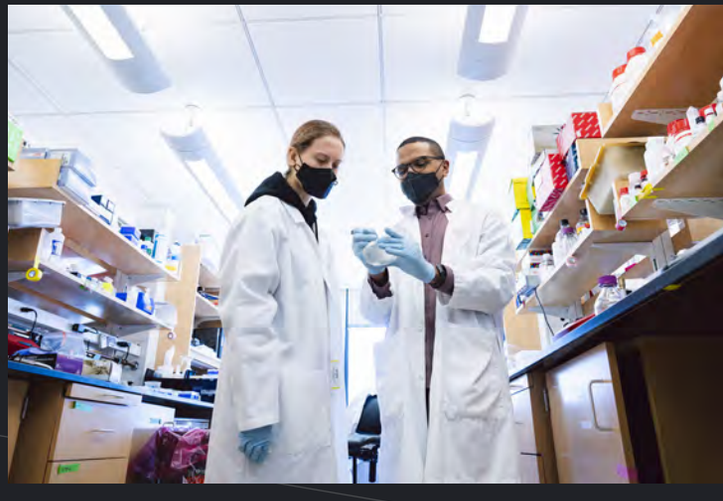
Massachusetts Institute of Technology

UROP Impact Report 2022

Student research. Real world impact.



MIT | UROP Undergraduate Research Opportunities Program

→ Mind and Hand

Mens et Manus

Empowering our students to make real impact

Photo of Melissa Nobles by Gretchen Ertl

I've been proud to serve MIT for more than 25 years. Today, as Chancellor of the Institute, I am as committed as ever to expanding and deepening the meaning of an MIT education—to teaching the whole student, and to showing them what it means to put our mens et manus (mind and hand) ideals into action.

The Undergraduate Research Opportunities Program (UROP) is a foundational part of that commitment. It's a chance to step outside the classroom and think beyond the syllabus—to discover and explore out in the world. It brings students to the places and people that inspire and empower them to make a difference.

For more than 50 years, UROP has been a hallmark of the MIT experience. Through hands-on research experiences that run the gamut from vaccine development and space exploration to climate policy and groundbreaking inquiry in the humanities, UROP students go deep tackling real-world challenges. They work side-by-side with our outstanding faculty and researchers, building crucial research and technical competencies as well as essential, universal skills like problem-solving, collaboration, and communication. UROP provides students with essential chances to identify, explore, and pursue their passions, as well as a venue to think about how they might make a difference in the world. It's no wonder 93% of our undergraduates UROP at least once while at MIT.

This report features students talking about their own UROP experiences: what they've learned, how they've grown, and where they might go next. It also includes insights from our faculty on the remarkable contributions UROP students have made to their research—contributions that underscore the importance of programs like UROP, and also serve to highlight the passion and promise of our undergraduates.

I am grateful to the many researchers and supporters who work tirelessly to provide UROP opportunities to our students, and truly excited by the possibilities that lie ahead.

Sincerely,

Melissa Nobles

Chancellor and Class of 1922 Professor of Political Science

Urban Studies and Planning

Laurena Huh ’23

Driving Self-Discovery

Laurena Huh ’23 explores the future of sustainable transport—and the road beyond her major.

Electric cars and autonomous vehicles are big buzzwords in the growing discourse around energy efficiency. But are they a viable large-scale solution to tackling our profound sustainability challenges? MIT student Laurena Huh '23 is hard at work trying to find out.

Huh's UROP has brought her to the JTL Urban Mobility Lab, which operates within MIT's Department of Urban Studies and Planning. As part of the JTL team, she is working to gather and analyze data that will help researchers better understand the trade-offs between energy efficiency and the financial feasibility of using electric and autonomous vehicles in taxi fleets.

"It's been really interesting getting to objectively analyze technology like electric vehicles and self-driving cars," Huh says. "Diving deep into the data—getting to test intuition and see what's actually happening—is a very exciting part of research."

Urban Mobility Lab Director Dr. Jinhua Zhao, who is an associate professor of city and transportation planning, praises Huh's work in examining the financial and environmental costs of hailing a robocab in certain auto markets.

"Diving deep into the data—getting to test intuition and see what's actually happening—is a very exciting part of research."

Questioning the status quo

"Laurena has been focusing on how the costs of electric, autonomous taxis compare to the status quo, the impact on emissions, and how consumer willingness to pay impacts uptake of a technology that could revolutionize how we live and work," he says.

Huh, who is earning a BS in computer science, economics, and data science, and another in finance, is putting the skills she developed in the classroom to good use in the lab. And she appreciates that UROP is allowing her to explore work in fields outside her majors.

"MIT can be hard. Classes are hard," she says. "Sometimes it's nice to explore something outside my main academic interests."

That exploration is empowering Huh to utilize and further develop transferable skills like computer science, coding, and data analysis, as well as home in on her next steps and ultimate career aspirations. Her work at the Mobility Lab has given her a taste for work that has implications outside of academia, and it is also helping her gauge her interest in potential graduate work.

"One of the great things about doing a UROP is that you come to understand what it would be like to go down the PhD route," she says. "You're doing research, putting out papers, and going through the research revision process. It was really interesting for me to have an inside view of what that all looks like."

Positive Feedback Loop

Biological Engineering

Prof. Bryan Bryson

The UROP journey of Professor Bryan Bryson

There's something truly special about the attitude and energy Professor Bryan Bryson is bringing to his pursuit of a tuberculosis vaccine. It's a positive, no-boundaries worldview he attributes to his own UROP experience as an MIT undergraduate—one he now shares with the undergraduates working in his lab.

"UROP provides this scientifically optimistic environment where there's a belief that you can do it," he says. "It's not just about teaching students how to design a good experiment—it's about encouraging them to have the authority to feel like they did the right thing."

Bryson arrived at MIT as a student in 2003. He was eager to study biomedical engineering, but at the time no such major existed. So he began looking for other ways to pursue this passion. It's a journey that led him to his first UROP: working in the Griffith Lab, led by MacArthur "Genius Grant" winner, biomedical engineering pioneer, and his current faculty colleague, Linda Griffith.

"If not for UROP, I wouldn't have the same level of self-confidence that I do," Bryson says. "That came from having the opportunity to take basic knowledge about biology, physics, and engineering and build something that's going to solve a problem."

Training wheels of research

Today, as an associate professor in the Department of Biological Engineering, Bryson is bringing the best of his own UROP experience to the undergraduates working in his lab. His students are gathering data that will be used to design a prototype, employing techniques such as visualizing how immune cells engulf and digest bacteria through the use of green fluorescent protein.

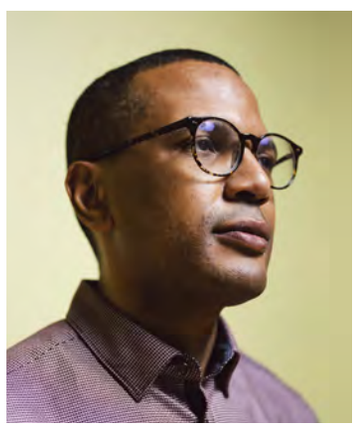
UROP, he says, provides the "training wheels of research" by giving students both unique resources and opportunities, as well as the chance to build their confidence and believe in themselves.

"In the classroom, you either have the answer or you don't," he says. "But research is a totally different ball game. It's about grit, creativity, and a willingness to embrace risk. You're also mixing with a set of people who have an unabashed curiosity, and a fierce belief in the possibility of the impossible. So UROP is a perfect storm for a program that really launches careers."

Bryson's work on a tuberculosis vaccine uses engineering principles to illuminate the specifics of how the immune system identifies and eliminates a pathogen. His UROP students play an important role in the lab, bringing in disparate interests and majors that allow for a broader, more collaborative effort.

"We have people doing machine learning, people doing protein engineering, and others who are doing standard immunology," Bryson says.

"It's about grit, creativity, and a willingness to embrace risk. You're also mixing with a set of people who have an unabashed curiosity, and a fierce belief in the possibility of the impossible."



"UROP is about 'yes'—yes, we're going to try this amazing, crazy idea. And if you don't figure this out, you're going to figure out a bunch of other important things along the way."

Diverse skills and fresh energy

UROP students bring diverse skills, perspectives, and approaches to the lab, but also come armed with passion, enthusiasm, and energy—qualities that Bryson says sometimes fade as researchers progress in their careers.

"UROP is about 'yes,'" he says. "Yes, we're going to try this amazing, crazy idea. And if you don't figure this out, you're going to figure out a bunch of other important things along the way."

Kelly Xu, a sophomore working on single-cell RNA sequencing analysis for the Bryson Lab, says it's just that kind of outlook that has made her UROP experience so rewarding.

"Professor Bryson is a wonderful mentor—he gives great advice and support while encouraging independence," she says. "He's provided a lot of wisdom, and I feel comfortable asking him for help, which is especially important coming in as a new student."

For Bryson and his UROP students, that positive energy seems to be paying off. He anticipates having a prototype of the tuberculosis vaccine within the next 18 months.

"I can't tell you if it's going to work," he says. But true to form, he's optimistic.

↓ Prof. Bryan Bryson with UROP student Nicole Shigiltchoff.

Where Computation Meets Compassion

Prof. Stephanie Ann Frampton

UROPs at the heart of Digital Humanities

↑ Prof. Stephanie Ann Frampton (left) with UROP student Anna B. Aldins.

MIT's Digital Humanities Lab operates at an important and interesting intersection: It depends not only on the faculty's expertise in the humanities, arts, and social sciences, but also on the engineering and computational prowess of enthusiastic MIT undergraduates.

It's a cross-sectional lab model where interdisciplinary faculty fellows join the lab for a full semester, giving the UROP students a crash course in their discipline while simultaneously investigating research topics.

"One half of our mission is to give undergraduate students, who are primarily STEM majors, deep exposure to humanities and social sciences questions," says Stephanie Ann Frampton, associate professor and faculty director, Programs in Digital Humanities. "Another is to provide faculty with exposure to and fluency in some of the emerging computational methods and digital tools used by students."

Exploring self-sufficient cities

The current core research initiative within Digital Humanities, the Self-Sufficient Cities project, involves approximately 20 UROP students. Project researchers are working to document the rise and fall of U.S. urban communities that grew their own food in the 20th century. Ultimately, they aim to create an online platform highlighting how changes in landscapes, land use, and infrastructure affect community well-being.

Kate Brown, professor and principal investigator of the Self-Sufficient Cities project, says the work involves examining massive amounts of public records data, including censuses, maps, and oral history transcripts.

"Students learn to determine what biases are written into research sources and how to look for clues and analyze what they found," she says. "I have heard them marvel at how cool it is to spy on people in the past."

Case in point: Nisha Nkya '25. She describes the work as an eye-opening look into how underlying historical issues can influence our present day—and says the lab itself is a safe space to be passionate about making a difference, even as a beginner.

"One half of our mission is to give undergraduate students, who are primarily STEM majors, deep exposure to humanities and social sciences questions."

→

Prof. Kate Brown (standing) with Nisha Nkya and Paula Contreras Nino (left to right).

↑ Prof. Kate Brown (standing) with UROP students Nisha Nkya, Quincy Johnson, and Kateryna Morhun (left to right).

"Students learn to determine what biases are written into research sources and how to look for clues and analyze what they found."

"As an aspiring computer science student with no prior coding experience, the lab was very gracious and nurtured my coding skills from scratch whilst being patient with me," she says. "There's a special kind of happiness when you work on something you are passionate about with someone who shares that passion."

It's not all lighthearted sleuthing, though. Brown says that students have also been visibly disturbed by the impact of racism on health, wealth, and welfare.

But Frampton believes that discomfort is an important part of the process. She says that students with ambitions for changing the world need to understand how STEM fields can be motivated by, and intersect with, problems that are emerging in humanities.

"The problems that are coming out of our fields are subtle and not straightforward, and so they're actually really good domains for engineering complexity," she explains. "What we're doing is teaching them how to think creatively and substantively about really complex problems."

Prof. Kate Brown

The Search for New Exoplanets

—

Dr. George Ricker

UROP students add rocket fuel to NASA's TESS project

Dr. George Ricker has watched the UROP program grow dramatically since its inception in the 1970s. Over the years, he's worked with UROP student researchers on projects that run the gamut from studying the Crab Nebula in Canada to building and launching high-altitude balloons in Texas and Australia.

Ricker, who today serves as the principal investigator for NASA's Transiting Exoplanet Sky Survey (TESS) Explorer mission and senior research scientist at the MIT Kavli Institute for Astrophysics and Space Research, considers himself fortunate to have been a contemporary of UROP's founder, Margaret L. A. MacVicar. He says that MacVicar's infectious passion for research helped shape the program, and continues to influence it to this day.

"UROP students don't have a set of preconceived notions," Ricker says. "They come in with eyes wide open and a lot of curiosity."

"UROP students don't have a set of preconceived notions. They come in with eyes wide open and a lot of curiosity."

↑ Dr. George Ricker (left) with Ashley Yuan, Dr. Michelle Kunimoto, and Maya Beleznay (left to right) make use of a custom thermal vacuum chamber, where an engineering model TESS Wide Field Camera is undergoing testing.

Expanding knowledge by mapping the sky

Ricker's current UROP students are conducting research at Kavli's TESS mission. They're working alongside postdocs in a sky-mapping endeavor that seeks to expand knowledge of exoplanets, which are planets that orbit stars outside of Earth's solar system.

> "It's like going to a crime scene and laying out all the different pieces. Students love it because the data's just there—you have to go through and look at the pieces and figure out how they all come together."

TESS is monitoring distant stars in order to find planets similar to Earth, work that has led to a vast increase in the number of known exoplanets. Over the past four years, the TESS team has cataloged details such as size and orbit for more than 5,000 systems, including 25 of the 62 exoplanet targets being observed by the newly launched James Webb Space Telescope.

The group discovers exoplanets by searching for what is known as a transit event, which occurs when a planet crosses in front of a star and causes a dip in the visible light coming from that star. Studying this dip allows researchers to determine the planet's size and orbit, and paves the way for additional research to determine mass, composition, and atmosphere.

This work produces enormous amounts of data: Because transit events are quite rare, researchers must observe a massive amount of sky to see them. In fact, at any given time TESS is examining five and a half percent of the sky.

"It's like going to a crime scene and laying out all the different pieces," Ricker says. "Students love it because the data's just there—you have to go through and look at the pieces and figure out how they all come together."

Real research with real impact

But Ricker says it's important to understand that the UROP experience—whether with TESS or one of the hundreds of other opportunities available each semester—is most definitely not an exercise in busy work. Students make meaningful contributions, develop practical skills, and gain valuable insights that inform their future directions. Sometimes work completed as part of a UROP can even become the foundation of a student's career.

"These students aren't off just doing calculations. They're actually in the lab working on the science instrumentation that we do, or actually taking data from the satellites," he says. "There have been quite a number of instances where UROP students have been first authors on major scientific papers published from the research."

Ricker says it's also important to note that students aren't the only ones who benefit from being part of UROP. Because participating undergraduates come to the lab with a diverse collection of knowledge and experience, they often expose faculty to new ideas and insights.

"Students will actually say to faculty, 'Okay, well, that's not a really great way to do it. Here's a much better way,'" Ricker says. "So we get a lot out of the process, as well."

↑ Andrew Jenkins, Dr. Daniel Muthukrishna, Anahita Srinivasan, Saul Balcarcel, and Paige Yeung (left to right).

>5,000

SOLAR SYSTEMS MAPPED BY THE TESS MISSION

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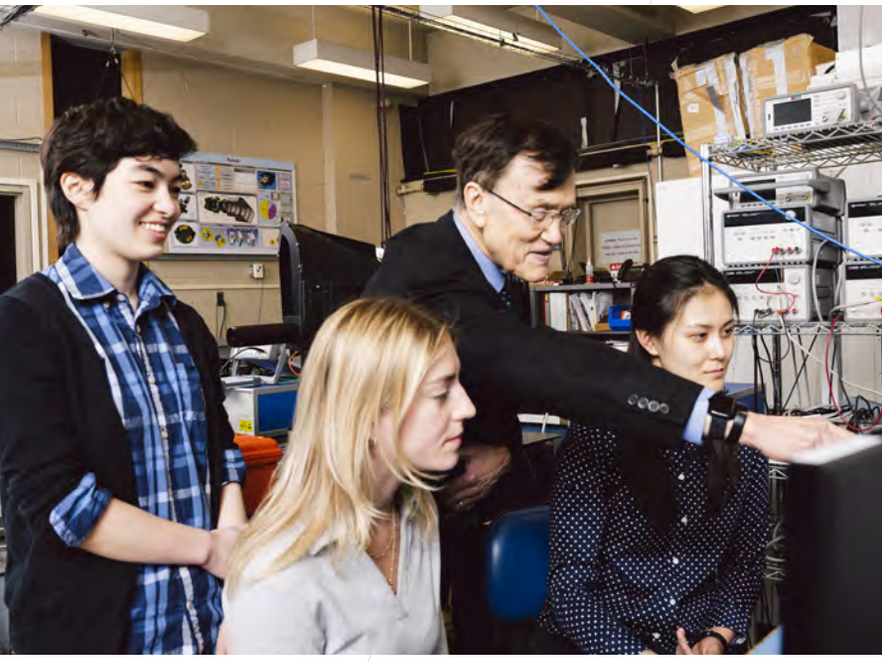


← Dr. Michelle Kunimoto, Maya Beleznay, Dr. George Ricker, and Ashley Yuan (left to right).

She
Orzach ’22

The Power of Policy

Shelli Orzach and the Climate Pathways Project

↑ MIT Sloan professor John D. Sterman.

Much of the conversation around the climate crisis centers on renewable technology and the measures individuals and households can take to reduce their carbon footprints. But MIT student Shelli Orzach '22 has set her sights on something different: policy.

"We can't just rely on technology like solar power or electric cars," she says. "Public policy and taxes are also an integral part of the solutions needed to address climate change."

Originally an aerospace engineering major, Orzach changed course sophomore year after attending an interactive event hosted by the Climate Pathways Project, an initiative led by MIT Sloan professor John D. Sterman.

The power of system dynamics

UROP has given Orzach the opportunity to work with Sterman and his Climate Pathways team on En-ROADS, a climate solutions simulator. En-ROADS allows users to explore the impact of roughly 30 policies on hundreds of different factors, with an eye on exploring the most achievable ways of using policy to curb climate change.

"If our tool says that a $50 carbon tax will decrease projected temperature rise by a certain amount, for example, that is information that can help policymakers," Orzach explains.

18 INTERACTIVE VARIABLES USED BY EN-ROADS TO GENERATE CUSTOMIZABLE CLIMATE SCENARIOS

Available to the public and used by policymaking bodies worldwide, including 130 members of the U.S. Congress, En-ROADS functions with the support of a large system dynamics model. Orzach's UROP role involves using simulation software called Vensim to model the impact of carbon sequestration technologies for use in the program's calculations.

"For instance, we figure out how much strain a certain measure would put on the electricity grid," she says. "We look at how fast the solution would develop, long-term and short-term demand, and pricing in order to provide a more calculated model of what might actually happen and how that might change factors in the rest of the model."

Orzach is thankful that UROP has allowed her to build important skills and apply them to an established, highly consequential project, as well as work closely with a mentor as inspiring and motivating as Sterman.

"In today's world, you could pretty much learn any skill that you want, especially as an MIT student," she says. "But with UROP, it's about interacting with mentors. Professor Sterman is very im pactful and has made a big difference in the climate sphere."

Orzach plans to continue on to a PhD program after graduation, but first—energized by her UROP experience—she's planning a cross-country hiking trip with her dog.

"I'm going to visit a lot of national parks," she says. "I want to learn more about everything I'm seeking to protect."

"In today's world, you could pretty much learn any skill that you want, especially as an MIT student... with UROP, it's about interacting with mentors."

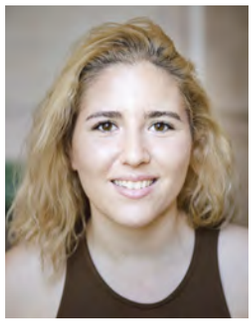
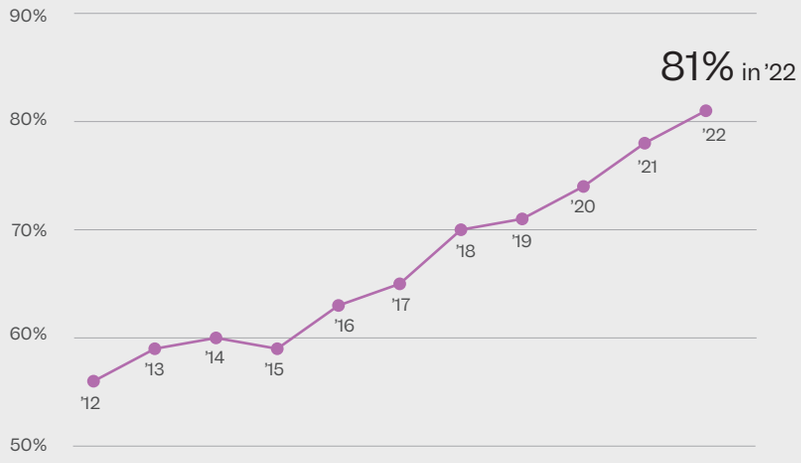


Photo of John Sterman by Andrew Kubica

UROP at a Glance

Percentage of Paid UROP Projects

Academic years 2012–2022

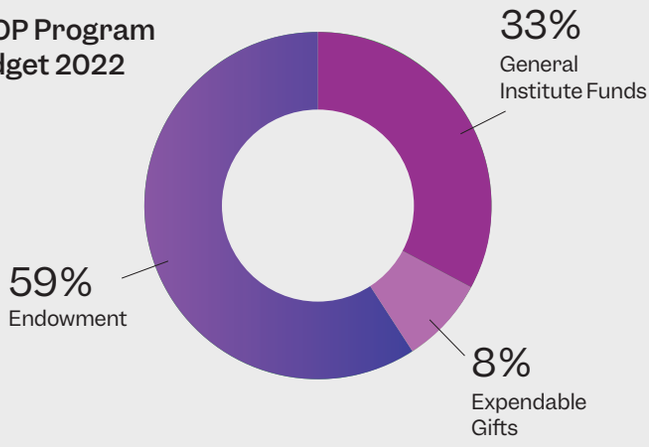


The Partnership Model

Supported through Institute funds and faculty research expenditures, UROP enables students to work as full-fledged members of the MIT research community.

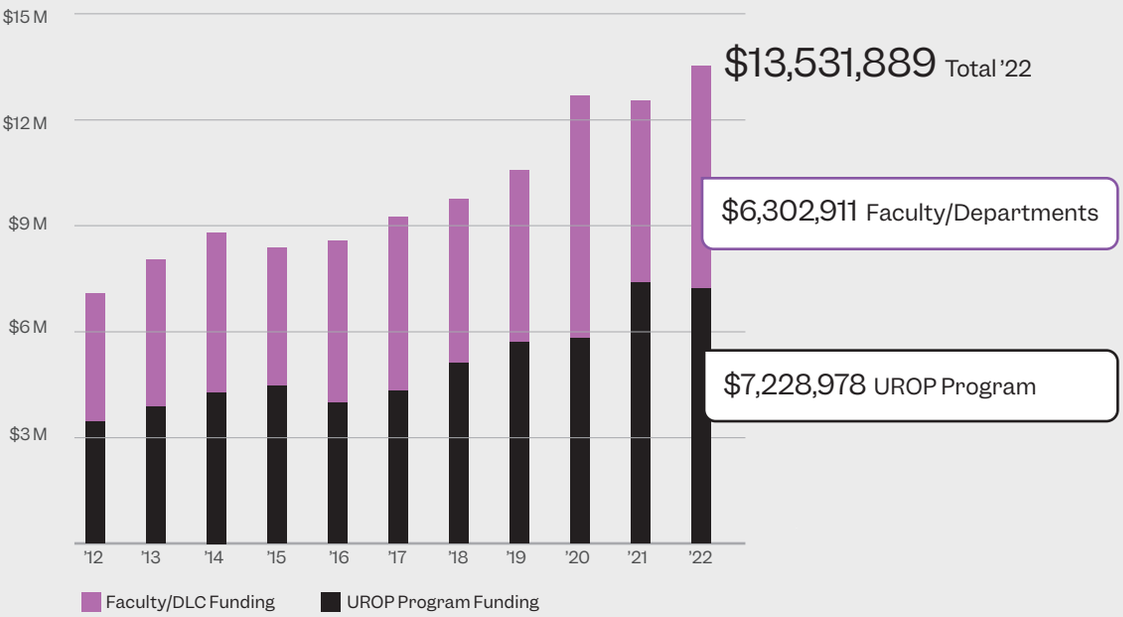
→ UROP supports nearly 6,000 projects yearly with 2,800 MIT students participating.

UROP Program Budget 2022



Funding

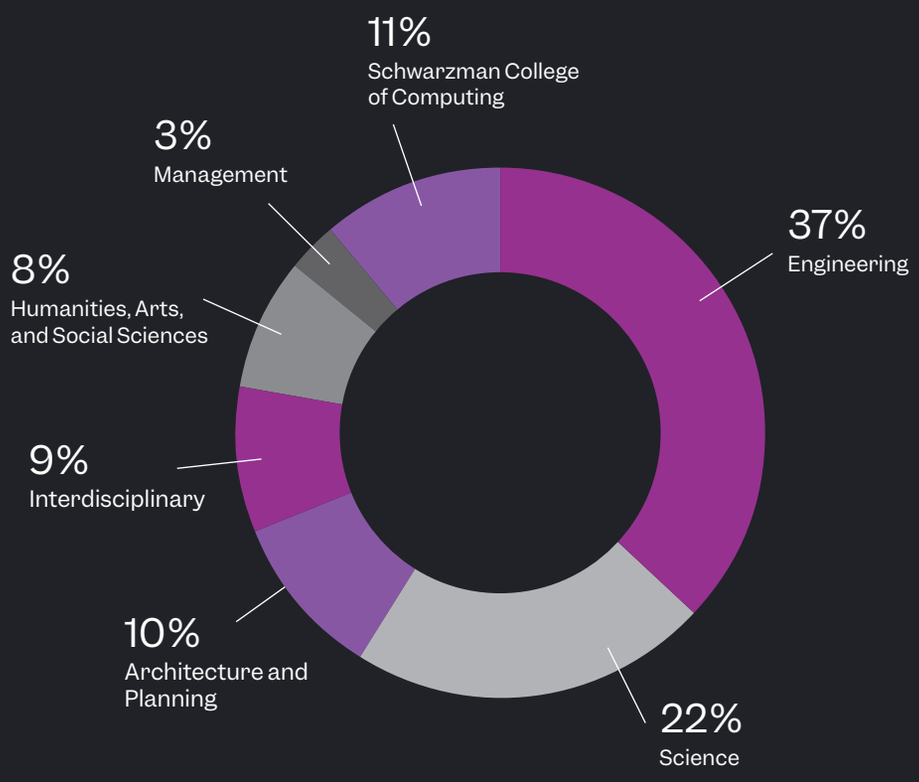
Academic years 2012–2022



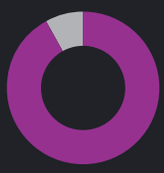
Report photography by Ben Gebo. Design by Leone Design. Writing by 43,000 Feet.

UROP Projects by School

Academic Year 2021 2022

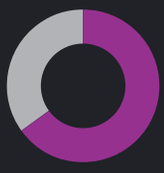


UROP by the Numbers 2022



92%

OF THE 2022 MIT CLASS PARTICIPATED IN UROP



64%

OF FIRST YEAR STUDENTS PARTICIPATED IN UROP

58%

OF FACULTY PARTICIPATED IN UROP AS MENTORS

UROP Empowers

Students tell us that their UROP experiences help them:

- Get to know faculty.
- Develop technical skills.
- Present their work.
- Create research posters.
- Publish their results.
- Prepare for graduate school and careers.

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