Science @ MIT
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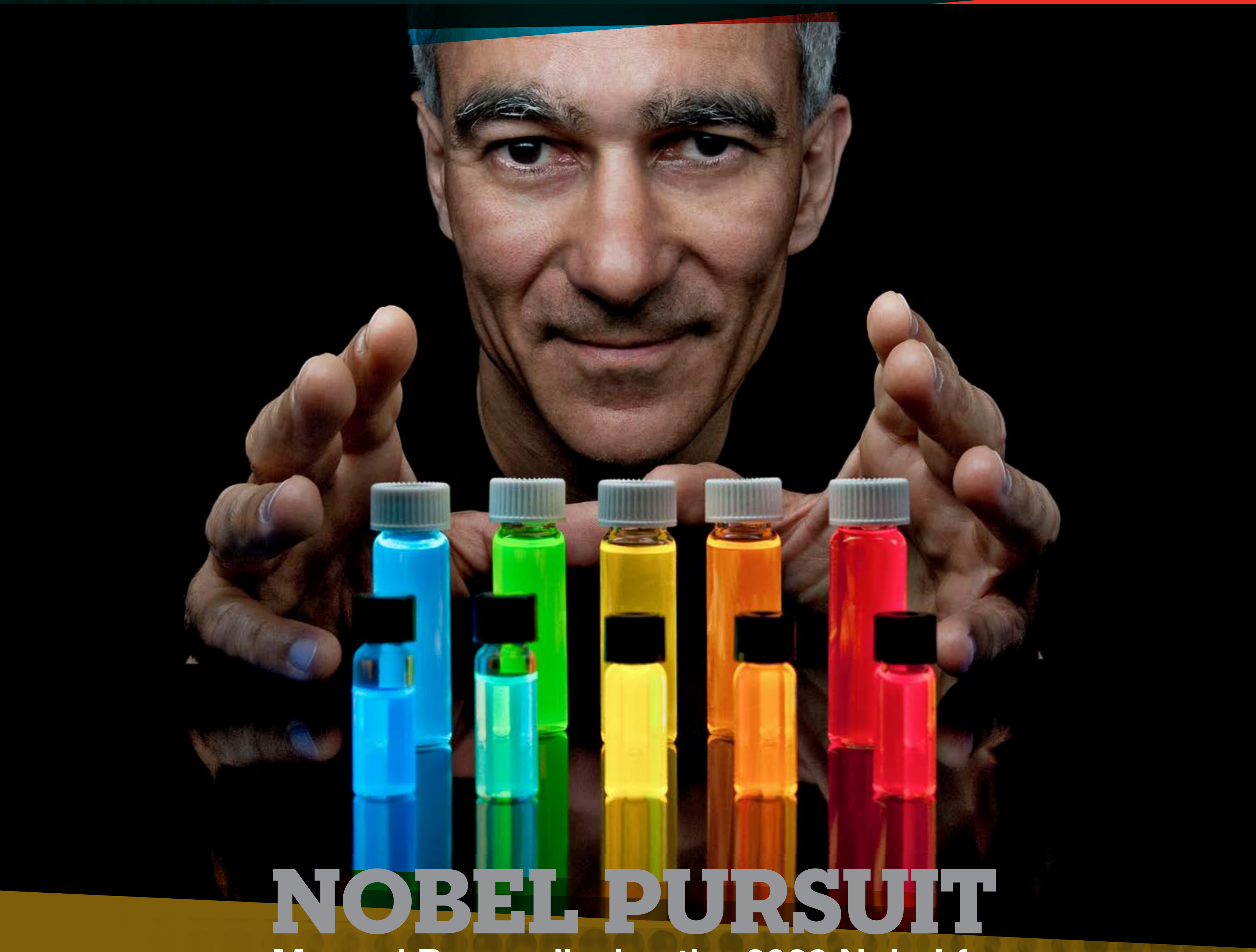

NOBEL PURSUIT

Moungi Bawendi wins the 2023 Nobel for quantum dots

Science AT MIT

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Letter from the Dean

My fellow alumni and friends,

On Oct. 4, 2023 I woke up to the announcement that MIT professor Moungi Bawendi won the Nobel Prize in Chemistry. I bicycled in early to prepare for the festivities and celebrations that followed. Our colleague had won a Nobel Prize! What an amazing place to work that I can make such a statement. The Nobel is a recognition of decades of cutting-edge science from the Bawendi research group on quantum dots — particles of matter so extraordinarily small that their properties, including their color, are governed not by the conventional rules of chemistry but by quantum phenomena.

I was a graduate student here at MIT when Moungi first announced fine-tuning the production of quantum dots. My roommates at the time were doctoral students in chemistry. I remember how excited we were to hear about this fundamental scientific discovery. As the resident physicist-in-training in the household, I took it upon myself to explain what, in fact, quantum dots were. I must admit, at the time, I got that description quite wrong.

Fortunately, you can read more about this discovery in our feature article about his research (without the errors I made). And in early February, you can tune into an MIT-wide lecture given by Moungi that will be livestreamed by the MIT Alumni Association.

This issue is filled with breakthroughs and the culmination of decadeslong research.

One of our new professors Mikhail Ivanov recently received the New Horizons in Physics Breakthrough Prize for contributions to our understanding of the large-scale structure of the universe and the development of new tools to extract fundamental physics from galaxy surveys. Combining theory with astrophysical data, Mikhail seeks to resolve fundamental challenges of modern physics, such as the nature of dark matter, dark energy, inflation, and gravity.

Also working on inflation theory in the Center for Theoretical Physics, postdoc Morgane König is one of our new Martin Luther King (MLK) Jr. Visiting Scholars. Morgane recounts her journey to cosmology, studying the whole of the universe — its content and its origin, much like an archaeologist.

Members of our School of Science faculty, with generous support from Frank Laukien, recently held a symposium to highlight progress in glycoscience research — the science of sugars, at the intersection of chemistry and biology — with implications for new therapeutics applications in cancer and autoimmune and infectious diseases.

Some of you were also able to join us for our fall Dean's breakfast lecture series talk given by Professor Laura Schulz in the Department of Brain and Cognitive Sciences (BCS). Laura discussed fundamental advances in how we understand the process by which we generate knowledge. Her test subjects and experiments? Children and the study of how they play. By observing how children play with the objects and scenarios presented to them in the laboratory, Laura can measure the ways in which they explore uncertainty, test variables, and look for patterns of cause and effect. All crucial skills for human development — and ultimately, the advancement of cognitive science.

Other BCS faculty, such Josh McDermott and his colleagues in the Laboratory for Computational Audition seek to understand our ability to perceive sound and will develop a computer model, which he hopes will contribute to engineering solutions for hearing impairment or loss. Folks in Southern California and the Bay Area were able to meet with Josh and Department Head Michale Fee at their Brain Bites talks to learn more about the intersection of computation and brain science.

In news from our Earth, Atmospheric and Planetary Sciences (EAPS) Department, NASA recently launched its Psyche spacecraft mission, setting course for a metallic space rock that could be the remnant of a planetary core like our own. The team, with deep MIT roots, is led by principal investigator and former professor Lindy Elkins-Tanton '87, SM '87, PhD '02; and its deputy principal investigator is Ben Weiss, an MIT professor of planetary science.

This space mission launch is just one of the many research accomplishments overseen by outgoing department head Rob van der Hilst who will be stepping down from head of EAPS at the end of this academic year. In addition to enabling exciting science, one of Rob's major initiatives has been developing, funding, and constructing the Tina and Hamid Moghadam Building that's rapidly nearing completion at the foot of the Green Building. In the spring, Rob will help us celebrate the grand opening of this new space, as well as the department's 40th anniversary. At these events, I hope you will join me in thanking Rob for his 12-year leadership of EAPS and his help in advancing climate science at MIT.

We have much to look forward to in the spring! I hope you can join us on campus to celebrate these milestones and research achievements!

With my very best wishes,

Dean Nergis Mavalvala PhD '97

MIT professor Moungi Bawendi shares Nobel Prize in Chemistry

For his work on techniques to generate quantum dots of uniform size and color, Bawendi is honored along with Louis Brus and Alexei Ekimov

Anne Trafton | MIT News

Faculty members of the Department of Chemistry gather for a champagne toast to celebrate Professor Moungi Bawendi's 2023 Nobel Prize win.
Photo: Jodi Hilton

Moungi Bawendi, the Lester Wolfe Professor of Chemistry at MIT and a leader in the development of tiny particles known as quantum dots, has won the Nobel Prize in Chemistry for 2023. He will share the prize with Louis Brus of Columbia University and Alexei Ekimov of Nanocrystals Technology, Inc.

The researchers were honored for their work in discovering and synthesizing quantum dots — tiny particles of matter that emit exceptionally pure light. In its announcement, the Nobel Foundation cited Bawendi for work that "revolutionized the chemical production of quantum dots, resulting in almost perfect particles."

Bawendi, who has been a professor at MIT since 1990, told MIT News that he felt "surprise and shock" upon receiving the call from the Nobel committee, adding, "it was such an honor to wake up to."

Quantum dots consist of tiny particles of semiconductor material that are so small that their properties differ from those of the bulk material. Instead, they are governed in part by the laws of quantum mechanics that describe how atoms and subatomic particles behave. When illuminated with ultraviolet light, the dots fluoresce brightly in a range of colors determined by the sizes of the particles.

These tiny particles are now used in many types of biomedical imaging, as well as computer and television displays, and they also hold potential in fields such as photocatalysis and quantum computing.

"It's hard to think of a more elegant expression of 'mind and hand,'" MIT president Sally Kornbluth wrote about Bawendi's work, in a letter to the MIT community, in reference to MIT's motto, "mens et manus." "We join Moungi's family, his department, and his friends and colleagues around the world in celebrating this rare honor."

Sculpting tiny particles

Quantum dots are particles only a few nanometers in diameter — about one-millionth the size of a pinhead. Since the 1930s, scientists had predicted that particles so tiny would show unusual behavior because at such tiny scales there is less space for a material's electrons, so they become squeezed together. As a result, it was believed that the particles' size would influence physical properties such as color.

However, this hypothesis was difficult to test because there were no ways to produce such tiny particles — until the early 1980s, when Brus and Ekimov independently succeeded at creating quantum dots. Working with quantum dots floating freely in a solution, Brus demonstrated that the size of the particles affected the color that they emitted. Ekimov discovered the same phenomenon working with nanoparticles of glass tinted with copper chloride.

The techniques used by Brus and Ekimov, however, did not yield quantum dots of uniform size. In 1993, Bawendi and his students were the first to report a method for synthesizing quantum dots while maintaining precise control over their size.

By systematically varying the conditions under which the quantum dots were crystallized, Bawendi and his research group succeeded in growing nanocrystals of a specific size. At the time, the researchers were interested in making quantum dots so they could further study their unique properties, with no inkling of what they would later become useful for.

"We just pushed and pushed, and we eventually developed a process to make particles good enough for basic science studies, and it turned out the process could be used for far more than that, which we never would have thought at the time," Bawendi told MIT News.

Since then, he has also devised ways to control the efficiency of the dots' light emission and to eliminate their tendency to blink on and off, making them more practical for applications in many fields.

Quantum dots are now used in flat screen TVs and other displays, where they generate more vivid images than traditional LED screens. They are also used to label molecules inside cells, allowing them to be imaged more easily, and they have been explored as a tool to guide doctors during surgery by illuminating tissue.

"It's really great to see how they have been used in so many areas, but it's not something we were expecting at the time," said Bawendi, who is also a core member of the Microsystems Technology Laboratories at MIT. "We were just interested in studying the materials."

Introducing Bawendi at an MIT press conference, Kornbluth described his Nobel achievement as "a banner day" for the Institute.

"We cannot imagine anything more electrifying," Kornbluth said. "Obviously, that excitement reflects our respect for this extraordinary honor, but it runs deeper because

> **"The atmosphere at MIT is really what allowed me to explore other fields of science, which has been key to the advances I've been able to make."**

Dean Nergis Mavalvala stands (middle) with Nobel Winner Moungi Bawendi and his wife Rachel Zimmerman. *Photo: Jodi Hilton*

you'd be hard pressed to find a community with a greater reverence for the wondrous beauty of basic discovery science and the incredible power of innovation to better our world than the people of MIT. I hope this award and all of this week's science Nobels can serve to remind the nation and the world of why fundamental science deserves our sustained and enthusiastic support."

A new field of science

Born in Paris to a French mother and Tunisian father, Bawendi moved to West Lafayette, Indiana, as a young boy when his father, a mathematician, became a professor at Purdue University. In 1982, he earned his undergraduate degree from Harvard University, where as a first-year student, he failed his first chemistry exam. That experience taught him a valuable lesson in perseverance, which he described at the press conference.

"You have a setback, but you can persevere and overcome this and learn from your experience, which obviously I did," he said. "And I could have just decided this wasn't for me, but I liked what I was doing, and so I learned how to become successful as a student."

Bawendi went on to earn a PhD from the University of Chicago in 1988. As a postdoc, he worked with Brus, who was then at AT&T Bell Laboratories and had recently made his original discovery regarding the properties of different sized quantum dots.

"That was what made me excited to work with him, because it opened up a brand-new field of science, which creates a lot of opportunity to make new discoveries," Bawendi told MIT News.

Scientists are now exploring the possibility of using quantum dots to improve the performance of many other technologies, including solar cells, flexible electronics, and photocatalysts. In recent years, Bawendi's lab has also developed spectrometers based on quantum dots, which are small enough to fit inside a smartphone camera. Such devices could be used to diagnose diseases, especially skin conditions, or to detect environmental pollutants.

When asked at the press conference what the future might hold for quantum dot research, Bawendi said he expects to be surprised.

"That's a really good question because I'm constantly surprised when I go to conferences about the progress and the directions of the field," he said. "I think 30 years ago, none of us who started the field could have predicted 30 years later we'd be where we are today. And it's just amazing to me, if you have really great people working on a brand-new field with brand-new materials, innovation comes out in directions that you can't predict."

Being at MIT, with its focus on interdisciplinary research, has been a critical factor in his success, Bawendi told MIT News.

"The atmosphere at MIT is really what allowed me to explore other fields of science, which has been key to the advances I've been able to make," he said. "It's a unique place, and it's wonderful to be part of it."

Everything, everywhere all at once

Cosmologist and MLK Scholar Morgane König uses gravitational waves to study the universe's origins, inflation, and present trajectory

Sophie Hartley | School of Science

The way Morgane König sees it, questioning how we came to be in the universe is one of the most fundamental parts of being human.

When she was 12 years old, König decided the place to find answers was in physics. A family friend was a physicist, and she attributed her interest in the field to him. But it wasn't until a trip back to her mother's home country of Côte d'Ivoire that König learned her penchant for the subject had started much younger. No one in Côte d'Ivoire was surprised she was pursuing physics — they told her she'd been peering upward at the stars since she was a small child, wondering how they all had come together.

That wonder never left her. "Everyone looks at the stars. Everyone looks at the moon. Everybody wonders about the universe," says König. "I'm trying to understand it with math."

König's observations have led her to MIT, where in 2021 she continued studying theoretical cosmology as a postdoctoral fellow with MIT physicist and cosmologist Alan Guth '69, PhD '72 and MIT physicist and historian of science David Kaiser. Now, she is a member of MIT's 2023–24 Martin Luther King Visiting Professors and Scholars Program cohort alongside 11 others. This year, members of the MLK Scholars are researching and teaching diverse subjects including documentary filmmaking, behavioral economics, and writing children's books.

On a chalkboard within the Center for Theoretical Physics, MLK Visiting Scholar and postdoc Morgane König writes the gravitational Kompaneets equation to describe her cosmology research. *Photo: Sophie Hartley*

Once she was set on physics, König finished her undergraduate studies in 2012, double majoring in mathematics and physics at Pierre and Marie Curie University in Paris.

Still compelled by questions about the universe, König narrowed in on cosmology, and graduated with her master's from Pierre and Marie Curie in 2014. The way König describes it, cosmology is like archaeology, just up in space. While astronomers study galaxy formations and mutations — all of the stuff in the universe — cosmologists study everything about the universe, all at once.

"It's a different scale, a different system," says König. "Of course, you need to understand stars, galaxies, and how they work, but cosmologists study the universe and its origin and contents as a whole."

From practice to theory

Throughout her studies, König says, she was often the only woman in the room. She wanted to pursue the theories behind cosmology but wasn't encouraged to try. "You have to understand that being a woman in this field is super, incredibly difficult," says König. "I told everyone I wanted to do theory, and they didn't believe in me. So many people told me not to do it."

When König had the opportunity to pursue a PhD in observational cosmology in Marseille and Paris, she almost accepted. But she was more drawn to theory. When she was offered a spot with a little more freedom to study cosmology at the University of California at Davis, she took it. Alongside Professor Nemanja Kaloper, König dove into inflation theory, looking all the way back to the universe's beginning.

It is well known that the universe is always expanding. Think about inflation as the precursor to that expansion — a quick and dramatic beginning, where the universe grew exponentially fast.

"Inflation is the moment in history that happened right after the beginning of the universe," says König. "We're not talking about one second, not even a millisecond. We are talking 10 to the negative 32nd seconds." In other words, it took 0.000,000,000,000,000,000,000,000,000,000,01 seconds for the universe to go from something miniscule to, well, everything. And today, the universe is only getting bigger.

Only a sliver of the universe's composition is understandable using current technology — less than 5 percent of the universe is composed of matter we can see. Everything else is dark matter and dark energy.

For decades, cosmologists have been trying to excavate the universe's mysterious past using photons, the tiny, particle form of light. Since light travels at a fixed speed, light emitted further back in the universe's history — from objects that are now farther away from us due to the expansion of the universe — takes longer to reach Earth. "If you look at the sun — don't do it! — but if you did, you'd actually be seeing it eight minutes in the past," says König. As they carve their way through the universe, photons give cosmologists historical information, acting as messengers across time. But photons can only account for the luminous 4.9 percent of the universe. Everything else is dark.

Since dark matter doesn't emit or reflect photons like luminous matter, researchers can't see it. König likens dark matter to an invisible person wearing a tuxedo. She knows something is there because the tuxedo is dancing, swinging its arms and legs around. But she can't see or study the person inside the suit using the technology at hand. Dark matter has stirred up countless theories, and König is interested in the methods behind those theories. She is asking: How do you study something dark when light particles are necessary for gathering historical information?

According to König and her MIT collaborators Guth, the forerunner of inflation theory, and Kaiser, Germeshausen Professor of the History of Science, the answer might lie in gravitational waves. König is using her time at MIT to see if she can side step light particles entirely by using the ripples in spacetime called gravitational waves. These waves are caused by the collision of massive, dense stellar objects such as neutron stars. Gravitational waves also transmit information across the universe, in essence giving us a new sense, like hearing is to seeing. With data from instruments such as the Laser Interferometer Gravitational-Wave Observatory (LIGO) and the North American Nanohertz Observatory for Gravitational Waves, "not only can we look at it, now we can hear the cosmos, too," she says.

Black in physics

Last year, König worked on two all-Black research teams with physicists Marcell Howard and Tatsuya Daniel. "We did great work together," König says, but she points out how their small group was one of the largest all-Black theoretical physics research teams — ever. She emphasizes how they cultivated creativity and mentorship while doing highly technical science, producing two published papers "Elastic Scattering of Cosmological Gravitational Wave Backgrounds," and "An SZ-Like Effect on Cosmological Gravitational Wave Backgrounds."

MLK Scholar König created this image of a young black girl looking up at the stars using DALL-E, a generative AI program, because there weren't images like this readily available — a lack of representation in art that she also sees in the field of cosmology and astrophysics. *Illustration: DALL-E/König*

Out of the 69,238 people who earned doctorates in physics and astronomy since 1981, only 122 of them were Black women according to the National Center for Science and Engineering Statistics. When König finished her PhD in 2021, she became the first Black student at UC Davis to receive a PhD in physics and the ninth Black woman to ever complete a doctorate in theoretical physics in the United States.

This past October, in a presentation at MIT, König ended with an animated slide depicting a young Black girl sitting in a dark meadow, surrounded by warm lights and rustling grass. The girl is looking up at the stars, her eyes full of wonder. "I had to make this with AI," says König. "I couldn't find an image online of a young black girl looking up at the stars. So, I made one."

In 2017, König went to Côte d'Ivoire, spending time teaching school children about physics and cosmology. "The room was full," she says. Adults and students alike came to listen to her. Everyone wanted to learn, and everyone echoed the same questions about the universe as König did when she was younger. But, she says, "the difference between them and me is that I was given a chance to study this. I had access to people explaining how incredible and exciting physics is."

König sees a stark disconnect between physics in Africa and physics everywhere else. She wants universities around the world to make connections with African universities, building efforts to encourage students of all backgrounds to pursue the field of physics.

König explains that ushering in more Black and African physicists means starting at the beginning and encouraging more undergraduates and young students to enter the field. "There is an enormous amount of talent and brilliance there," König says. She sees an opportunity to connect with students across Africa, building the bridges needed to help everyone pursue the questions that keep them looking up at the stars.

While König loves her research, she knows theoretical cosmology has far to go to as a discipline. "There is so much room to grow in the field. It's not all figured out."

Making math work

MathWorks Fellows Davis Evans and Elena Kim study the next big things with mathematics

Sandi Miller | Department of Mathematics

MATLAB, a widely-used software program, is the signature product and most renowned creation of MathWorks, a company founded by John N. Little ’78 and Cleve Moler. Designed for scientists and engineers, MATLAB is a programming environment that enables users to combine mathematics, graphics, and coding to develop algorithms, perform computations, and generate simulations for research. Faculty, students, and researchers across MIT extensively use the software — as do more than four million users in industry, government, and academia in 185 countries. A complimentary program, Simulink, MathWorks’ graphic modeling and simulation program, is also well-known.

“Our tagline is: ‘Accelerating the pace of engineering and science,’” says Little, president of MathWorks. “That’s what we’re about and what we do. We have a strong belief in the importance of engineers and scientists. They act to increase human knowledge and profoundly improve our standard of living. We created products like MATLAB and Simulink to help them do their best work.”

Two students, Davis Evans and Elena Kim were recently named MathWorks Fellows.

Davis Evans

With Davis Evans’ applied mathematics background, he can work on everything from brains to semiconductors to fluid dynamics, all with the help of MATLAB software.

MATLAB has been a core element of Evans’ workflow for 10 years since he used it at an internship modeling helicopter dampers. Evans studied engineering science at Penn State, where, in an interdisciplinary program, he researched mathematical models of injury induced pressure waves in the brain.

After graduation, he worked in industry for a few years, working on vibration and servo control schemes for state-of-the-art machines that print computer chips at a company called ASML.

“The technology at ASML is very impressive — they are basically keeping Moore’s Law alive,” says Evans. “I learned a lot there and was very thankful to contribute to such an effort.”

MathWorks Fellow Davis Evans. *Photo: Steph Stevens*

Mathworks Fellow Elena Kim. *Photo: Steph Stevens*

But he decided to move over to mathematics when he came to MIT. “I found that applied mathematics is a very powerful way to communicate across technical disciplines.”

He was excited to work on hydrodynamic quantum analogues in Professor John Bush’s lab. Evans runs experiments where a droplet of silicone oil is made to bounce on the surface of a vibrating bath.

These experiments with droplets create a visual analogy for what might be happening with electrons, which are much harder to visualize.

“The differential equations that describe the motion of these droplets usually can’t be solved with pen and paper: that’s where MATLAB comes in,” says Evans. “We also need it to analyze the data that come from our experiments.”

The bounces set down waves, from which the droplet is propelled around the bath. He also develops dynamical models of these bouncing droplets, and studies to what extent they resemble quantum systems.

“I have always been fond of physical analogues, where two systems are described by the same governing equations,” he says. “To have a macroscopic system with particle-wave duality, poses some very deep and exciting questions about quantum mechanics.”

After graduation he’s looking forward to teaching and research. But while he’s at MIT, he enjoys learning to sail, and hiking in the White Mountains in New Hampshire. He plays the organ and other keyboard instruments, and recently ran the MIT Math IAP music concert, where he most recently performed on the harpsicord.

Elena Kim

Elena Kim is a third-year PhD student in the MIT Department of Mathematics, where she is studying semiclassical measures for quantum cat maps.

Quantum cat maps are toy models in the field of quantum chaos, and semiclassical measures help quantify the limit behavior of their eigenfunctions. Her goal is to prove characteristics of the support of semiclassical measures. She uses MATLAB to create pictures illustrating the support of the semiclassical measures, helping inform conjectures.

Kim is originally from Greenwich, Connecticut. She completed her undergraduate at Pomona College, majoring in mathematics. In her free time, she likes going on bike rides. Otherwise, she just enjoys spending as much time as possible outdoors.

Since spring 2023, she has worked as a tutor for the Boston Pre-Release Center, a minimum and pre-release correctional facility that runs a program called the School of Reentry, a collaboration between the Department of Mathematics and The Educational Justice Institute. Kim supports math instruction, working with students in college bridge courses such as pre-algebra up through pre-calculus.

“I help students one-on-one, guiding them through problems in their textbook,” she says. “It’s very rewarding for me to help students master the fundamentals of math and make a subject that many students view as scary and intimidating more accessible and friendly.”

Beyond tutoring, Kim has a broader interest in mentoring and building community in math. She was an organizer for Pure Math Graduate Student Seminar, a seminar for graduate students by graduate students. Additionally, she has worked as a graduate student mentor for the University of Michigan-Dearborn Research Experience for Undergraduates program. At MIT, she has been an academic mentor at √MathROOTS, a summer program for high school students from underrepresented backgrounds, and participated in the Department of Mathematics’s Directed Reading Program for undergraduates.

Passing the baton of science

Hologic-funded Jay A. Stein (1968) Professorship of Biology celebrates MIT innovation across generations

Kris Willcox | Department of Biology

Jay Stein PhD '68 came to MIT as a doctoral student in physics to study the composition of stars using X-rays. Though he was interested in astronomical objects, he was even more fascinated by the tools of his trade. "I found that I enjoyed building the equipment to measure stars more than finding out what was happening in the stars," he recalls.

Stein spent the next several decades creating innovative tools to solve complex problems. In 1985, he cofounded Hologic, a health technology company that has had a profound impact on medicine. Among Hologic's many achievements are groundbreaking diagnostic and screening technologies that have reshaped the field of mammography.

Last fall, at Stein's retirement party, friends and colleagues surprised him with a very special gift: the Jay A. Stein (1968) Professorship of Biology at MIT, established by Hologic. "It was the perfect gift," says Stein. "The greatest compliment of all was that my colleagues understood me so well." Through the professorship, Stein says he has been given "a permanent link to the future" and to MIT innovators.

The inaugural Jay A. Stein Professor of Biology is Amy Keating, head of the Department of Biology and a noted leader in the field of biological engineering. Keating, who is also a member of the Koch Institute for Integrative Cancer Research, uses computational techniques to study protein structure, function, and interactions and to design molecules that can be used to probe and disrupt processes relevant to human disease.

Monica Aguirre, vice president and chief of staff at Hologic, considers Stein both a colleague and a dear friend. She says it was an honor to plan his retirement celebration and the Stein Professorship, adding that "Jay has made a lasting impression on almost everyone he's worked with." She describes him as possessing the inquisitive spirit of an inventor (he has more than 100 patents to his name), the grit of a hands-on collaborator, and the generosity of a mentor. "He's a true leader, inside and out."

Jay Stein PhD '68 and Amy Keating, the Jay A. Stein (1968) Professor of Biology. *Photo: Simon Simard*

When considering Stein's retirement gift, says Aguirre, "we knew it needed to be something lasting, that would impact many lives, and we knew it had to be MIT, because he loves MIT deeply." By supporting faculty, the gift supports individuals whose careers, like Stein's, will have "a ripple effect in the world," according to Aguirre, who points out that the Stein Professorship also reflects Hologic's values: "Our mission is to encourage innovation, with the goal of doing good for people. That is what Jay did, and it's the foundation of who we are at Hologic."

Follow the nerd, not the herd

Stein says it was MIT's culture of "open-minded acceptance" that enabled him to pivot from physics to biomedical technology. He credits MIT faculty mentors with inspiring him to follow his curiosity. He also prized the mentorship of MIT technicians and machinists who taught him the value of finding the right tool for every job, and of taking the time to do the job right.

Stein's personal motto is one that any MIT alum can appreciate: "The secret of innovation is simply this: Follow the nerd, not the herd."

Today, Stein remains a trusted partner to Hologic's leaders, offering suggestions and ideas at quarterly meetings (written recaps of these reflections are titled, affectionately, "The Word from the Nerd") and has recently rejoined Hologic as a consultant on a project to develop new techniques for painless mammography. As he continues to follow his path of innovation, the Stein Professorship offers him a permanent link to the Institute, and to leading faculty like Keating.

According to Stein, the professorship "is a way to pass the baton of science, from one generation to the next — hopefully, forever."

This article first appeared in the fall 2023 issue of Spectrum.

What's the point of play?

Jesse Feiman | School of Science

■ Laura Schulz delivers the fall 2023 Dean's lecture. *Photo: Steph Stevens*

On Oct. 19, 2023, alumni and friends gathered for a breakfast talk hosted by the MIT School of Science featuring Laura Schulz, professor and associate head of the Department of Brain and Cognitive Sciences. Nergis Mavalvala, the Curtis (1963) and Kathleen Marble Professor of Astrophysics and dean of the School of Science, invited Schulz to share her work.

A developmental psychologist, Schulz studies how the mind creates knowledge by observing the best learners on the planet — young children. Researchers do not fully understand how children learn so much about the world so quickly while relying on their limited experiences. Schulz's research examines how kids accomplish this feat while primarily engaging in play. Introducing Schulz's talk, entitled "Understanding Why: Problems, Play, and Human Cognition," Mavalvala noted that answering the question of what play contributes to cognition would give us insight into the origins of knowledge and fundamental principles of learning.

Schulz set the stage by questioning established theories of play. It could be a way to practice life skills, but Schulz noted that no research has shown a causal relationship between, for example, children's play with toy hammers and their carpentry skills as adults. Play could be a venue for learning about physical forces, movement through space, and social interaction, but Schulz pointed out that most games require prior knowledge of space, objects, and forces. Following the assumption that learning is related to play, Schulz says she "finds ways to use play as a dependent measure of expected information gain."

Treating children like "intuitive scientists," Schulz and her team tested the knowledge-building practices kids use to gather information, test hypotheses, and formulate conclusions. In one experiment, Schulz hypothesized that when a child was asked to identify the number of marbles contained in an opaque box, there would be a direct relationship between the difficulty of the task and how long they would play with the box. She believed a child prompted to make a gross distinction, between for example two marbles or eight, would play less than if asked to make a fine distinction, such as between five marbles and seven. Schulz shared footage of three- and four-year-olds shaking the boxes, testing their weight, and listening to the marbles roll around. The results showed a strong correlation between the difficulty of the discrimination and the duration of the subjects' play.

While reflecting on the accuracy of her predictive model, Schulz noted that the experiment had shed light on how children learn but, she asked, what did it teach us about play? Do we really believe kids play in order to acquire information and make logical discriminations? She suggested that when you give children a device and a set of instructions, more often than not what you get is chaos. To demonstrate her point, Schulz played a montage of outtakes in which test subjects failed to follow directions, in this case determining which of a set of switches activated a motor that turned a pair gears. The audience delighted as the children on screen spun the gears on their fingers, listened to the whirring of the motor, and ran the gears against their open mouths. "You wouldn't laugh if this was *your* dissertation research," Schulz quipped.

If it is not just a process of information gathering or skill building, then how does play contribute to cognition? Rather than ignoring confounding aspects of play, Schulz asked, "What if the arbitrariness is the point?" Humans play by setting up frivolous problems and testing their potential solutions. Each problem is rich in information that constrains its possible solutions and points toward a satisfactory answer. In the boardgame *Clue*, for example, players asked who killed a victim, where, and with which weapon know that the solution must include a person, a location, and an object. A problem facilitates the formation of pertinent ideas regardless of whether they are right or wrong. Therefore, play is a tool to encourage *thinking* rather than learning.

"What if the arbitrariness is the point?"

In an effort to study play on its own terms, Schulz and her team investigated the satisfaction derived from completing an arbitrary task. They prompted adults to fill in a 10 × 10 grid of circles on a computer screen, with each click of the mouse turning an outline of a circle into a solid blue circle. The test subjects had to accomplish this task five times and report how much fun they had. Some did so efficiently, clicking the circles line-by-line and top-to-bottom; others played, designing patterns and varying their approaches from one grid to the next. The participants who took the longest reported the highest levels of fun during the experiment. Schulz concluded that play must be rewarding, since some adults were willing to expend excess time and effort to complicate their solutions to the presented problem, even though they all received the same compensation.

If play is both useless and satisfying, Schulz asked, "What does that say about us? Are we doomed?" Certainly not. From her perspective, play is arbitrary but it is not irrational. The motivational system that rewards play frees our minds to invent ideas unconstrained by practicality. Problems without conclusive solutions can be sources of unexpected insights. Citing historical examples, Schulz noted that first-order logic derived from medieval attempts to concretely prove the existence of the Christian divinity, and that cryptography developed from the effort to prove that Francis Bacon was the author of Shakespeare's plays. Play may be the most effective way to generate knowledge and to discover phenomena that are genuinely new.

Did you hear that?

Brain Bites offers alumni and friends a window into the world of how our brains perceive sound

Devan Monroe | Department of Brain and Cognitive Sciences

In October, Brain and Cognitive Sciences hosted a series of Brain Bites receptions in Los Angeles and Palo Alto, California, drawing a diverse crowd of more than 100 alumni and friends.

Department Head Michale Fee, the Glen V. and Phyllis F. Dorflinger Professor of Neuroscience and investigator in the McGovern Institute for Brain Research, and Professor Josh McDermott PhD '06 participated in a fireside chat discussing McDermott's research at the intersection of psychology, neuroscience, and engineering on how people and machines perceive sound.

McDermott and his colleagues in the Laboratory for Computational Audition have developed a computer model for human sound perception that he hopes will contribute to engineering solutions for hearing impairment or loss.

"We now have a model that can actually localize sounds in the real world," McDermott said about his research recently published in *Nature Human Behavior*. "And when we treated the model like a human experimental participant and simulated this large set of experiments that people had tested humans on in the past, what we found over and over again is it the model recapitulates the results that you see in humans."

Department Head Michale Fee introduces Professor Josh McDermott (front row, far left) to talk about his cognitive science research. *Photo: Devan Munroe*

Scientists have long sought to build computer models that can perform the same kind of calculations that the brain uses to localize sounds. These models sometimes work well in idealized settings with no background noise, but never in real-world environments, with their noises and echoes.

To develop a more sophisticated model of localization, the MIT team turned to convolutional neural networks. This kind of computer modeling has been used extensively to model the human visual system, and more recently, McDermott and other scientists have begun applying it to audition as well.

Convolutional neural networks can be designed with many different architectures, so to help them find the ones that would work best for localization, the MIT team used a supercomputer that allowed them to train and test about 1,500 different models. That search identified 10 that seemed the best suited for localization, which the researchers further trained and used for all of their subsequent studies.

In addition to analyzing the difference in arrival time at the right and left ears, the human brain also bases its location judgments on differences in the intensity of sound that reaches each ear. Previous studies have shown that the success of both of these strategies varies depending on the frequency of the incoming sound. In the new study, the MIT team found that the models showed this same pattern of sensitivity to frequency.

"The model seems to use timing and level differences between the two ears in the same way that people do, in a way that's frequency-dependent," McDermott says.

The researchers also showed that when they made localization tasks more difficult, by adding multiple sound sources played at the same time, the computer models' performance declined in a way that closely mimicked human failure patterns under the same circumstances.

The research was funded by the National Science Foundation and the National Institute on Deafness and Other Communication Disorders.

Additional reporting on the published research provided by Anne Trafton, MIT News.

Mikhail Ivanov wins 2024 New Horizons in Physics Breakthrough Prize

MIT assistant professor of physics shares award for understanding the large-scale structure of the universe

Sandi Miller | Department of Physics

Assistant professor of physics Mikhail Ivanov will receive the 2024 New Horizons in Physics Prize, which he will share with Marko Simonović from the National Institute for Nuclear Physics at the University of Florence, and Oliver Philcox from Columbia University and the Simons Foundation.

The New Horizons Prize, which is given to promising, early career physicists and mathematicians making strides in their research fields, recognizes Ivanov, Simonović, and Philcox "for contributions to our understanding of the large-scale structure of the universe and the development of new tools to extract fundamental physics from galaxy surveys."

"It is a great honor for me to receive this award, and I'm deeply grateful to the selection committee for this privilege," says Ivanov. "It is a symbol of academic recognition, but also a symbol of responsibility. It means I have an obligation to continue carrying out quality research and mentoring the younger generation of physicists."

The three researchers were recognized for their study of the structure of the cosmos at the galactic scale, and for finding ways to use that knowledge to bring fresh insights to fundamental physics. This large-scale structure of the universe has the potential to become a new gold mine of cosmological information that could provide crucial insights into the nature of dark matter, dark energy, and the early universe, says Ivanov.

They created theoretical and practical tools for cosmological parameter estimation from galaxy clustering data to produce novel measurements of cosmological parameters and constraints on physics beyond the standard cosmological model from the BOSS (Baryon Oscillation Spectroscopic Survey) and eBOSS surveys. These results set the stage for new studies of fundamental physics with upcoming high-precision galaxy clustering data.

Ivanov is a researcher in MIT's Center for Theoretical Physics (CTP), a division of the Laboratory for Nuclear Science. Ivanov's research is at the interface of theoretical physics and data analysis, bridging state-of-the-art theoretical ideas with observational data. He seeks to use effective field theory in combination with astrophysical data in order to resolve fundamental challenges of modern physics, such as the nature of dark matter, dark energy, inflation, and gravity.

"Professor Ivanov joined our department this fall, and we are delighted and proud that he has received this important recognition of his work," says physics department head Deepto Chakrabarty.

Under the supervision of Sergey Sibiryakov in 2019, Ivanov received his PhD from the École Polytechnique fédérale de Lausanne (EPFL) and spent a year at the Institute for Advanced Study in Princeton, New Jersey, as a fellow of the Swiss National Science Foundation. He was a postdoc at New York University and a NASA Einstein Fellow at the Institute for Advanced Study, and joined the CTP as an assistant professor in July.

Other recognitions include the 2021–23 NASA Hubble Fellowship Program Einstein Fellowship, the 2021 Second Buchalter Cosmology Prize, the 2019 EPFL PhD Distinction Prize for "an outstanding thesis in physics," and a 2018–19 Swiss National Science Foundation Mobility Fellowship.

The trio are among 12 early career physicists and mathematicians sharing six $100,000 New Horizons in Physics Prizes.

Founded by a group of Silicon Valley entrepreneurs, the Breakthrough Prizes recognize the world's top scientists in life sciences, fundamental physics, and mathematics. The laureates are to be honored at the 10th annual Breakthrough Prize ceremony in Los Angeles on April 13, 2024.

Frank Laukien bets on MIT to unlock the grand challenges of glycobiology

Leah Campbell | School of Science

Frank Laukien ’84, the president and CEO of Bruker, a leading manufacturer of scientific instruments, is helping facilitate the creation of a new initiative at MIT that could enable major advances in our understanding of human health and disease.

Glycobiology is the study of the carbohydrates and sugar-coated molecules that are fundamental to most basic biological functions. Understanding the structure and function of these so-called glycans is critical for understanding disease, development, immune response, and more. But it requires expertise across the biological, chemical, and even physical sciences.

To that end, Laukien is working closely with researchers across the Institute to develop an MIT initiative around glycobiology that will facilitate innovative and interdisciplinary research to crack this “sugar code of life,” as he calls it.

“This emerging field is at an inflection point,” says Laukien. “Better methods for studying glycans are becoming available, but they need further science and technological and computational innovations — all areas where MIT excels.”

Laukien’s interest in glycobiology came first and foremost through his own experience as a scientist. He graduated from MIT with an SB in physics in 1984 and went on to receive his doctorate in chemical physics at Harvard. For several years, before taking the helm at Bruker, he lectured in physics at the University of Bremen in Germany, and in 2017, he was elected to the German National Academy of Science and Engineering. Today, he is a visiting scholar at Harvard University in the Origins of Life Initiative and the Department of Chemistry and Chemical Biology.

Throughout his career, Laukien has remained a close partner of MIT, serving in the past on the Dean’s Advisory Committee for the School of Science and currently on the Chemistry Visiting Committee. He’s also been an active and enthusiastic supporter of diverse research efforts, from fighting cancer to advancing fusion energy.

Glycobiology has been an obvious area for him to focus his time and energy, both for the field’s interdisciplinary and its potential for widespread, valuable applications. Investing in fundamental science on glycans today, he says, could have enormous benefits for society in the future. Yet, it’s a field, he adds, that has been historically neglected by funding agencies and philanthropists.

“One of the functionally most important processes that occur to proteins is glycosylation, and yet there have been no good lampposts for elucidating that process,” laments Laukien. “Even with all brilliant researchers at MIT, there was no integration of capabilities or coordination to get the crucial resources and tools needed to move this work forward.”

Though Laukien’s partnership with MIT to help remedy that has been ongoing, it kicked off visibly with a symposium on Oct. 5, bringing together several researchers to discuss their work and the future of the field. Since then, he says, faculty from across the Institute have reached out, excited to get involved.

■ Alumnus Frank Laukien speaks with Professor Katharina Ribbeck at the poster session. *Photo: Steph Stevens*

"The first GlycoMIT symposium didn't only have intriguing talks, but the energy and enthusiasm was incredible and reflects the great scientific opportunities in a future MIT initiative in glycobiology," he says.

There are several things, Laukien believes, that make MIT an ideal proving ground for this work, including the Institute's close relationships with other world-class hospitals, universities, and research organizations and its location in the Cambridge, Massachusetts, biotech hub. On top of that, he points to MIT's strengths in science, technology, and, in particular, computation, emphasizing the exciting potential of bringing computer science and math to bear on this scientific endeavor.

In short, he says, "GlycoMIT could not be in a better place in the world to drive scientific and medical breakthroughs."

"GlycoMIT could not be in a better place in the world to drive scientific and medical breakthroughs."

Explained: The sugar coating of life

Researchers work to advance the field of glycoscience, illuminating the essential role of carbohydrates for human health and disease

Leah Campbell | School of Science

School of Science professors Laura Kiessling, Barbara Imperiali, and Matthew Shoulders present their research at the first glycoscience symposium at MIT. *Photo: Steph Stevens*

On Oct. 5, researchers from across MIT gathered for a daylong symposium, sponsored by MIT alumnus Frank Laukien '84 to share research and celebrate recent advancements in glycobiology — an old discipline in the midst of a renaissance that could reshape scientists' understanding of the building blocks of life.

In the narrowest sense, glycobiology is the study of the structure, biology, and evolution of glycans, the carbohydrates and sugar-coated molecules found in every living organism. Originally coined in the 1980s to describe the merging of traditional research in carbohydrate chemistry and biochemistry, glycobiology has come to encompass a much broader and multidisciplinary set of ideas. Glycoscience may actually be a more appropriate name for the rapidly growing field, reflecting its broad application not just to biology and chemistry but also to bioengineering, medicine, materials science, and more.

"It's becoming increasingly clear that these glycans have a very important role to play in health and disease," says Laura Kiessling, the Novartis Professor of Chemistry. "It may seem daunting initially, but devising new tools and identifying new kinds of interactions requires exactly the sort of creative problem-solving skills that people have at MIT."

The sugar coat of the body

Glycans include a diverse set of molecules with linear and branched structures that are critical for basic biological functions. With no known exception, all cells in nature are coated with these sugar molecules — from the intricate chains of sugars surrounding most cellular surfaces to the conjugated molecules formed when sugars attach like scaffolding to lipids and proteins. They're absolutely fundamental to life. For example, Kiessling points out that the most abundant organic molecule on the planet is the carbohydrate cellulose.

"Sperm-egg binding is mediated by an interaction between a protein and a carbohydrate," she says. "None of us would exist without these interactions."

Though talking about carbs and sugars might leave some people focused on their diet, glycans are actually among the most important biomolecules out there. They store energy and, in some cases like cellulose, provide the structural framework for multicellular organisms. They mediate communication between cells; influence interactions like that between a host and parasite; and shape immune responses, disease progression, development, and physiology.

"It turns out that some of these structures, which we didn't even know existed in the body in such abundance until recently, have so many different biological functions," says Andrew (1956) and Erna Viterbi Professor of Biological Engineering Katharina Ribbeck. "With this rapid expansion of knowledge, it feels like we're just beginning to understand how diverse and important those functions are to biology."

With a better understanding of how ubiquitous and critical these molecules are, researchers in applied fields like biotechnology and medicine have turned their attention to glycoscience as a tool to pinpoint the drivers of disease.

Many conditions have been linked to defects in how glycans are produced in the body or issues with glycosylation, the process by which carbohydrates attach to proteins and other molecules. That includes certain forms of cancer. Cancer cells have even been shown to cloak themselves in certain glycoproteins to evade an immune response.

On the flip side, glycans may be a repository of potential therapeutics. The blood thinner heparin, one of the world's best-selling prescription drugs, for example, is a carbohydrate-based drug.

Glycans and sugar-binding proteins like lectins even help influence the exchange of microbes across mucus layers in the human body, from the brain to the gut. Glycans dangling off mucus interact with microbes, letting good ones in and reducing the virulence of problematic ones by interrupting cell signaling or stopping pathogens from releasing toxins.

New tools to advance old science

Despite how crucial this "sugar coat" is, for a long time, molecular biologists focused on nucleic acids and proteins, paying relatively little attention to the sugars that coated them.

"The tools we have to examine the functions of other molecules are largely absent for glycans," Kiessling says.

For example, the DNA and RNA sequences of a cell predict what proteins that cell makes, so scientists can track where a protein is and what it's doing using a genetically-encoded tag. But the structure of glycans isn't so obviously encoded in a cell's DNA, and a single protein can be decorated with many different chains of carbohydrates.

In addition, the immense diversity of forms carbohydrates can take, and the fact that they break down quickly in the bloodstream, has made it challenging to synthesize glycans or target them for drug development. So, creative new methods are needed to track them.

It's a classic chicken-and-egg situation. As scientists better understand the importance of glycans for so many biological processes, it has incentivized them to develop better tools for studying glycans, in turn, producing even more data on just what these molecules can do. In 2022, in fact, the Nobel Prize was awarded to Carolyn Bertozzi at Stanford University, a pioneer in glycobiology, for her work on tracking molecules in cells, which she and others have applied to glycans.

But artificial intelligence (AI) could facilitate an evolutionary leap in the field.

"I think glycobiology is more than almost any other field ripe and ready for an AI interpretation," Ribbeck says, explaining how AI might enable scientists to read the "glycan code" in the same way they have with the human genome. That would allow researchers to predict the actual function of a glycan based on data about its structure. From there, they could identify what changes lead to disease or increase disease susceptibility — and, most importantly, come up with ways to repair those defects.

An inter- and trans-disciplinary effort

The increasing interest in computation reflects the inherent interdisciplinarity that has defined glycoscience from the beginning.

Just at MIT, for example, related research is happening across the Institute. Kiessling describes MIT as a "playground for interdisciplinary research," which has enabled significant advances in the field with applications to biotechnology, cancer research, brain science, immunology, and more.

In the Department of Chemistry, Kiessling is studying carbohydrate-binding proteins, and how their interactions with glycans affect the immune system. She's also working with Bryan Bryson, associate professor in the Department of Biological Engineering and Dr. Deborah Hung at The Broad Institute of MIT and Harvard, using carbohydrate analogs to test differences in strains of tuberculosis in South Africa. Meanwhile, assistant professor of biological engineering Jessica Stark is pioneering approaches to better understand the roles of glycans in the immune system. Tobi Oni, a fellow at the Whitehead Institute for Biomedical Research, is looking to glycans to help detect and target tumors in pancreatic cancer. Barbara Imperiali, the Class of 1922 Professor of Biology and Chemistry, is studying the carbohydrates that envelop the cells of microbes like bacteria, and Professor Matthew Shoulders in the Department of Chemistry is studying the role of glycans in synthesizing and folding proteins.

"We're at a very exciting and unique position combining disciplines to address and answer entirely new questions relevant for disease and health," says Ribbeck. "The field in and of itself is not new, but what is new is the contribution that MIT, in particular, could make with a creative combination of science, engineering, and computation."

GlycoMIT Symposium celebrates advancements in glycobiology

Danielle Randall Doughty | Department of Chemistry

On Oct. 5, the Department of Chemistry, funded by a generous donation from Frank Laukien '84 hosted the GlycoMIT Symposium, an interdepartmental celebration of advancements in glycobiology research. Defined broadly by the National Institutes of Health, glycobiology is "the study of the structure, biosynthesis, biology, and evolution of saccharides (also called carbohydrates, sugar chains, or glycans) that are widely distributed in nature and of the proteins that recognize them." Various applications for glycobiology research include neurobiology and aging, cancer, and infectious disease and the microbiome.

"Of the three chemical motifs involved in the recognition of pathogens — nucleic acids, proteins, and glycans — glycans are by far the most diverse and poorly understood," said department head and Haslam and Dewey Professor Troy Van Voorhis. "By breaking new ground in glycoscience, MIT can make new discoveries about the chemical building blocks of life and pioneer new therapeutics for human health. This field is inherently multidisciplinary — combining a variety of perspectives from the chemical, biological, and physical sciences to control and measure complex glycan assemblies in living systems. It is therefore crucial that this effort involves not just chemistry, but biology, physics, and computation."

More than 100 members of the MIT community and beyond gathered in the Bartos Theater for a series of faculty presentations and a keynote speech from Richard D. Cummings, the S. Daniel Abraham Professor of Surgery at

■ Researchers at the MIT Glycoscience Symposium. *Photo: Steph Stevens*

> "This field is inherently multidisciplinary — combining a variety of perspectives from the chemical, biological, and physical sciences. ... It is therefore crucial that this effort involves not just chemistry, but biology, physics, and computation."

Beth Israel Deaconess Medical Center and Harvard Medical School. Faculty presented updates on their glycobiology findings, and how these advancements pertain to research across all fields, and to humanity in general.

Following a luncheon with Laukien and School of Science dean Nergis Mavalvala, MIT faculty members Barbara Imperiali, Laura Kiessling, Tobi Oni, Katharina Ribbeck, Matthew Shoulders, and Jessica Stark each presented a 20-minute talk about their research.

After the faculty presentations concluded, attendees of the symposium gathered for a reception to enjoy hors d'oeuvres, drinks, and poster presentations on further glycobiology research from members of each of the speakers' groups, as well as others from across the Institute.

Kiessling, who spearheaded the event alongside fellow professor of chemistry Matthew Shoulders, presented a talk entitled "Glycans in Health and Disease." In the Department of Chemistry, the Kiessling Group uses chemical biology to elucidate the biological roles of carbohydrates, with a focus on learning new mechanistic concepts.

Imperiali, the Class of 1922 Professor of Biology and Chemistry, holds a dual appointment in both departments, and delivered a talk entitled "Bacterial Glycan Biology: Making Sense of the Madness." Research in the Imperiali Lab employs a multidisciplinary approach involving synthesis, state-of-the-art spectroscopy, molecular modeling, enzymology, and molecular biology to address fundamental problems at the interface of chemistry and biology.

Oni, a fellow at the Whitehead Institute for Biomedical Research, presented a talk titled "Leveraging Glycan-Dependent Epitopes for Tumor Targeting and Detection." The Oni Lab seeks new methods of understanding, detecting, and potentially treating pancreatic cancer.

Ribbeck is the Andrew (1956) and Erna Viterbi Professor of Biological Engineering, and her talk was entitled "From Molecular Mysteries to Medicine: The Therapeutic Promise of Glycans." Her research group's focus is on basic mechanisms by which mucus barriers exclude or allow passage of different molecules and pathogens, and the mechanisms pathogens have evolved to penetrate mucus barriers. Her research provides the foundation for a theoretical framework that captures general principles governing selectivity in mucus, and likely other biological hydrogels, such as the extracellular matrix and bacterial biofilms.

Shoulders, the symposium's co-organizer and a professor in the Department of Chemistry, presented a talk titled "N-Glycosylation: The Fulcrum of Collagen Proteostasis." Members in the Shoulders Lab study how cells fold proteins and develop and apply next-generation protein engineering and directed evolution techniques to address biotechnology challenges.

Stark, a professor of biological engineering, presented her research in a talk tilted "Antibody-Lectin Chimeras for Glyco-Immune Checkpoint Blockade." The Stark Lab is pioneering approaches to understand and engineer the roles of glycans in the immune system in order to fill key knowledge gaps in immunobiology and develop next-generation immunotherapies. Their work is highly interdisciplinary, integrating approaches from molecular, synthetic, and systems biology, immunology, and biological engineering. They are interested in fundamental questions and therapeutic applications in multiple contexts, including cancer, autoimmunity, and infection.

Robert van der Hilst to step down as head of the Department of Earth, Atmospheric and Planetary Sciences

Professor led EAPS for more than a decade, cultivating a focus on Earth systems, planets, climate science, and the origins of life

School of Science | Department of Earth, Atmospheric and Planetary Sciences

Robert van der Hilst, the Schlumberger Professor of Earth and Planetary Sciences, has announced his decision to step down as the head of the Department of Earth, Atmospheric and Planetary Sciences at the end of this academic year. A search committee will convene later this spring to recommend candidates for Van der Hilst's successor.

"Rob is a consummate seismologist whose images of Earth's interior structure have deepened our understanding of how tectonic plates move, how mantle convection works, and why some areas of the Earth are hot spots for seismic and geothermal activity," says Nergis Mavalvala, the Curtis (1963) and Kathleen Marble Professor of Astrophysics and the dean of the MIT School of Science. "As an academic leader, Rob has been a steadfast champion of the department's cross-cutting research and education missions, especially regarding climate sciences writ large at MIT. His commitment to diversity and community have made the department — and indeed, MIT — a better place to do our best work."

"For 12 years, it has been my honor to lead this department and collaborate with all our community members — faculty, staff, and students," says Van der Hilst. "EAPS is at the vanguard of climate science research at MIT, as well Earth and planetary sciences and studies into the coevolution of life and changing environments."

Among his other leadership roles on campus, Van der Hilst most recently served as co-chair of the faculty review committee for MIT's Climate Grand Challenges in which EAPS researchers secured nine finalists and two, funded flagship projects. He also serves on the Institute's Climate Nucleus to help enact Fast Forward: MIT's Climate Action Plan for the Decade.

In his more-than-decade as department head, one of Van der Hilst's major initiatives has been developing, funding, and constructing the Tina and Hamid Moghadam Building, rapidly nearing completion adjacent to Building 54. The $35 million, LEED-platinum Building 55 will be a vital center and showcase for environmental and climate research on MIT's campus. With assistance from the Institute and generous donors, the renovations and expansion will add classrooms, meeting and event spaces, and bring headquarters offices for EAPS, the MIT–Woods Hole Oceanographic Institution Joint Program in Oceanography/Applied Ocean Science and Engineering, and MIT's Environmental Solutions Initiative together, all under one roof.

He also helped secure the generous gift that funded the Rasmussen Laboratory for climate research in Building 4, as well as the Peter H. Stone and Paola Malanotte Stone Professorship, now held by prominent atmospheric scientist Arlene Fiore.

On the academic side of the house, Van der Hilst and his counterpart from the Department of Civil and Environmental Engineering (CEE), Ali Jadbabaie, the JR East Professor and CEE department head, helped develop MIT's new bachelor of science in climate system science and engineering (Course 1-12), jointly offered by EAPS and CEE.

As part of MIT's commitment to aid the global response to climate change, the new degree program is designed to train the next generation of leaders, providing a foundational understanding of both the Earth system and engineering principles — as well as an understanding of human and institutional behavior as it relates to the climate challenge.

Outgoing department head Robert van der Hilst stands in front of the nearly completed Moghadam Building. *Photo: Steph Stevens*

Beyond climate research, Van der Hilst's tenure at the helm of the department has seen many research breakthroughs and accomplishments: from high-profile NASA missions with EAPS science leadership, including the most recent launch of the Psyche mission (see back cover) and the successful asteroid sample return from OSIRIS-REx, to the development of next-generation models capable of describing Earth systems with increasing detail and accuracy. Van der Hilst helped enable such scientific advancements through major improvements to experimental facilities across the department, and, more generally, his mission to double the number of fellowships available to EAPS graduate students.

"By reducing the silos and inequities created by our disciplinary groups, we were able to foster collaborations that allow faculty, students, and researchers to explore fundamental science questions in novel ways that expand our understanding of the natural world — with profound implications for helping to guide communities and policymakers toward a sustainable future," says Van der Hilst.

Community focused

In 2019, Van der Hilst began looking ahead to the department's 40th anniversary in 2023 and charged a number of working groups to evaluate the department's past and present, and to reimagine its future. Led by faculty, staff, and students, Task Force 2023 was a yearlong exercise of data gathering and community deliberation, looking broadly at three focus areas: Image, Visibility, and Relevance; External Synergies: Collaboration and Partnerships across Campus; and Departmental Organization and Cohesion. Despite being interrupted by the pandemic, the resulting reports became a detailed blueprint for EAPS to capitalize on its strengths and begin to effect systemic improvements in areas like undergraduate education, external messaging, and recognition and belonging for administrative and research staff.

In addition to helping the department mark its 40th anniversary with a celebration this coming spring, Van der Hilst will oversee the dedication of the Moghadam Building, including the renaming of lecture hall 54-100 for Dixie Lee Bryant, who, in 1891 was the first recipient (woman or man) of a geology degree from MIT.

As department head, faculty renewal and retention were key areas of focus for Van der Hilst. In addition to improvements in the faculty search process, he was responsible for the appointment of 20 new faculty members, and in the process shifted the gender ratio from one-fifth to one-third of the faculty identifying as female; he also oversaw the development and implementation of a successful junior faculty mentoring program within EAPS in 2013.

Van der Hilst also made great strides toward improving diversity, equity, and inclusion within the department in other ways. In 2016, he formed the inaugural EAPS Diversity Council (now the Diversity, Equity, and Inclusion Committee) and, in 2020, made EAPS the first department at MIT to appoint an associate department head for diversity, equity, and inclusion, tapping Associate Professor David McGee to guide ongoing community dialogues and initiatives supporting improvements in composition, achievement, belonging, engagement, and accountability.

With McGee and EAPS student leadership, Van der Hilst supported the EAPS response to calls for social justice leadership and participation in national initiatives, such as the American Geophysical Union's Unlearning Racism in Geoscience program, and he helped navigate the changes brought on by the Covid-19 pandemic while maintaining a sense of community.

A longer version of this announcement appeared on MIT News on Nov. 6, 2023 and can be found at science.mit.edu/news.

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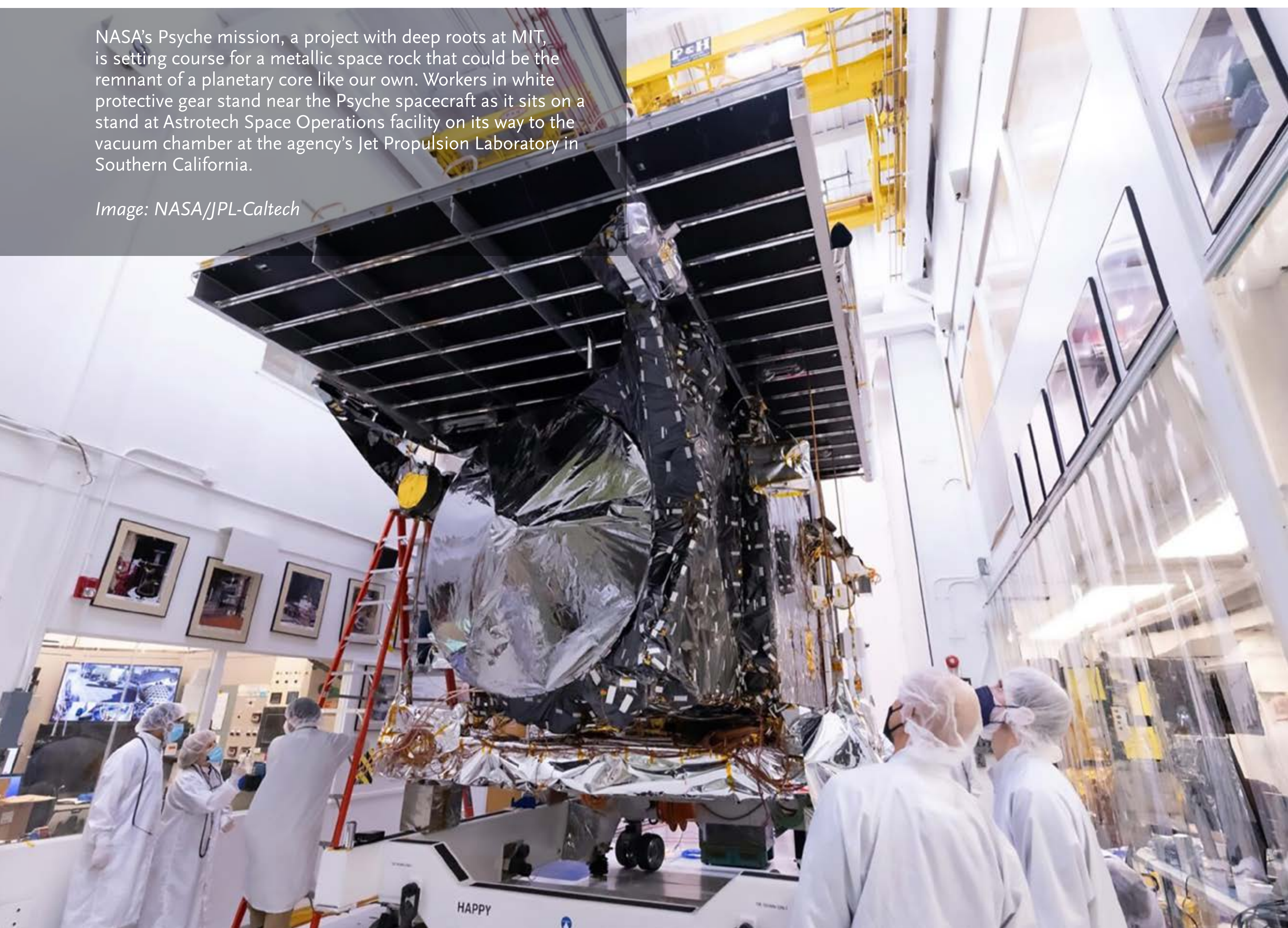

NASA's Psyche mission, a project with deep roots at MIT, is setting course for a metallic space rock that could be the remnant of a planetary core like our own. Workers in white protective gear stand near the Psyche spacecraft as it sits on a stand at Astrotech Space Operations facility on its way to the vacuum chamber at the agency's Jet Propulsion Laboratory in Southern California.

Image: NASA/JPL-Caltech