vickmark



By studying the roundworm *C. elegans,* neuroscientist Steven Flavell explores how neural circuits give rise to behavior. *Photo: Bryce Vickmark*

How behavior arises

Early in his career, Flavell's work on *C. elegans* revealed the neural mechanisms that underlie the animal's stable behavioral states. When worms are foraging for food, they alternate between stably exploring the environment and pausing to feed. "The transition rates between those states really depend on all these cues in the environment. How good is the food environment? How hungry are they? Are there smells indicating a better nearby food source? The animal integrates all of those things and then adjusts their foraging strategy," Flavell says.

These stable behavioral states are controlled by neuromodulators like serotonin. By studying serotonergic regulation of the worms' behavioral states, Flavell's lab has been able to uncover how this important system is organized. In a recent study, Flavell and his colleagues published an "atlas" of the *C. elegans* serotonin system. They identified every neuron that produces serotonin, every neuron that has serotonin receptors, and how brain activity and behavior change across the animal as serotonin is released.

"Our studies of how the serotonin system works to control behavior have already revealed basic aspects of serotonin signaling that we think ought to generalize all the way up to mammals," Flavell says. "By studying the way that the brain implements these long-lasting states, we can tap into these basic features of neuronal function. With the resolution that you can get studying specific *C. elegans* neurons and the way that they implement behavior, we can uncover fundamental features of the way that neurons act."

In parallel, Flavell's lab has also been mapping out how neurons across the *C. elegans* brain control different aspects of behavior. In a 2023 study, Flavell's lab mapped how changes in brain-wide activity relate to behavior. His lab uses special microscopes that can move along with the worms as they explore, allowing them to simultaneously track every behavior and measure the activity of every neuron in the brain. Using these data, the researchers created computational models that can accurately capture the relationship between brain activity and behavior.

This type of research requires expertise in many areas, Flavell says. When looking for faculty jobs, he hoped to find a place where he could collaborate with researchers working in different fields of neuroscience, as well as scientists and engineers from other departments.

"Being at MIT has allowed my lab to be much more multidisciplinary than it could have been elsewhere," he says. "My lab members have had undergrad degrees in physics, math, computer science, biology, neuroscience, and we use tools from all of those disciplines. We engineer microscopes, we build computational models, we come up with molecular tricks to perturb neurons in the *C. elegans* nervous system. And I think being able to deploy all those kinds of tools leads to exciting research outcomes."

MIT welcomes 2025 Heising-Simons Foundation 51 Pegasi b Fellow Jess Speedie

The fellowship supports research contributing to the field of planetary science and astronomy

Paige Colley | Earth, Atmospheric and Planetary Sciences

The MIT School of Science welcomes Jess Speedie, one of eight recipients of the 2025 51 Pegasi b Fellowship. The announcement was made March 27 by the Heising-Simons Foundation.

The 51 Pegasi b Fellowship, named after the first exoplanet discovered orbiting a sunlike star, was established in 2017 to provide postdocs with the opportunity to conduct theoretical, observational, and experimental research in planetary astronomy.

Speedie, who expects to complete her PhD in astronomy at the University of Victoria, Canada, this summer, will be hosted by the Department of Earth, Atmospheric and Planetary Sciences. She will be mentored by Kerr-McGee Career Development Professor Richard Teague as she uses a combination of observational data and simulations to study the birth of planets and the processes of planetary formation.

“The planetary environment is where all the good stuff collects . . . it has the greatest potential for the most interesting things in the universe to happen, such as the origin of life,” she says. “Planets, for me, are where the stories happen.”

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.

“One of the big, big questions right now in the community focused on planet formation is, where are the planets? It is that simple. We think they’re developing in these disks, but we’ve detected so few of them,” she says.

While working as a fellow, Speedie is aiming to develop an algorithm that carefully aligns and stacks a decade of ALMA observational data to correct for a blurring effect that happens when combining images captured at different times. Doing so should produce the sharpest, most sensitive images of early planetary systems to date.

She is also interested in studying infant planets, especially ones that may be forming in disks around protoplanets, rather than stars. Modeling how these ingredient materials in orbit behave could give astronomers a way to measure the mass of young planets.

“What’s exciting is the potential for discovery. I have this sense that the universe as a whole is infinitely more creative than human minds — the kinds of things that happen out there, you can’t make that up. It’s better than science fiction,” she says.

The other 51 Pegasi b Fellows and their host institutions this year are Nick Choksi (Caltech), Yan Liang (Yale University), Sagnick Mukherjee (Arizona State University), Matthew Nixon (Arizona State University), Julia Santos (Harvard University), Nour Skaf (University of Hawaii), and Jerry Xuan (University of California at Los Angeles).

The fellowship provides up to $450,000 of support over three years for independent research, a generous salary and discretionary fund, mentorship at host institutions, an annual summit to develop professional networks and foster collaboration, and an option to apply for another grant to support a future position in the United States.

51 Pegasi b Fellow Jess Speedie will combine observational data and simulations to trace the imprints of newborn worlds and reveal hidden processes of planet formation. “Planets, for me, are where the stories happen,” she says. *Photo courtesy of the Heising-Simon Foundation*

Drawing inspiration from ancient chemical reactions

By studying cellular enzymes that perform difficult reactions, MIT chemist Daniel Suess hopes to find new solutions to global energy challenges

Anne Trafton | MIT News

To help find solutions to the planet's climate crisis, MIT associate professor Daniel Suess is looking to Earth's ancient past.

Early in the evolution of life, cells gained the ability to perform reactions such as transferring electrons from one atom to another. These reactions, which help cells to build carbon-containing or nitrogen-containing compounds, rely on specialized enzymes with clusters of metal atoms.

By learning more about how those enzymes work, Suess hopes to eventually devise new ways to perform fundamental chemical reactions that could help capture carbon from the atmosphere or enable the development of alternative fuels.

"We have to find some way of rewiring society so that we are not just relying on vast reserves of reduced carbon, fossil fuels, and burning them using oxygen," he says. "What we're doing is we're looking backward, up to a billion years before oxygen and photosynthesis came along, to see if we can identify the chemical principles that underlie processes that aren't reliant on burning carbon."

His work could also shed light on other important cellular reactions such as the conversion of nitrogen gas to ammonia, which is also the key step in the production of synthetic fertilizer.

Exploring chemistry

Suess, who grew up in Spokane, Washington, became interested in math at a young age, but ended up majoring in chemistry and English at Williams College, which he chose based on its appealing selection of courses.

"I was interested in schools that were more focused on the liberal arts model, Williams being one of those. And I just thought they had the right combination of really interesting courses and freedom to take classes that you wanted," he says. "I went in not expecting to major in chemistry, but then I really enjoyed my chemistry classes and chemistry teachers."

In his classes, he explored all aspects of chemistry and found them all appealing.

"I liked organic chemistry, because there's an emphasis on making things. And I liked physical chemistry because there was an attempt to have at least a semiquantitative way of understanding the world. Physical chemistry describes some of the most important developments in science in the 20th century, including quantum mechanics and its application to atoms and molecules," he says.

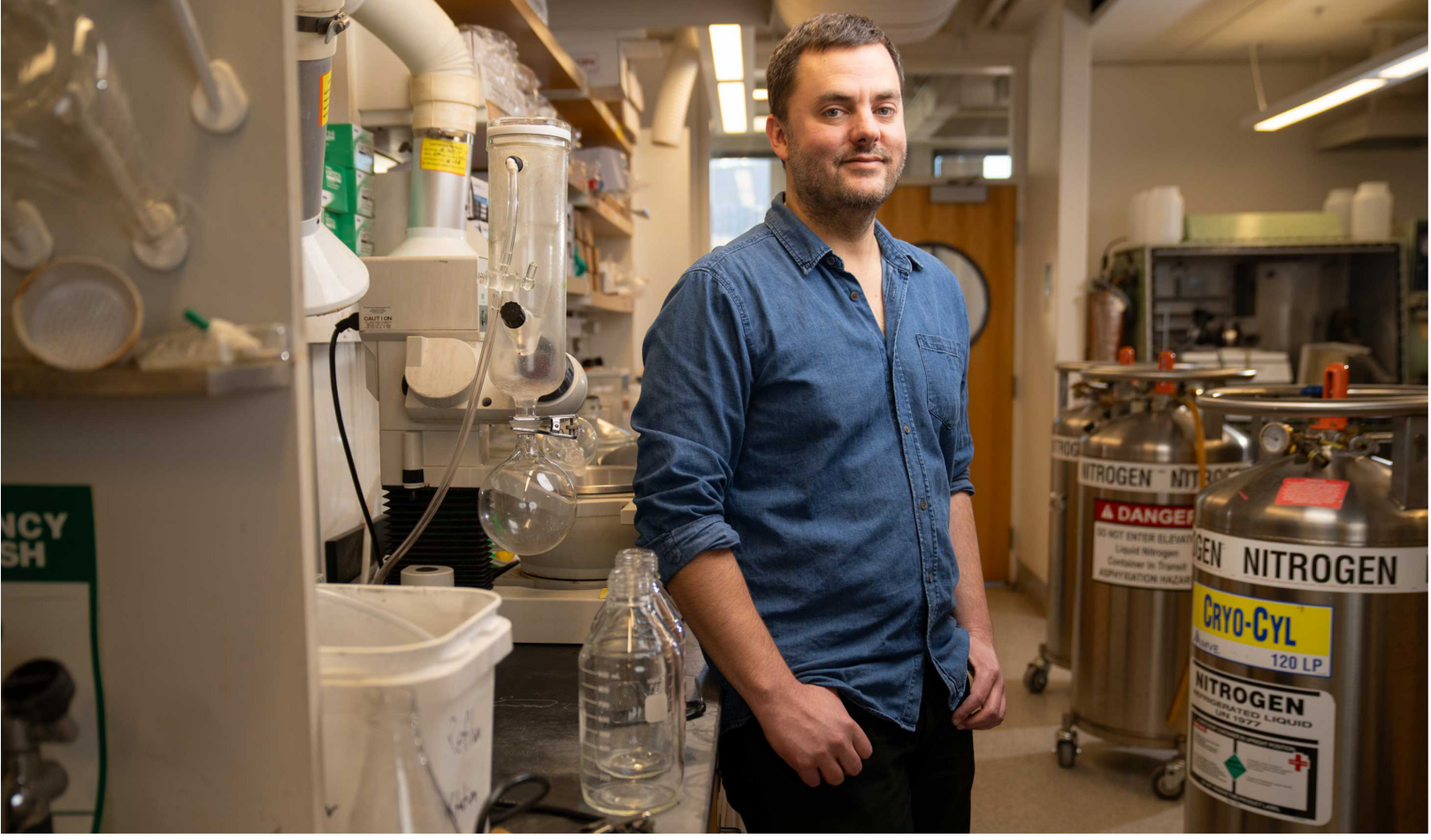
After college, Suess came to MIT for graduate school and began working with chemistry professor Jonas Peters, who had recently arrived from Caltech. A couple of years later, Peters ended up moving back to Caltech, and Suess followed, continuing his PhD thesis research on new ways to synthesize inorganic molecules.

His project focused on molecules that consist of a metal such as iron or cobalt bound to a nonmetallic group known as a ligand. Within these molecules, the metal atom typically pulls in electrons from the ligand. However, the molecules Suess worked on were designed so that the metal would give up its own electrons to the ligand. Such molecules can be used to speed up difficult reactions that require breaking very strong bonds, like the nitrogen-nitrogen triple bond in N_2.

During a postdoc at the University of California at Davis, Suess switched gears and began working on biomolecules — specifically, metalloproteins. These are protein enzymes that have metals tucked into their active sites, where they help to catalyze reactions.

Suess studied how cells synthesize the metal-containing active sites in these proteins, focusing on an enzyme called iron-iron hydrogenase. This enzyme, found mainly in anaerobic bacteria, including some that live in the human digestive tract, catalyzes reactions involving the transfer of protons and electrons. Specifically, it can combine two protons and two electrons to make H_2, or can perform the reverse reaction, breaking H_2 into protons and electrons.

"That enzyme is really important because a lot of cellular metabolic processes either generate excess electrons or require excess electrons. If you generate excess electrons, they have to go somewhere, and one solution is to put them on protons to make H_2," Suess says.



By studying enzymes that perform evolutionarily ancient reactions, Dan Suess hopes to find solutions to global energy challenges. He's interested in reactions that are "occurring on the microscopic scale but happening on a huge scale" around the world. *Photo: Bryce Vickmark*

Global scale reactions

Since joining the MIT faculty in 2017, Suess has continued his investigations of metalloproteins and the reactions that they catalyze.

"We're interested in global-scale chemical reactions, meaning they're occurring on the microscopic scale but happening on a huge scale," he says. "They impact the planet and have determined what the molecular composition of the biosphere is and what it's going to be."

Photosynthesis, which emerged around 2.4 billion years ago, has had the biggest impact on the atmosphere, filling it with oxygen, but Suess focuses on reactions that cells began using even earlier, when the atmosphere lacked oxygen and cell metabolism could not be driven by respiration.

Many of these ancient reactions, which are still used by cells today, involve a class of metalloproteins called iron-sulfur proteins. These enzymes, which are found in all kingdoms of life, are involved in catalyzing many of the most difficult reactions that occur in cells, such as forming carbon radicals and converting nitrogen to ammonia.

To study the metalloenzymes that catalyze these reactions, Suess's lab takes two different approaches. In one, they create synthetic versions of the proteins that may contain fewer metal atoms, which allows for greater control over the composition and shape of the protein, making them easier to study.

In another approach, they use the natural version of the protein but substitute one of the metal atoms with an isotope that makes it easier to use spectroscopic techniques to analyze the protein's structure.

"That allows us to study both the bonding in the resting state of an enzyme, as well as the bonding and structures of reaction intermediates that you can only characterize spectroscopically," Suess says.

Understanding how enzymes perform these reactions could help researchers find new ways to remove carbon dioxide from the atmosphere by combining it with other molecules to create larger compounds. Finding alternative ways to convert nitrogen gas to ammonia could also have a big impact on greenhouse gas emissions, as the Haber-Bosch process now used to synthesize fertilizer products requires huge amounts of energy.

"Our primary focus is on understanding the natural world, but I think that as we're looking at different ways to wire biological catalysts to do efficient reactions that impact society, we need to know how that wiring works. And so that is what we're trying to figure out," he says.

Atmosphere, there, and everywhere

Breakfast with Noelle Selin, professor of atmospheric chemistry and director of the MIT Center for Sustainability Science and Strategy

Jesse Feiman | School of Science

In the early morning of April 3, Noelle Selin, professor of atmospheric chemistry and director of the MIT Center for Sustainability Science and Strategy, addressed an enthusiastic crowd of MIT alumni and friends on the topic of hazardous pollutants and strategies to mitigate their impacts on health.

Selin told the group, "As an Earth scientist, if I really think about understanding the Earth, I have to understand the humans in it as well." She discussed two case studies to illustrate the need for circumspect approaches in tackling pollution: the insidious threat posed by mercury in the environment, and the risks of substituting ammonia for diesel as a fuel for maritime shipping.

Although humans have known for centuries that mercury is toxic, its unique properties have found applications in industries ranging from mining to medicine to makeup. Selin focused on atmospheric mercury and its primary sources: coal burning and small-scale gold mining. Mercury is a contaminant in coal, and emissions from power plants release it into the air. Miners use mercury to efficiently harvest gold particles from waterways, binding the elements together and burning off the mercury to leave behind pure

Atmospheric chemist Noelle Selin delivers the Dean's Breakfast talk on April 3, 2025. *Photo: Steph Stevens*

■ Dean Nergis Mavalvala talks with astrophysicist Andrea Dupree, the associate director of the Center for Astrophysics | Harvard & Smithsonian. *Photo: Steph Stevens*

gold. When mercury enters the atmosphere, it circulates the globe and deposits in lakes and oceans, where it enters the food chain and can concentrate in human food sources like fish.

In 2013, nearly 140 countries, including the United States, signed the Minamata Convention, a treaty designed to protect humans and the environment from mercury and mercury compounds. The treaty targeted emissions and outlined tools for small-scale miners to reduce or eliminate their use of mercury. After a decade, atmospheric detectors available to Selin and her team found significantly reduced levels of the element. Displaying a map of the globe, however, she demonstrated that the detectors who made their data available were concentrated in Europe and North America, highlighting the positive impacts of treaties like Minamata as well as limitations in measuring its effect. In a study authored by former Institute for Data, Systems, and Society postdoc Ari Feinberg, researchers employed box modeling and 3D chemical transport models to account for data gaps and to inform hypotheses about the decline in atmospheric mercury — pointing to changes in human-made emissions as a likely explanation.

Turning to another source of atmospheric pollution, Selin explained the perceived benefits and unintentional consequences of employing ammonia as a fuel for maritime shipping. Because ammonia combustion produces no carbon dioxide, switching to ammonia from fossil fuels is a possible path to decarbonization. However, despite being carbon-free, ammonia produces other emissions — NO_x, NH_3, and N_2O — which could worsen air quality. In a study led by Anthony Wong, a postdoc in the MIT Center for Global Change Science, scientists attempted to model the system impact of this switch. They considered scenarios with two types of ammonia ship engines and three differing sets of regulatory policy to calculate emissions and their impact on pollution and human health.

Smarter modeling takes human interaction with the environment into account. Flexible, reconfigurable models can help to untangle complex environmental knots. In the case of mercury and ammonia, models shed light on the push and pull of human behavior, policy, public health, and science. Selin's work brings this climate knowledge to other sectors and international decision makers. "With some simple things," she says, "we can make a lot of progress."

Breakfast of champions: MIT hosts top young scientists

At an MIT-led event at AJAS/AAAS, researchers connect with MIT faculty, Nobel Laureates, and industry leaders to share their work, gain mentorship, and explore future careers in science

Jessica Chomik-Morales | School of Science

On Feb. 14, some of the nation's most talented high school researchers convened in Boston for the annual American Junior Academy of Science (AJAS) conference, held alongside the American Association for the Advancement of Science (AAAS) annual meeting. As a highlight of the event, MIT once again hosted its renowned Breakfast with Scientists, offering students a unique opportunity to connect with leading scientific minds from around the world.

The AJAS conference began with an opening reception at the MIT Schwarzman College of Computing, where professor of biology and chemistry Catherine Drennan delivered the keynote address, welcoming 162 high school students from 21 states. Delegates were selected through state Academy of Science competitions, earning the chance to share their work and connect with peers and professionals in science, technology, engineering, and mathematics (STEM).

Over breakfast, students engaged with distinguished scientists, including MIT faculty, Nobel Laureates, and industry leaders, discussing research, career paths, and the broader impact of scientific discovery.

Amy Keating, head of the MIT Department of Biology, sat at a table with students ranging from high school juniors to college sophomores. The group engaged in an open discussion about life as a scientist at a leading institution like MIT. One student expressed concern about the competitive nature of innovative research environments, prompting Keating to reassure them, saying, "MIT has a collaborative philosophy rather than a competitive one."

At another table, Nobel Laureate and former MIT postdoc Gary Ruvkun shared a lighthearted moment with students, laughing at a TikTok video they had created to explain their science fair project. The interaction reflected the innate curiosity and excitement that drives discovery at all stages of a scientific career.

Donna Gerardi, executive director of the National Association of Academies of Science, highlighted the significance of the AJAS program. "These students are not just competing in science fairs; they are becoming part of a larger scientific community. The connections they make here can shape their careers and future contributions to science."

Alongside the breakfast, AJAS delegates participated in a variety of enriching experiences, including laboratory tours, conference sessions, and hands-on research activities.

"I am so excited to be able to discuss my research with experts and get some guidance on the next steps in my academic trajectory," said Andrew Wesel, a delegate from California.

A defining feature of the AJAS experience was its emphasis on mentorship and collaboration rather than competition. Delegates were officially inducted as lifetime fellows of the American Junior Academy of Science at the conclusion of the conference, joining a distinguished network of scientists and researchers.

Sponsored by the MIT School of Science and School of Engineering, the breakfast underscored MIT's longstanding commitment to fostering young scientific talent. Faculty and researchers took the opportunity to encourage students to pursue careers in STEM fields, providing insights into the pathways available to them.

"It was a joy to spend time with such passionate students," says Kristala Prather, head of the Department of Chemical Engineering at MIT. "One of the brightest moments for me was sitting next to a young woman who will be joining MIT in the fall — I just have to convince her to study ChemE!"

Institute Professor Phillip Sharp speaks with high school attendees at the American Junior Academy of Sciences conference breakfast hosted by MIT in February. *Photo: Mandana Sassanfar*

New initiative to advance innovations in pediatric care

The Hood Pediatric Innovation Hub aims to break down barriers to pediatric innovation and foster transformative research to improve children's health outcomes

Zach Goodale | School of Engineering

The MIT Health and Life Sciences Collaborative (MIT HEALS) has announced the establishment of the Hood Pediatric Innovation Hub, an ambitious effort designed to drive cutting-edge innovation in children's health care. Launched in collaboration with the Charles H. Hood Foundation, the hub will focus on addressing unmet needs in pediatric medicine by developing technologies and treatments tailored specifically for children.

Leveraging the Institute's strengths in the life sciences, the hub will provide seed funding and strategic support for bold, high-impact research projects with the potential to transform health care for children. It will also act as a springboard for emerging scientific leaders, empowering them to help shape the future of pediatric health.

"The Hood Pediatric Innovation Hub represents an extraordinary opportunity to create meaningful and lasting change in the lives of children," says Anantha Chandrakasan, dean of the MIT School of Engineering, MIT's chief innovation and strategy officer, and head of MIT HEALS. "By collaborating with the Charles H. Hood Foundation, we're harnessing MIT's interdisciplinary strengths to tackle some of the most pressing challenges in pediatric health care."

Addressing critical gaps in pediatric health care

Despite making up a significant portion of the global population, children have been largely underserved when it comes to medical innovation, leaving immense gaps in care. Pediatric conditions that shape a lifetime of health and well-being often lack dedicated solutions — forcing reliance on repurposed adult treatments or no solution at all. From 2008 to 2018, only 10 percent of U.S. Food and Drug Administration approvals were designated for individuals under the age of 18.

There is a massive opportunity to prioritize innovation for people during their formative years and drive breakthroughs that not only improve individual lives but also elevate health outcomes for generations to come. The Hood Pediatric Innovation Hub seeks to lead this transformation by creating a dedicated community for advancing technologies and research.

"We are thrilled to collaborate with MIT to launch the hub, a bold initiative that will drive groundbreaking science and technology for children. MIT's unparalleled expertise in engineering and life sciences, combined with our deep commitment to pediatric innovation, creates a powerful force for change," says Hood Foundation president Neil Smiley, on behalf of the foundation's board of trustees. "We look forward to this catalytic gift igniting transformative programs that will shape the future of children's health and well-being for generations to come."

The Hood Foundation, based in Massachusetts, has committed $15 million over five years to support the creation and development of the hub, reinforcing its long-standing dedication to advancing groundbreaking pediatric research. Since its establishment in 1942, the Charles H. Hood Foundation has sought to fill gaps in the pediatric health care system by awarding research grants and supporting the development of pediatric related tools and treatments.

In addition to its established grant programs, over the course of the past decade the Hood Foundation has served as a pioneer in supporting young companies trying to bring pediatric innovations to the patients who need them, by way of program-related investments made via its venture arm, CH Innovations.

"The Hood Foundation's longstanding dedication to improving child health has led to the formation of an extensive and robust network of researchers, clinician-scientists, entrepreneurs, and other leaders in science and business who stand well-positioned to engage with and contribute to the hub's efforts," adds Smiley.

A central role in the MIT Health and Life Sciences Collaborative

The Hood Pediatric Innovation Hub, which will be administered in the MIT School of Engineering, will serve as a cornerstone of MIT HEALS, an Institute-wide initiative

"As scientists, engineers, and clinicians, we are obliged to ensure that what we learn and what we invent is available to all. Ironically, those most in need of innovation are least able to access and benefit from it — children especially," says Professor Elazer Edelman, faculty lead of the Hood Pediatric Innovation Hub. *Photo: Yakobchuk Olena / Adobe Stock*

to address society's most urgent health challenges. The hub's cross-disciplinary approach underscores MIT's commitment to inspiring, accelerating, and delivering solutions at scale to some of society's most urgent and intractable health challenges.

Elazer R. Edelman will serve as faculty lead, with Joseph J. Frassica as the executive director of the hub. Edelman is the Edward J. Poitras Professor in Medical Engineering and Science in MIT's Institute for Medical Engineering and Science (IMES) and director of MIT's Center for Clinical and Translational Research. He also serves as a professor of medicine at Harvard Medical School and a cardiologist at Brigham and Women's Hospital's cardiac intensive care unit in Boston. Frassica serves as professor of the practice in IMES at MIT. He is also a member of the teaching and research staff of the Massachusetts General Hospital (pediatric critical care) and serves as pediatric editor for the *Journal of Intensive Care Medicine*.

"As scientists, engineers, and clinicians, we are obliged to ensure that what we learn and what we invent is available to all. Ironically, those most in need of innovation are least able to access and benefit from it — children especially. The support of the Hood Foundation and collaboration with our MIT and extended community can help address this gap and fill this vital void," says Edelman.

"The Hood Pediatric Innovation Hub will serve as a catalyst, mentor, and advocate for pediatric innovation, harnessing MIT's world-class expertise and Hood's extensive network of pediatric innovators to tackle the most pressing challenges in pediatric care. Thanks to the generous support of the Hood Foundation, we plan to build the infrastructure and programs needed to transform groundbreaking ideas into real-world solutions that improve the lives of children and the providers who care for them," Frassica adds.

Driving research, advocacy, and education

Beyond supporting research, the hub seeks to bolster the broader pediatric research community through outreach, education, and advocacy. By working closely with key collaborators and leveraging relationships with other stakeholders such as hospitals, industry, patient advocates, and funders, the hub will identify, develop, and advance efforts to find economically viable pathways to bring treatments to young patients.

The hub will also create the infrastructure to seamlessly share deep organizational understanding of the regulatory processes governing innovation for children with researchers and innovators in the hub community.

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