MIT Briefing Book

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MIT Massachusetts Institute of Technology

MIT Briefing Book

Massachusetts Institute of Technology
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MIT Washington Office

The MIT Washington Office was established in 1991 to provide a presence in the nation's capital for MIT, one of the country's premier academic institutions with a long history of contributing to U.S. leadership in science and technology. A part of the MIT President's Office, the Washington Office works closely with the Institute's senior leaders to develop and advance policy positions on R&D and education issues. The office also supports major MIT initiatives in areas where national policy is being developed, currently including advanced manufacturing and the innovation ecosystem; the convergence of the life, engineering and physical sciences; energy; the environment; and innovative educational technologies. MIT students work with the Washington Office to gain hands-on experience in the science and technology policy-making process.

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Facts and History

The Massachusetts Institute of Technology is one of the world's preeminent research universities, dedicated to advancing knowledge and educating students in science, technology, and other areas of scholarship that will best serve the nation and the world. It is known for rigorous academic programs, cutting-edge research, a diverse campus community, and its long-standing commitment to working with the public and private sectors to bring new knowledge to bear on the world's great challenges.

William Barton Rogers, the Institute's founding president, believed that education should be both broad and useful, enabling students to participate in "the humane culture of the community" and to discover and apply knowledge for the benefit of society. His emphasis on "learning by doing," on combining liberal and professional education, and on the value of useful knowledge continues to be at the heart of MIT's educational mission.

MIT's commitment to innovation has led to a host of scientific breakthroughs and technological advances. Achievements by the Institute's faculty and graduates include the first chemical synthesis of penicillin and vitamin A, the development of inertial guidance systems, modern technologies for artificial limbs, and the magnetic core memory that enabled the development of digital computers. Today, MIT is making a better world by focusing its strengths in research, innovation, and education in such areas as: the secrets of the brain and mind and the origins and evolution of life; practical solutions for environmental sustainability, clean energy, and water and food security; the convergence of disciplines in tackling human health challenges, from disease prevention to personalized medicine to affordable health care; improved innovation and entrepreneurship systems that speed ideas to impact; and pedagogical innovation on campus and online thanks to new avenues in the science of learning and cutting-edge digital tools.

University research is one of the mainsprings of growth in an economy that is increasingly defined by technology. A study released by MIT in December 2015 estimated that MIT graduates had founded at least 30,000 active companies. These firms employed approximately 4.6 million people, and generated annual world sales of $1.9 trillion, or the equivalent of the tenth-largest economy in the world in 2014.

MIT has forged educational and research collaborations with universities, governments, and companies throughout the world, and draws its faculty and students from every corner of the globe. The result is a vigorous mix of people, ideas, and programs dedicated to enhancing the world's well-being.

Two of MIT's current major endeavors contributing to MIT's continued commitment to the evolution of education and research are the MIT Campaign for a Better World and the MIT Stephen A. Schwarzman College of Computing. They are described below:

MIT Campaign for a Better World

The MIT Campaign for a Better World is a $6 billion fundraising initiative that seeks to advance the Institute's work on some of the most urgent global challenges facing humanity. The Campaign—which spans the breadth of MIT's schools and departments, labs, and centers—focuses MIT's distinctive strengths in education, research, and innovation on defining the future of human health; transforming our world through fundamental scientific research; addressing mankind's critical environmental and sustainability challenges; accelerating pioneering research and innovation in computing and exploring the societal and ethical implications of advanced technologies; reimagining education for the 21st-century learner; accelerating the journey from idea to impact; and attracting extraordinary students and faculty to MIT and providing them with the tools and infrastructure to do their pioneering work.

As part of its commitment to strengthening the MIT Core, the Campaign is increasing resources for undergraduate financial aid, graduate fellowships, and professorships; reimagining residential living and educational spaces; and transforming MIT's presence in the innovation hub of Kendall Square.

Support for the Campaign from MIT's alumni and friends has been directed toward such areas as education, machine learning and health care, water and food security, autism research, human and machine intelligence, and urbanization. Across campus, new teaching, learning, and research spaces are providing MIT's faculty and students with the advanced facilities they need. Further, donor support means that MIT can invest in the daring, high-risk research that is the Institute's hallmark as well as sustain support for students, faculty, and the physical campus.

MIT Stephen A. Schwarzman College of Computing

The MIT Stephen A. Schwarzman College of Computing has been established as a bold initiative to accelerate pioneering research and innovation in computing, build a profound awareness of the ethical implications and societal impact, and, above all, educate leaders for the algorithmic future. The college aims to address the global opportunities and challenges presented by the ubiquity of computing—across industries and academic disciplines—perhaps most notably illustrated by the rise of artificial intelligence. The College, under the leadership of Dean Dan Huttenlocher, began operations in September 2019.

Fields of Study

MIT supports a large variety of fields of study, from science and engineering to the arts. MIT's five academic schools and college are organized into departments and other degree-granting programs. In addition, several programs, laboratories, and centers cross traditional boundaries and encourage creative thought and research.

School of Architecture and Planning
Architecture
Media Arts and Sciences
Urban Studies and Planning
Center for Real Estate

School of Engineering
Aeronautics and Astronautics
Biological Engineering
Chemical Engineering
Civil and Environmental Engineering
Electrical Engineering and Computer Science*
Materials Science and Engineering
Mechanical Engineering
Nuclear Science and Engineering

School of Humanities, Arts, and Social Sciences
Anthropology
Comparative Media Studies/Writing
Economics
Global Studies and Languages
History
Linguistics and Philosophy
Literature
Music and Theater Arts
Political Science
Science, Technology, and Society

Sloan School of Management
Management

School of Science
Biology
Brain and Cognitive Sciences
Chemistry
Earth, Atmospheric and Planetary Sciences
Mathematics
Physics

MIT Stephen A. Schwarzman College of Computing
Data, Systems, and Society
Electrical Engineering and Computer Science*

http://catalog.mit.edu/

*Reports to the School of Engineering and the MIT Stephen A. Schwarzman College of Computing

Research Laboratories, Centers, and Programs

In addition to teaching and conducting research within their departments, faculty, students, and staff work in laboratories, centers, and programs.

Some of these include:

Abdul Latif Jameel Poverty Action Lab (J-PAL)
Abdul Latif Jameel World Water and Food Security Lab (J-WAFS)
Center for Archaeological Materials
Center for Bits and Atoms (CBA)
Center for Collective Intelligence (CCI)
Center for Computational Engineering (CCE)
Center for Computational Research in Economics and Management Science (CCREMS)
Center for Energy and Environmental Policy Research (CEEPR)
Center for Environmental Health Sciences (CEHS)
Center for Global Change Science (CGCS)
Center for Information Systems Research (CISR)
Center for International Studies (CIS)
Center for Real Estate (CRE)
Center for Transportation and Logistics (CTL)
Clinical Research Center (CRC)
Computer Science and Artificial Intelligence Lab (CSAIL)
Concrete Sustainability Hub
D-Lab
Deshpande Center for Technological Innovation
Division of Comparative Medicine (DCM)
Edgerton Center
Haystack Observatory
Initiative on the Digital Economy (IDE)
Institute for Data, Systems, and Society (IDSS)
Institute for Medical Engineering and Science (IMES)
Institute for Soldier Nanotechnologies (ISN)
Institute for Work and Employment Research (IWER)
Internet Policy Research Initiative (IPRI)
Joint Program on the Science and Policy of Global Change
Knight Science Journalism Program

Koch Institute for Integrative Cancer Research (KI)
Laboratory for Financial Engineering (LFE)
Laboratory for Information and Decision Systems (LIDS)
Laboratory for Manufacturing and Productivity (LMP)
Laboratory for Nuclear Science (LNS)
Legatum Center for Development and Entrepreneurship
Leventhal Center for Advanced Urbanism (LCAU)
Lincoln Laboratory
Martin Trust Center for MIT Entrepreneurship
Materials Research Laboratory (MRL)
McGovern Institute for Brain Research (MIBR)
Microsystems Technology Laboratories (MTL)
MIT Center for Art, Science, and Technology (CAST)
MIT Energy Initiative (MITEI)
MIT Environmental Solutions Initiative (ESI)
MIT Innovation Initiative (MITII)
MIT Kavli Institute for Astrophysics and Space Research
MIT Media Lab
MIT.nano
MIT Portugal Program
MIT Program in Art, Culture, and Technology (ACT)
MIT Sea Grant College Program
MIT-Woods Hole Oceanography/ Applied Ocean Science and Engineering
Nuclear Reactor Laboratory (NRL)
Operations Research Center (ORC)
Picower Institute for Learning and Memory (PILM)
Plasma Science and Fusion Center (PSFC)
Research Laboratory of Electronics (RLE)
Simons Center for the Social Brain
Singapore-MIT Alliance for Research and Technology (SMART)
Sociotechnical Systems Research Center (SSRC)
Women's and Gender Studies Program (WGS)

http://web.mit.edu/research/

Digital Learning

MIT is at the forefront of enhancing teaching and learning by leveraging educational technology. Individual faculty initiatives, departmental projects, and Institute-wide innovations enrich education at MIT and worldwide. Technology-enabled changes in how we teach and learn have accelerated, delivering:

- New pedagogies and tools. Digital technologies enable students to do more outside the class: view lectures via video, receive rapid feedback on homework, and access adaptive hints to foster learning. This approach carves out valuable in-class time for active discussion, hands-on instruction, problem solving, case studies and labwork. Technologies, such as the Residential MITx platform, provide flexibility in course delivery, enabling students to access content anytime, anywhere. Tools such as virtual reality, gaming, and other resources open new ways of presenting and understanding educational materials to enhance comprehension and learning.

- Scalable and open teaching. The open education movement, pioneered in large part by MIT's OpenCourseWare and joined by hundreds of institutions worldwide, lowers financial, geographical, and political barriers to accessing quality educational content. MITx brings MIT faculty and their courses to millions of learners via the edX platform. MicroMasters programs offer a valuable professional credential at the Masters level, and a new path to a Master's degree at MIT and other universities.

- Supporting pK–12 learning. MIT supports learning from infancy through high school, especially in the areas of science and technology. This includes efforts such as Scratch, a platform that teaches children to code and allows them to share their creations within online communities; the Edgerton Center's hands-on science and engineering challenges; as well as classroom and teacher support, through games, tools, curriculums and teacher training.

- Flexible workforce development. Online and blended classes tailored for professional education enable a global workforce to acquire new skills and keep pace with technological developments, making learning accessible anytime, anywhere. Online courses are sometimes combined with bootcamps, workshops, and other in-person experiences to deliver transformational learning experiences for entrepreneurs, technologists and professionals.

- Digital learning research and learning analytics. Online learning systems have the ability to amass huge volumes of data on student use and assessment as they work their way through courses, which can be used to model student learning approaches. The MIT Integrated Learning Initiative is a cross-disciplinary, Institute-wide effort that fosters rigorous, quantitative research on teaching and learning.

MIT Open Learning is an Institute-wide initiative that seeks to transform teaching and learning at MIT and around the globe through the innovative use of digital technologies. It is the umbrella entity for the Office of Digital Learning (ODL), which offers digital products and services; MIT Integrated Learning Initiative (MITili), which conducts research on teaching and learning (see page 112 for additional information); and the Jameel World Education Lab (J-WEL), which convenes a global community to spread research and best practice in teaching and learning (see page 113 for additional information).

MIT Open Learning: Supports MIT faculty and students in bold experiments to enhance our residential education; Promotes and enables research on teaching and learning; Provides platforms for digital education; Shares research and best practices by convening and partnering with schools, universities, companies, NGOs and governments; And extends MIT's knowledge and classrooms to the world.

http://openlearning.mit.edu/

Academic and Research Affiliations

Collaborative Partnership
edX
A not-for-profit enterprise of its founding partners Harvard University and MIT, edX is focused on transforming online and on-campus learning through ground-breaking methodologies, game-like experiences, and cutting-edge research on an open source platform.

https://www.edx.org/

Engineering Biology Research Consortium
"The Engineering Biology Research Consortium, or EBRC, aims to be the leading organization bringing together an inclusive community committed to advancing biological engineering to address national and global needs." EBRC is a network including biotechnology firms and research universities and institutions, including MIT, Caltech, Stanford, University of California at Berkeley, and Harvard University.

https://www.ebrc.org/

Idaho National Laboratory
The Idaho National Laboratory (INL) is dedicated to supporting the U.S. Department of Energy's missions in nuclear and energy research, science, and national defense. The INL established a National Universities Consortium (NUC) of universities from around the nation to engage in collaborative research in the nation's strategic nuclear energy objectives, clean energy initiatives, and critical infrastructure security goals. The NUC consists of MIT, Oregon State University, North Carolina State University, The Ohio State University, and University of New Mexico.

https://www.inl.gov/inl-initiatives/education/nuc/

Magellan Project
The Magellan Project is a five-university partnership that constructed, and now operates, two 6.5-meter optical telescopes at the Las Campanas Observatory in Chile. The telescopes allow researchers to observe planets orbiting stars in solar systems beyond our own and to explore the first galaxies that formed near the edge of the observable universe. Collaborating with MIT on the Magellan Project are Carnegie Institute of Washington, Harvard University, University of Arizona, and University of Michigan.

Massachusetts Green High Performance Computing Center
The Massachusetts Green High Performance Computing Center (MGHPCC) is a collaboration of five of the state's most research-intensive universities—Boston University, Harvard University, MIT, Northeastern University, and the University of Massachusetts—the Commonwealth of Massachusetts, Cisco Systems, and EMC Corporation. The MGHPCC is a datacenter dedicated to providing the growing research computing capacity needed to support breakthroughs in science.

http://www.mghpcc.org/

Northeast Radio Observatory Corporation
The Northeast Radio Observatory Corporation is a nonprofit consortium of educational and research institutions that was formed in 1967 to plan an advanced radio and radar research facility in the Northeast. Current member institutions are MIT, Boston College, Boston University, Brandeis University, Dartmouth College, Harvard University, Harvard-Smithsonian Center for Astrophysics, Merrimack College, University of Massachusetts—Amherst and Lowell, University of New Hampshire, and Wellesley College.

http://www.haystack.mit.edu/hay/neroc.html

Major Collaborator
Broad Institute
The Broad Institute seeks to transform medicine by empowering creative and energetic scientists of all disciplines from across the MIT, Harvard, and the Harvard-affiliated hospital communities to work together to address even the most difficult challenges in biomedical research.

http://www.broadinstitute.org/

Charles Stark Draper Laboratory
Since 1973, The Charles Stark Draper Laboratory, Inc. has created premiere guidance, navigation and control technologies, the expertise it became known for when it was the MIT Instrumentation Laboratory. Expanding its scope over the decades, Draper uses multidisciplinary approaches in designing, developing and deploying advanced technological solutions for the world's most challenging and important problems, spanning national security, space, biomedical solutions and energy.

http://www.draper.com/

Howard Hughes Medical Institute

The Howard Hughes Medical Institute (HHMI) is a scientific and philanthropic organization that conducts biomedical research in collaboration with universities, academic medical centers, hospitals, and other research institutions throughout the country. Sixteen HHMI investigators hold faculty appointments at MIT.

http://www.hhmi.org/

Ragon Institute of MGH, MIT and Harvard

The Ragon Institute was established at Massachusetts General Hospital, MIT, and Harvard in 2009. The Institute brings scientists and clinicians together with engineers in an interdisciplinary effort to better understand how the body fights infections and, ultimately, to apply that understanding against a wide range of infectious diseases and cancers. The dual mission of the Institute is to contribute to the discovery of an HIV/AIDS vaccine and the collaborative study of immunology.

http://ragoninstitute.org/

Whitehead Institute for Biomedical Research

The Whitehead Institute for Biomedical Research is a nonprofit, independent research institution whose research excellence is nurtured by the collaborative spirit of its faculty and the creativity and dedication of its graduate students and postdoctoral scientists. Whitehead's primary focus is basic science, with an emphasis on molecular and cell biology, genetics and genomics, and developmental biology. Specific areas of inquiry at Whitehead include cancer, transgenic science, stem cells, regenerative biology, genetics, genomics, membrane biology, vertebrate development, and neurological disorders. Whitehead is affiliated with MIT through its members, who hold faculty positions at MIT. A small number of junior investigators also hold positions at Whitehead Institute as part of the Whitehead Fellows program.

http://wi.mit.edu/

Other Affiliation

MIT-Woods Hole Oceanographic Institution Joint Program in Oceanography and Applied Ocean Science and Engineering

The Woods Hole Oceanographic Institution (WHOI) is the largest independent oceanographic institution in the world. The MIT/WHOI Joint Program provides a high quality doctoral education leading to an internationally-recognized Ph.D. degree awarded by both institutions. The Joint Program is organized within five sub-disciplinary areas, each administered by a Joint Committee consisting of MIT faculty and WHOI scientists: Applied Ocean Science and Engineering, Biological Oceanography, Chemical Oceanography, Marine Geology and Geophysics, and Physical Oceanography.

http://mit.whoi.edu/

Naval Construction and Engineering

The graduate program in Naval Construction and Engineering (Course 2N) is intended for active duty officers in the U.S. Navy, U.S. Coast Guard, and foreign Navies who have been designated for specialization in the design, construction, and repair of naval ships. The curriculum prepares Navy, Coast Guard, and foreign officers for careers in ship design and construction and is sponsored by Commander, Naval Sea Systems Command. Besides providing the officers a comprehensive education in naval engineering, the program emphasizes their future roles as advocates for innovation in ship design and acquisition.

http://web.mit.edu/2n/

Reserve Officer Training Corps Programs

Military training has existed at MIT since students first arrived in 1865. In 1917, MIT established the nation's first Army Reserve Officer Training Corps (ROTC) unit. Today, Army, Air Force, and Naval ROTC units are based at MIT. These programs enable students to become commissioned military officers upon graduation. More than 12,000 officers have been commissioned from MIT, and more than 150 have achieved the rank of general or admiral.

Study at Other Institutions

MIT has cross-registration arrangements with several area schools. At the undergraduate level, students may cross-register at Harvard University, Wellesley College, and the Massachusetts College of Art and Design. At the graduate level, qualified students may enroll in courses at Harvard University, Wellesley College, Boston University, Brandeis University, and Tufts University.

Education Highlights

MIT has long maintained that professional competence is best fostered by coupling teaching with research and by focusing education on practical problems. This hands-on approach has made MIT a consistent leader in outside surveys of the nation's best colleges. MIT was the first university in the country to offer curriculums in architecture (1865), electrical engineering (1882), sanitary engineering (1889), naval architecture and marine engineering (1895), aeronautical engineering (1914), meteorology (1928), nuclear physics (1935), and artificial intelligence (1960s). More than 4,000 MIT graduates are professors at colleges and universities around the world. MIT faculty have written some of the best-selling textbooks of all time, such as *Economics* by Paul A. Samuelson and *Calculus and Analytic Geometry* by George Thomas. The following are some notable MIT teaching milestones since 1968.

1968 MIT and Woods Hole Oceanographic Institute create a joint program for graduate studies in oceanography. This is the first higher education partnership of its kind.

1969 MIT launches the Undergraduate Research Opportunities Program (UROP), the first of its kind. The program, which enables undergraduates to work directly with faculty on professional research, subsequently is copied in universities throughout the world.

1970 The Harvard-MIT Program in Health Sciences and Technology is established to focus advances in science and technology on human health and to train physicians with a strong base in engineering and science.

1970 The Department of Mechanical Engineering initiates the course 2.70 (now 2.007) design contest, created by professor Woodie C. Flowers. The competition was to build a mechanical device, out of a set of relatively simple wooden and metal parts, that would roll down a ramp at a precisely controlled rate.

1971 MIT holds its first Independent Activities Period (IAP), a January program that emphasizes creativity and flexibility in teaching and learning.

1974 The Minority Introduction to Engineering and Science (MITES) program is established to provide a rigorous six-week residential, academic summer program for promising high school juniors who are interested in careers in science and engineering.

1977 MIT organizes the Program in Science, Technology, and Society to explore and teach courses on the social context and consequences of science and technology—one of the first programs of its kind in the United States.

1981 The MIT-Japan Program is created to send MIT students to Japan for internships. In 1994, the program becomes part of the MIT International Science and Technology Initiatives (MISTI). Today, the program also fosters research collaboration between faculty at MIT and in Asia through the MISTI ULVAC-Hayashi Seed Grant.

1981 MIT launches Project Athena, a $70 million program to explore the use of computers in education. Digital Equipment Corporation and IBM each contribute $25 million in computer equipment.

1981 The MIT Sloan School of Management launches its Management of Technology program, the world's first master's program to focus on the strategic management of technology and innovation.

1983 MIT establishes the Center for Real Estate and the first Master of Science in Real Estate Development (MSRED) degree program in the U.S.

1984 MIT establishes the Media Laboratory, bringing together pioneering educational programs in computer music, film, graphics, holography, lasers, and other media technologies.

1990 MIT initiates an artist-in-residence program to provide students with opportunities to interact with nationally and internationally recognized artists through master classes, lecture-demonstrations, performances and workshops.

1992 MIT establishes the MacVicar Faculty Fellows Program, named in honor of the late Margaret A. MacVicar, to recognize outstanding contributions to teaching. MacVicar, a professor of physics, had conceived of, designed, and launched UROP (see 1969, above).

1992 MIT launches the Laboratory for Advanced Technology in the Humanities to extend its pioneering work in computer- and video-assisted language learning to other disciplines. Its first venture was a text and performance multimedia archive for studies of Shakespeare's plays.

1992 MIT Faculty approves the Master of Engineering program in Electrical Engineering and Computer Science, an integrated five-year program leading to the simultaneous award of a bachelor's and a master's degree.

1993 In recognition of the increasing importance of molecular and cell biology, MIT becomes the first college in the nation to add biology to its undergraduate requirement.

1994 The MIT International Science and Technology Initiatives (MISTI) are created to connect MIT students to internships and research around the world. MIT's primary international program, MISTI is a pioneer in applied international studies—a distinctively MIT concept.

1995 The School of Engineering and the Sloan School of Management join to create a graduate program in system design and management (SDM), in which students can complete most course requirements at their job sites through interactive distance-learning.

1998 MIT teams up with Singapore's two leading research universities to create a global model for long-distance engineering education and research. This large-scale experiment, the first truly global collaboration in graduate engineering education and research, is a model for today's distance education.

1998 The Division of Bioengineering & Environmental Health (BEH) begins operation with the mission of fostering MIT education and research fusing engineering with biology.

1998 The School of Engineering establishes the Engineering Systems Division (ESD), focused on the development of new approaches, frameworks, and theories to better understand engineering systems behavior and design.

2000 MIT Faculty approve the Communication Requirement (CR). The CR integrates substantial instruction and practice in writing and speaking into all four years and across all parts of MIT's undergraduate program. Students participate regularly in activities designed to develop both general and technical communication skills.

2001 Studio Physics is introduced to teach freshman physics. Incorporating a highly collaborative, hands-on environment that uses networked laptops and desktop experiments, the new curriculum lets students work directly with complicated and unfamiliar concepts as their professors introduce them.

2001 MIT launches OpenCourseWare, a program that makes materials for nearly all of its courses freely available on the web and serves as a model for sharing knowledge to benefit all humankind.

2001 MIT establishes WebLab, a microelectronics teaching laboratory that allows students to interact remotely on the Web with transistors and other microelectronics devices anywhere and at any time.

2001 MIT's Earth System Initiative launches Terrascope, a freshman course in which students work in teams to solve complex earth sciences problems. Bringing together physics, mathematics, chemistry, biology, management, and communications, the course has enabled students to devise strategies for preserving tropical rainforests, understand the costs and the benefits of oil drilling in the Arctic National Wildlife Refuge, and plan a mission to Mars.

2002 To give engineering students the opportunity to develop the skills they'll need to be leaders in the workplace, MIT introduces the Undergraduate Practice Opportunities Program (UPOP). The program involves a corporate training workshop, job seminars taught by alumni, and a 10-week summer internship.

2003 MIT Libraries introduce DSpace, a digital repository that gathers, stores, and preserves the intellectual output of MIT's faculty and research staff, and makes it freely available to research institutions worldwide. Within a year of its launch, DSpace material had been downloaded more than 8,000 times, and more than 100 organizations had adopted the system for their own use.

2007 MIT makes material from virtually all MIT courses available online for free on OpenCourseWare. The publication marks the beginning of a worldwide movement toward open education that now involves more than 160 universities and 5,000 courses.

2009 MIT launches the Bernard M. Gordon-MIT Engineering Leadership Program. Through interaction with industry leaders, faculty, and fellow students, the program aims to help undergraduate engineering students develop the skills, tools, and character they will need as future engineering leaders.

2009 MIT introduces a minor in energy studies, open to all undergraduates. The new minor, unlike most energy concentrations available at other institutions, and unlike any other concentration at MIT, is designed to be inherently cross-disciplinary, encompassing all of MIT's five schools.

2010 MIT introduces the flexible engineering degree for undergraduates. The degree, the first of its kind, allows students to complement a deep disciplinary core with an additional subject concentration. The additional concentration can be broad and interdisciplinary in nature (energy, transportation, or the environment), or focused on areas that can be applied to multiple fields (robotics and controls, computational engineering, or engineering management).

2011 MIT announces MITx, an online learning initiative that will offer a portfolio of free MIT courses through an online interactive learning platform. The Institute expects the platform to enhance the educational experience of its on-campus students and serve as a host for a virtual community of millions of learners around the world. The MITx prototype course—6.002x or "Circuits and Electronics"—debuts in March 2012 with almost 155,000 people registering for the course.

2012 MIT and Harvard University announce edX, a transformational new partnership in online education. Through edX, the two institutions will collaborate to enhance campus-based teaching and learning and build a global community of online learners. An open-source technology platform will deliver online courses that move beyond the standard model of online education that relies on watching video content and will offer an interactive experience for students. The University of California at Berkeley later joins edX. The three institutions offer the first edX courses in fall 2012.

2012 MIT announces the launch of the Institute for Medical Engineering and Science (IMES). IMES brings together research and education efforts at the nexus of engineering, science, and clinical medicine to advance human health.

2013 The School of Engineering and Lincoln Laboratory launch Beaver Works. This initiative facilitates project-based learning by leveraging partnerships between faculty and students at MIT and practicing engineers at Lincoln Laboratory to promote collaborative research and to enable the fabrication of prototype systems. The initiative's signature collaboration is the Beaver Works capstone project in areas such as unmanned aerial vehicles, small satellites, autonomous underwater systems, energy systems, cybersecurity, communications, big data analytics, and advanced devices.

2014 MITx on edX registers its one-millionth learner on May 27, 2014.

2014 MIT Professional Education, in cooperation with the Office of Digital Learning and edX, begins offering online courses designed specifically for industry and active professionals. Based on research in areas ranging from big data, cybersecurity, and entrepreneurship, these courses enable MIT to disseminate knowledge at scale to professionals around the world, in areas critical to industry. The first course on big data enrolled more than 7,000 paid enrollees from over 100 countries.

2015 SuperUROP, an amplified version of the Undergraduate Research Opportunities Program, is launched in the School of Engineering. First conceived and implemented in 2012 under the leadership of the Department of Electrical Engineering and Computer Science, SuperUROP is a year-long program that enables students to tackle complex problems and affords them the time, training, resources, and guidance necessary for deep scientific and engineering inquiry.

2015 MIT creates the MIT-Woodrow Wilson Academy of Teaching and Learning to advance pre-K through 12 education by combining MIT's "mind and hand" approach to learning with recent breakthroughs in cognitive science and digital learning. The program develops STEM teachers and school leaders around the world.

2015 The Residential MITx platform hosts its 100th course. Nearly 90 percent of MIT undergraduates have participated in one or more courses that use the platform.

2015 The Institute for Data, Systems, and Society (IDSS) is launched. A collaboration among all five of MIT's schools, IDSS brings together researchers working in the mathematical, behavioral, and empirical sciences to capitalize on their shared interest in tackling complex societal problems.

2015 MIT launches the first MicroMasters, a series of online courses that provide a professional and academic credential. MicroMasters certificate holders can apply for accelerated, on-campus master's degree programs at MIT and other top universities.

2016 MIT Integrated Learning Initiative (MITili) launches, aimed at conducting interdisciplinary research on learning and education.

2017 Abdul Latif Jameel World Education Lab (J-WEL) launches. Leveraging MIT's resources, J-WEL convenes a global community of collaborators for sustainable, high-impact transformation in education through research, policy, pedagogy, and practice.

2019 MIT Stephen A. Schwarzman College of Computing established to: (i) accelerate research, education and innovation in computer science and artificial intelligence for continued rapidly-growing need, (ii) develop the power of computing in disciplines across MIT, and (iii) establish profound awareness of and attention to ethical implications and societal impact of computing and artificial intelligence.

Research Highlights

The following are selected research achievements of MIT faculty and staff over the last five decades.

1969 The MIT Instrumentation Laboratory's (now Draper) Apollo guidance computer is used to send the first astronauts to the Moon's surface during the Apollo 11 mission. The 1-cubic-foot computer was the first significant use of silicon integrated circuit chips and greatly accelerated the development of the microchip technology that has gone on to change virtually every consumer product.

1970 David Baltimore reports the discovery of reverse transcriptase, an enzyme that catalyzes the conversion of RNA to DNA. The advance, which led to a Nobel Prize in Physiology or Medicine for Baltimore in 1975, provides a new means for studying the structure and function of genes.

1972 Lincoln Laboratory's Moving Target Detector (MTD) achieves a new performance level for the detection of aircraft in the presence of radar clutter, such as ground, weather, and birds. It employs an antenna with two fan beams to provide coverage from the immediate vicinity of an airport to a distance of 60 nautical miles. The MTD became the world-recognized standard for Airport Surveillance Radar.

1973 Jerome Friedman and Henry Kendall, with Stanford colleague Richard Taylor, complete a series of experiments confirming the theory that protons and neutrons are made up of minute particles called quarks. The three receive the 1990 Nobel Prize in Physics for their work.

1974 Samuel C. C. Ting, Ulrich Becker, and Min Chen discover the "J" particle. The discovery, which earns Ting the 1976 Nobel Prize in Physics, points to the existence of one of the six postulated types of quarks.

1975 The Lincoln Laboratory Experimental Test System (ETS) becomes operational. The ETS is used for deep-space surveillance, daylight satellite tracking, searching the geostationary belt, and making astronomical measurements.

1975–1977 Barbara Liskov and her students design the CLU programming language, an object-oriented language that helps form the underpinnings for languages like Java and C++. As a result of this work and other accomplishments, Liskov later wins the Turing Award, considered the Nobel Prize in computing.

1976 H. Gobind Khorana and his research team complete chemical synthesis of the first human-manufactured gene fully functional in a living cell. The culmination of 12 years of work, it establishes the foundation for the biotechnology industry. Khorana won the 1968 Nobel Prize in Physiology or Medicine for other genetics work.

1977 Phillip Sharp discovers the split gene structure of higher organisms, changing the view of how genes arose during evolution. For this work, Sharp shares the 1993 Nobel Prize in Physiology or Medicine.

1977 Ronald Rivest, Adi Shamir, and Leonard Adleman invent the first workable public key cryptographic system. The new code, which is based on the use of very large prime numbers, allows secret communication between any pair of users. Still unbroken, the code is in widespread use today.

1979 Robert Weinberg reports isolating and identifying the first human oncogene—an altered gene that causes the uncontrolled cell growth that leads to cancer.

1981 Alan Guth publishes the first satisfactory model, called cosmic inflation, of the universe's development in the first 10–32 seconds after the Big Bang.

1982 Alan Davison discovers a new class of technetium compounds that leads to the development of the first diagnostic technetium drug for imaging the human heart.

1985 Susumu Tonegawa describes the structure of the gene for the receptors—"anchor molecules"—on the white blood cells called T lymphocytes, the immune system's master cells. In 1987, Tonegawa receives the Nobel Prize in Physiology or Medicine for similar work on the immune system's B cells.

1985 The Terminal Doppler Weather Radar (TDWR) program is initiated at Lincoln Laboratory to develop an automated system for detecting weather hazards in the airport terminal area and to help pilots avoid them. A successful TDWR prototype leads to the procurement of 47 TDWRs from Raytheon in the 1990s, and there has not been a major U.S. wind-shear-related accident since 1994.

1986 H. Robert Horvitz identifies the first two genes found to be responsible for the process of cell death, which is critical both for normal body development and for protection against autoimmune diseases, cancer, and other disorders. Going on to make many more pioneering discoveries about the genetics of cell death, Horvitz shares the 2002 Nobel Prize in Physiology or Medicine for his work.

1988 Sallie Chisholm and associates report the discovery of a form of ocean plankton that may be the most abundant single species on Earth.

1990 Julius Rebek, Jr. and associates create the first self-replicating synthetic molecule.

1990 Building on the discovery of the metathesis—the process of cutting carbon-carbon double bonds in half and constructing new ones—Richard Schrock devises a catalyst that greatly speeds up the reaction, consumes less energy, and produces less waste. A process based on his discovery is now in widespread use for efficient and more environmentally friendly production of important pharmaceuticals, fuels, synthetic fibers, and many other products. Schrock shares the 2005 Nobel Prize in Chemistry for his breakthrough.

1993 H. Robert Horvitz, together with scientists at Massachusetts General Hospital, discover an association between a gene mutation and the inherited form of amyotrophic lateral sclerosis (Lou Gehrig's disease).

1993 David Housman joins colleagues at other institutions in announcing a successful end to the long search for the genetic defect linked with Huntington's disease.

1993 The Traffic Alert and Collision Avoidance System (TCAS) is deployed. TCAS reduces midair collisions by sensing nearby aircraft and issuing an advisory to the pilot. Lincoln Laboratory developed the surveillance technology used by TCAS and built and flight-tested the TCAS prototype. Now mandated on all large transport aircraft, TCAS has been credited with preventing several catastrophic accidents.

1995 Wolfgang Ketterle's research group achieves Bose-Einstein condensation (BEC) in a gas of sodium atoms. BEC is a state of matter of a dilute gas of low densities called bosons cooled to temperatures very close to absolute zero. For this work, Ketterle won the Nobel Prize in Physics jointly with Eric Cornell and Carl Wieman from the University of Colorado at Boulder NIST-JILA lab. This early effort led to founding the field of ultracold atoms.

1996 A group of scientists at MIT's Center for Learning and Memory, led by Matthew Wilson and Nobel laureate Susumu Tonegawa, use new genetic and multiple-cell monitoring technologies to demonstrate how animals form memory about new environments.

1997 MIT physicists create the first atom laser, a device that is analogous to an optical laser but emits atoms instead of light. The resulting beam can be focused to a pinpoint or made to travel long distances with minimal spreading.

1998 An interdisciplinary team of MIT researchers, led by Yoel Fink and Edwin L. Thomas, invent the "perfect mirror," which offers radical new ways of directing and manipulating light. Potential applications range from a flexible light guide that can illuminate specific internal organs during surgery to new devices for optical communications.

1999 Michael Cima, Robert Langer, and graduate student John Santini report the first microchip that can store and release chemicals on demand. Among its potential applications is a "pharmacy" that could be swallowed or implanted under the skin and programmed to deliver precise drug dosages at specific times.

1999 Alexander Rich leads a team of researchers in the discovery that left-handed DNA (also known as Z-DNA) that is critical for the creation of important brain chemicals. Having first produced Z-DNA synthetically in 1979, Rich succeeded in identifying it in nature in 1981. Rich also discovers its first biological role and received the National Medal of Science for this pioneering work in 1995.

2000 Scientists at the Whitehead Institute/MIT Center for Genome Research and their collaborators announce the completion of the Human Genome Project. Providing about a third of all the sequences assembled, the Center was the single largest contributor to this international enterprise.

2003 Enhanced Regional Situation Awareness (ERSA) system is developed by Lincoln Laboratory for the U.S. Air Force to provide improved defense of the airspace surrounding the National Capital Region (NCR). ERSA capabilities have improved airspace surveillance, threat assessment and decision support, distribution of a common air picture to multiple agencies, and new ways to respond to aircraft violating the NCR airspace.

2003 MIT scientists cool a sodium gas to the lowest temperature ever recorded—a half-a-billionth of a degree above absolute zero. Studying these ultra-low temperature gases provides valuable insights into the basic physics of matter; and by facilitating the development of better atomic clocks and sensors for gravity and rotation, they also could lead to vast improvements in precision measurements.

2005 MIT physicists, led by Nobel laureate Wolfgang Ketterle, create a new type of matter, a gas of atoms that shows high-temperature superfluidity.

2007 MIT mathematicians form part of a group of 18 mathematicians from the U.S. and Europe that maps one of the most complicated structures ever studied: the exceptional Lie group E8. The "answer" to the calculation, if written, would cover an area the size of Manhattan. The resulting atlas has applications in the fields of string theory and geometry.

2008 Mriganka Sur's laboratory discovers that astrocytes, star-shaped cells in the brain that are as numerous as neurons, form the basis for functioning brain imaging. Using ultra high-resolution imaging in the intact brain, they demonstrate that astrocytes regulate blood flow to active brain regions by linking neurons to brain capillaries.

2009 Gerbrand Ceder and graduate student Byoungwoo Kang develop a new way to manufacture the material used in lithium ion batteries that allows ultrafast charging and discharging. The new method creates a surface structure that allows lithium ions to move rapidly around the outside of the battery. Batteries built using the new method could take seconds, rather than the now standard hours, to charge.

2010 Michael Strano and his team of graduate students and researchers create a set of self-assembling molecules that can turn sunlight into electricity; the molecules can be repeatedly broken down and reassembled quickly by adding or removing an additional solution.

2010 Lincoln Laboratory develops the Space Surveillance Telescope (SST), an advanced ground-based optical system designed to enable detection and tracking of faint objects in space while providing rapid, wide-area search capability. The SST combines innovative curved charge-coupled device imager technology developed at Lincoln Laboratory with a very wide field-of-view, large-aperture (3.5 meter) telescope.

2011 A team, including Karen Gleason, Vladimir Bulović, and graduate student Miles Barr, develops materials that make it possible to produce photovoltaic cells on paper or fabric, nearly as simply as printing a document. The technique represents a major departure from the systems typically used to create solar cells, which require exposing the substrates to potentially damaging conditions, either in the form of liquids or high temperatures.

2011 Researchers, led by Daniel Nocera, produce an "artificial leaf"—a silicon solar cell with different catalytic materials bonded onto its two sides. The artificial leaf can turn the energy of sunlight directly into a chemical fuel that can be stored and used later as an energy source.

2012 NASA's Gravity Recovery And Interior Laboratory (GRAIL) twin spacecraft successfully enters lunar orbit. By precisely measuring changes in distance between the twin orbiting spacecraft, scientists constructed a detailed gravitational model of the Moon that is used to answer fundamental questions about the moon's evolution and its internal composition. GRAIL's principal investigator is Maria T. Zuber.

2013 A system being developed by Dina Katabi and her graduate student Fadel Adib, could give us the ability to see people through walls using low-cost Wi-Fi technology. The system, called "Wi-Vi," is based on a concept similar to radar and sonar imaging. But in contrast to radar and sonar, it transmits a low-power Wi-Fi signal and uses its reflections to track moving humans.

2014 Bryan Hsu PhD '14 and Paula Hammond, working with Myoung-Hwan Park of Sahmyook University in South Korea and Samantha Hagerman '14, develop a new drug-delivery system method that could enable pain medication and other drugs to be released directly to specific parts of the body. The method uses biodegradable, nanoscale "thin films" laden with drug molecules that are absorbed into the body in steady doses over a period of up to 14 months.

2014 Researchers at MIT, including John Foster, and at the University of Colorado, including Daniel Baker, and elsewhere, find there's a hard limit to how close ultrarelativistic electrons can get to the Earth. The team determines that no matter where these electrons are circling around the planet's equator, they can get no further than about 11,000 kilometers from the Earth's surface—despite their intense energy.

2016 Scientists, including MIT's Susan Solomon and Diane Ivy, identify signs that the Antarctic ozone hole has shrunk by more than 4 million square kilometers since 2000. The team used "fingerprints" of the ozone changes with season and altitude to attribute the ozone's recovery to the continuing decline of atmospheric chlorine originating from chlorofluorocarbons (CFCs). Susan Solomon was among the U.N.'s Intergovernmental Panel on Climate Change (IPCC) scientists who, together with the former Vice President Al Gore, were awarded the 2007 Nobel Peace Prize for their work to help the world understand the severity of global warming.

2016 Scientists and engineers at MIT's Plasma Science and Fusion Center set a new world record for plasma pressure in the Institute's Alcator C-Mod tokamak nuclear fusion reactor. Plasma pressure is the key ingredient to producing energy from nuclear fusion, and MIT's new result achieves over 2 atmospheres of pressure for the first time.

2017 MIT physicists, led by Wolfgang Ketterle, create a new form of matter, a supersolid, which combines the properties of solids with those of superfluids. By using lasers to manipulate a superfluid gas known as a Bose-Einstein condensate, the team is able to coax the condensate into a quantum phase of matter that has a rigid structure—like a solid—and can flow without viscosity—a key characteristic of a superfluid.

2017 For the first time, scientists directly detect gravitational waves—ripples in space-time—in addition to light from the spectacular collision of two neutron stars. The discovery is made using the U.S.-based Laser Interferometer Gravitational-Wave Observatory (LIGO); the Europe-based Virgo detector; and some 70 ground- and space-based observatories. The LIGO observatories were conceived, constructed, and operated by Caltech and MIT. Virgo is operated by the European Gravitational Observatory.

2018 MIT researchers, including Fadel Adib, working with scientists from Brigham and Women's Hospital, develop a way to power and communicate with devices implanted within the human body. The implants have no batteries and are powered by radio frequency waves, which can safely pass through human tissues. The prototype is about the size of a grain of rice.

2019 An international team of over 200 scientists, including researchers from MIT's Haystack Observatory and the MIT campus, capture the first direct image of a black hole. The images were taken by the Event Horizon Telescope (EHT) a planet-scale array comprised of eight radio telescopes spread throughout the globe. EHT was conceived by Sheperd Doeleman while leading a pioneering VLBI program at the Haystack Observatory and enabled by advances in digital systems created by Haystack engineers.

Faculty and Staff

As of October 31, 2018, MIT employs 12,707 persons on campus. In addition to the faculty, there are research, library, and administrative staff, and many others who, directly or indirectly, support the teaching and research goals of the Institute.

Faculty and Staff, 2018–2019

Employee Type	Count
Faculty	1,056
Other academic and instructional staff	1,136
Research staff and research scientists (includes postdoctoral positions)	3,237
Administrative staff	3,356
Support staff	1,655
Service staff	838
Clinical and Medical staff	143
Affiliated faculty, scientists, and scholars	1,286
Total campus faculty and staff	**12,707**

Faculty and Staff, 2018–2019
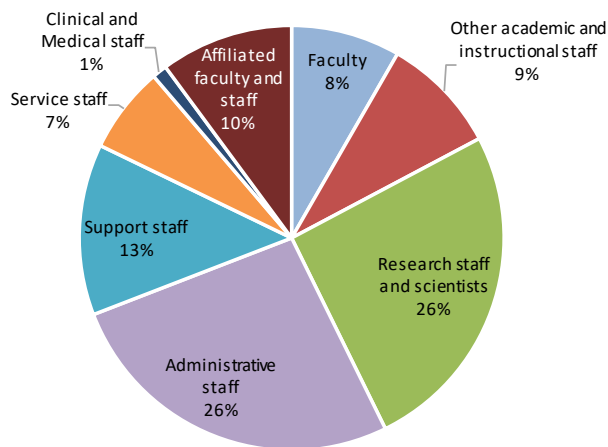
Each year, MIT employs about 1,370 graduate students as teaching assistants and 3,935 graduate students as research assistants.

MIT Lincoln Laboratory employs about 3,875 people, primarily at Hanscom Air Force Base in Lexington, Massachusetts. See page 82 for additional Lincoln Laboratory staffing information.

Faculty

The MIT faculty instruct undergraduate and graduate students, and engage in research and service.

Faculty Profile, 2018–2019

	Count	Percent of Total
Professors	663	63
Associate professors	226	21
Assistant professors	167	16
Total	**1,056**	**100**
Male	805	76
Female	251	24

See page 40 for a chart of faculty and students from 1865–2019.

Seventy-five percent of faculty are tenured.

Faculty by School, 2018–2019

School	Count	Percent of Total
Architecture and Planning	84	8
Engineering	385	36
Humanities, Arts, and Social Sciences	180	17
Management	116	11
Science	281	27
Other	10	1
Total	**1,056**	**100**

Sixty-three percent of the faculty are in science and engineering fields.

Twenty-one percent of faculty are members of a U.S. minority group; seven percent of faculty identify with an underrepresented minority (Hispanic or Latino, African American, American Indian or Alaskan Native, or Native Hawaiian or Other Pacific Islander) group.

Faculty by U.S. Minority Group, 2018–2019*

Ethnicity	Female Count	Male Count
Asian	32	111
Hispanic or Latino	8	36
African American	9	27
American Indian or Alaskan Native	0	1
Native Hawaiian or Other Pacific Islander	1	0

*Ethnicity is self-identified. Faculty members may identify with more than one group.

Forty-four percent of current faculty are internationally born. Over seventy countries are represented by these faculty members.

Country of Origin of Internationally Born Faculty, 2018–2019

- China 10%
- India 8%
- United Kingdom 8%
- Canada 7%
- Germany 6%
- Italy 4%
- Greece 4%
- Russian Federation 3%
- Israel 3%
- France 3%
- Spain 3%
- South Korea 3%
- All others 38%
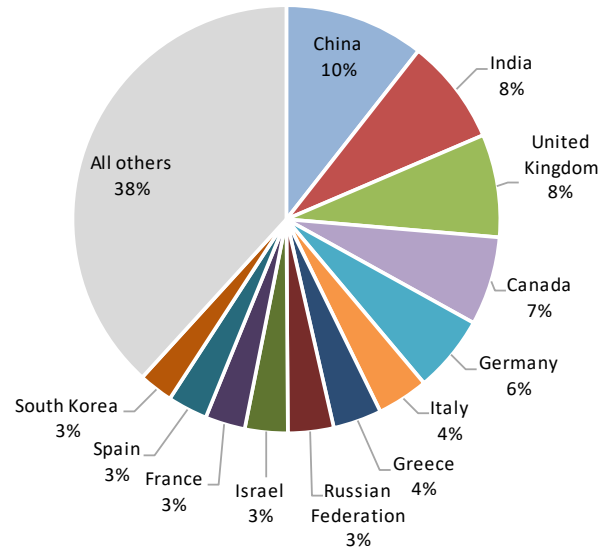
Underrepresented Minority Faculty and Students*, 1987–2019
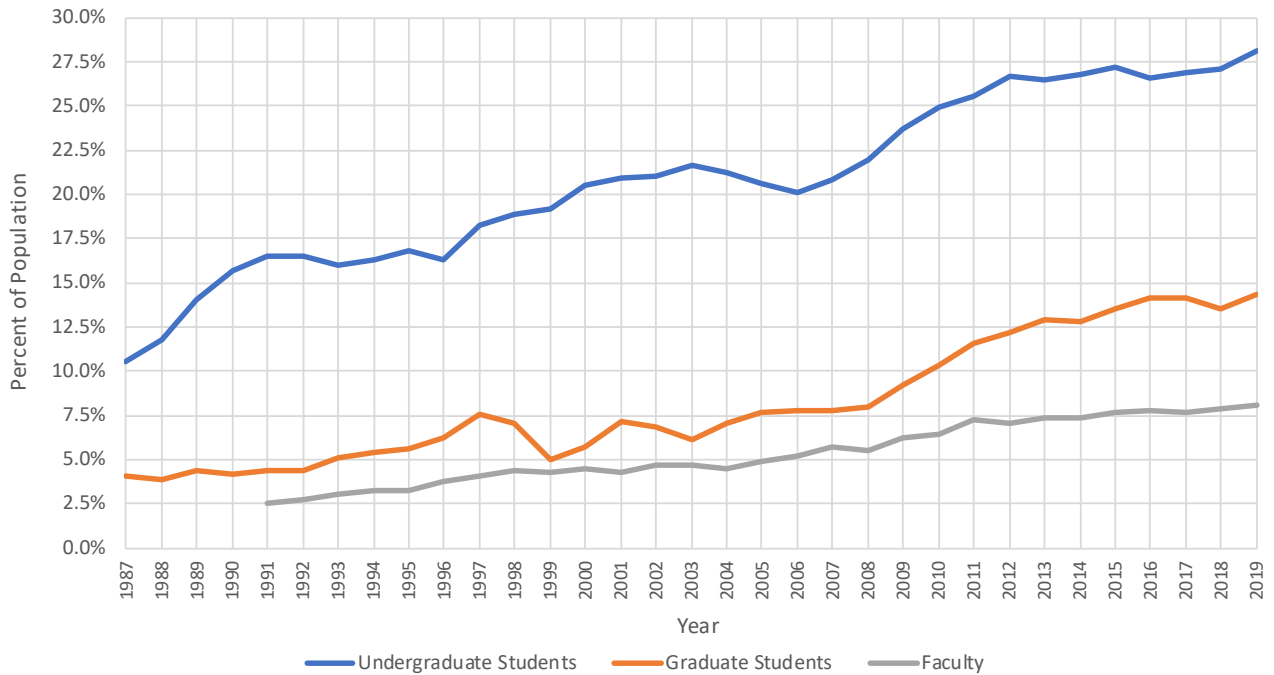
*Includes only domestic students (i.e., U.S. citizens and permanent residents)

Researchers

MIT campus research staff and scientists total 3,237. These researchers work with MIT faculty and students on projects funded by government, nonprofits and foundations, and industry.

Campus Research Staff and Scientists, 2018–2019

Employee Type	Count
Senior Researchers	50
Principal Researchers	113
Research Scientists and Technicians	1,177
Visiting Scientists	398
Postdoctoral Associates	1,044
Postdoctoral Fellows	455
Total	**3,237**
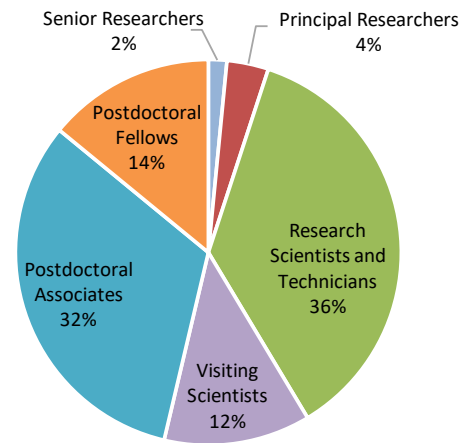
Approximately 3,935 graduate students were research assistants in academic year 2018–2019.

Campus Research Staff and Scientists, 2018–2019

Campus Research Staff and Scientists by Gender, 2018–2019
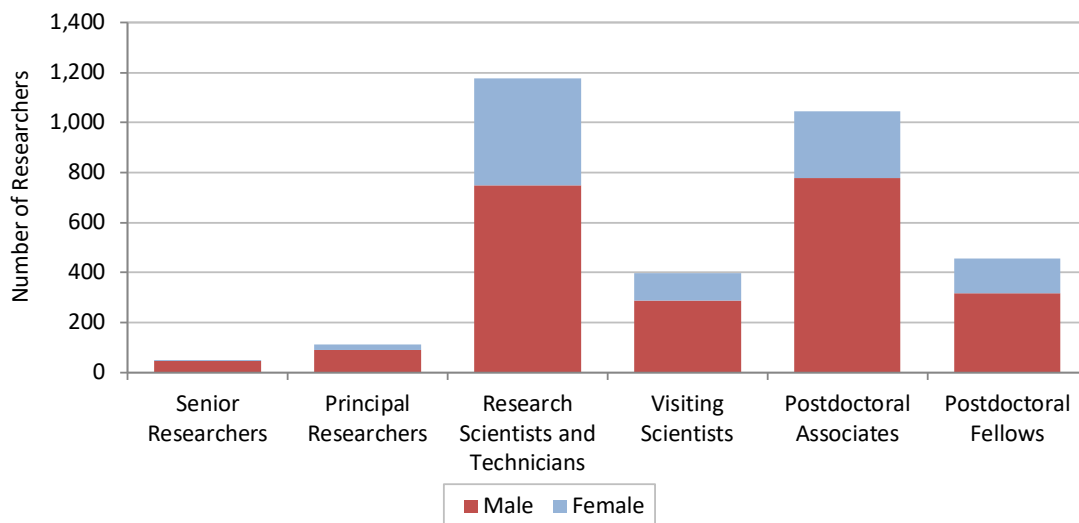
Postdoctoral Scholars

The MIT campus hosts 1,499 postdoctoral associates and fellows—404 females and 1,095 males. These individuals work with faculty in academic departments, laboratories, and centers.

U.S. Citizen and Permanent Resident Postdoctoral Scholars by Ethnicity, 2018–2019

Ethnicity	Count
Hispanic or Latino	31
African American	4
American Indian or Alaskan Native	1
Native Hawaiian or Other Pacific Islander	**1**
Total underrepresented minorities (URM)	**37**
White	282
Asian	85
Two or more races	13
Unknown	79
Total	**496**

International Postdoctoral Scholars be Country of Citizenship, 2018–2019

Country of Citizenship	Count
China	267
South Korea	68
India	67
Germany	60
Canada	48
France	45
Iran	41
Israel	38
Italy	33
All other countries	336
Total	**1,003**

Ethnicity of Postdoctoral Scholars, 2018–2019

Country of Citizenship of International Postdoctoral Scholars, 2018–2019
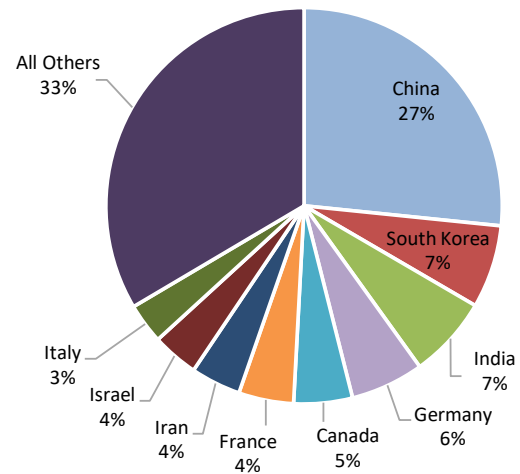
Postdoctoral scholars come from approximately eighty foreign countries.

Years at MIT of Postdoctoral Scholars, 2018–2019
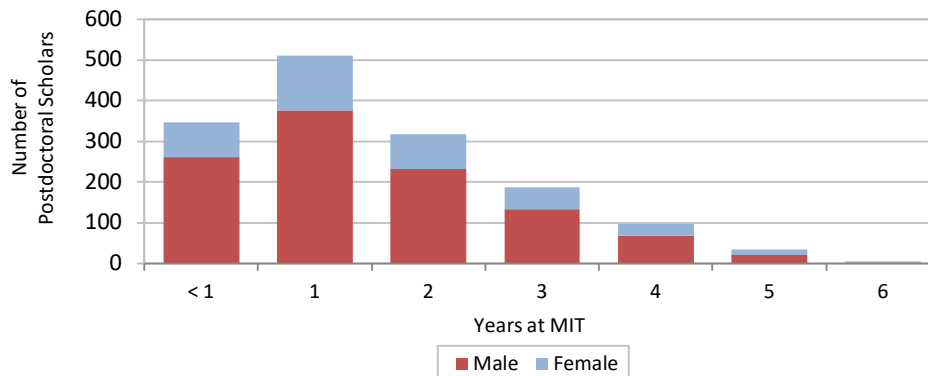
International Scholars

MIT hosts international scholars from around the world who come to the U.S. to teach, collaborate, observe, conduct research, and other purposes. This diverse group of professionals includes visiting scientists, professors, artists, and scholars, as well as postdoctoral fellows and associates, lecturers, instructors, research associates and scientists, and tenure-track faculty. During the year July 1, 2018 through June 30, 2019, The International Scholars Office (ISchO) served 2,456 international scholars affiliated with MIT and their accompanying family members ("international" is defined as non-U.S. citizen, non-U.S. permanent resident).

According to the most recently published Institute of International Education *Open Doors* 2018 report, MIT ranked 11th nationally with regard to the numbers of international scholars at U.S. institutions.

Foreign national scholars came to MIT from 99 different countries, with the highest numbers coming from China, India, South Korea, Germany, Japan, Canada, France, Italy, Spain, and Israel. Scholars from these top 10 countries constituted 65 percent of MIT's international scholar population. Seventy-five percent of international scholars at MIT were men and 25 percent were women. Postdoctoral associates and postdoctoral fellows accounted for 60 percent of MIT's international scholars. In descending order, the areas hosting the greatest number of international scholars were School of Engineering, followed by School of Science, the interdisciplinary laboratories and centers under the Vice President for Research, School of Architecture and Planning, School of Humanities, Arts and Social Sciences, Sloan School of Management, and Office of the Provost.

**International Scholars
by Country of Origin, 2018–2019**

Country	Count
China	520
India	157
South Korea	146
Germany	140
Japan	126
Canada	102
Italy	102
France	101
Spain	96
Israel	89
All other countries	877
Total	**2,456**

**International Scholars
by Geographic Region, 2018–2019**

Africa 1%
Oceania 1%
Mexico, Latin America and Caribbean 5%
North America 5%
Middle East 9%
Asia 44%
Europe 35%
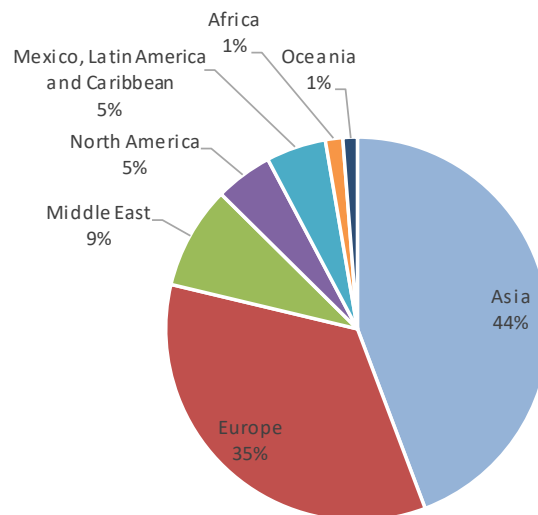
Awards and Honors of Current Faculty and Staff

Nobel Prize

Nine current faculty members at MIT have received the Nobel Prize. They are:

Holmstrom, Bengt	Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel (shared)
Horvitz, H. Robert	Nobel Prize in Medicine/Physiology (shared)
Ketterle, Wolfgang	Nobel Prize in Physics (shared)
Merton, Robert C.	Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel (shared)
Sharp, Phillip A.	Nobel Prize in Medicine/Physiology (shared)
Solomon, Susan	Nobel Prize in Peace (co-chair of IPCC Working Group One recognized under Intergovernmental Panel on Climate Change (IPCC), shared)
Ting, Samuel C. C.	Nobel Prize in Physics (shared)
Tonegawa, Susumu	Nobel Prize in Medicine/Physiology
Wilczek, Frank	Nobel Prize in Physics (shared)

Number of recipients of selected awards and honors current faculty and staff have received

Recipients	Award Name and Agency
153	American Academy of Arts and Sciences Member
95	American Association for the Advancement of Science Fellow
13	American Philosophical Society Member
91	American Physical Society Fellow
22	American Society of Mechanical Engineers Fellow
34	Association for Computing Machinery Fellow
4	John Bates Clark Medal, American Economic Association
2	Crafoord Prize, Royal Swedish Academy of Sciences
4	Dirac Medal, Abdus Salam International Centre for Theoretical Physics
9	Fulbright Scholar, Council for International Exchange of Scholars (CIES)
9	Gairdner Award, Gairdner Foundation
63	Guggenheim Fellow, John Simon Guggenheim Memorial Foundation
16	HHMI Investigator, Howard Hughes Medical Institute (HHMI)
57	Institute of Electrical and Electronics Engineers, Inc. Fellow
1	Japan Prize, Science and Technology Foundation of Japan
2	Kavli Prize, Norwegian Academy of Science and Letters
1	Kyoto Prize, Inamori Foundation of Japan
28	MacArthur Fellow, John D. and Catherine T. MacArthur Foundation
2	Millennium Technology Prize, Millennium Prize Foundation
74	National Academy of Engineering Member, National Academies
26	National Academy of Medicine Member, National Academies
85	National Academy of Sciences Member, National Academies
7	National Medal of Science, National Science & Technology Medals Foundation
1	National Medal of Technology and Innovation, National Science & Technology Medals Foundation
2	Rolf Nevanlinna Prize, International Mathematical Union (IMU)
41	Presidential Early Career Awards for Scientists and Engineers (PECASE)
3	Pulitzer Prize, Pulitzer Board
2	Queen Elizabeth Prize for Engineering, The Queen Elizabeth Prize for Engineering Foundation
4	Royal Academy of Engineering Fellow, Royal Academy of Engineering
6	A. M. Turing Award, Association for Computing Machinery
1	Von Hippel Award, Materials Research Society
4	Alan T. Waterman Award, National Science Foundation
4	Wolf Prize, Wolf Foundation

Award Highlights

Joseph Checkelsky, Kwanghun Chung, James M. LeBeau, Yen-Jie Lee, Benedetto Marelli, Tracy Slatyer, and Yogesh Surendranath
2019 Presidential Early Career Awards for Scientists and Engineers
Seven MIT faculty members, Joseph Checkelsky, Kwanghun Chung, James M. LeBeau, Yen-Jie Lee, Benedetto Marelli, Tracy Slatyer, and Yogesh Surendranath, were among the more than 300 recipients of the 2019 Presidential Early Career Awards for Scientists and Engineers (PECASE), the highest honor bestowed by the U.S. government to science and engineering professionals in the early stages of their independent research careers.

All of the 2019 MIT recipients were employed or funded by the following U.S. departments and agencies: Department of Defense, Department of Energy, and the Department of Health and Human Services.

https://bit.ly/2Hi877G

Sallie "Penny" Chisholm
2019 Crafoord Prize
MIT Institute Professor Sallie "Penny" Chisholm of the departments of Civil and Environmental Engineering and Biology is the recipient of the 2019 Crafoord Prize. Chisholm was awarded the prize "for the discovery and pioneering studies of the most abundant photosynthesizing organism on Earth, Prochlorococcus."

Prochlorococcus is a type of phytoplankton found in the ocean that is able to photosynthesize like plants on land. The process of photosynthesis is responsible for the oxygen humans breathe, which makes it critical to life on Earth. Prochlorococcus accounts for approximately 10 percent of all ocean photosynthesis, which draws carbon dioxide out of the atmosphere, provides it with oxygen, and forms the base of the food chain.

https://bit.ly/2DsJPGC

Stephen Buchwald
2019 Wolf Prize for chemistry
Camille Dreyfus Professor of Chemistry Stephen L. Buchwald has been named one of seven laureates across five categories honored with Israel's 2019 Wolf Prize. Buchwald shares the award in chemistry with Professor John Hartwig of the University of California at Berkeley for their development of the Buchwald-Hartwig amination, a process used to improve the synthesis of large organic molecules.

"This award is due to the hard work and creativity of the graduate students and postdoctoral coworkers that I have been fortunate enough to have in my group during my over 30 years at MIT," said Buchwald. "It also reflects the importance of funding basic research. In this case, the key finding came from work that had no practical application. However, based what we learned, we (and others) were able to develop new chemistry that is now widely used in industry as well as in academia."

https://bit.ly/2KVSZxK

Section 2
Major MIT Initiatives

National Policy Initiatives

MIT has had major involvement in technology policy at the national level since before World War II, with MIT faculty and administrators frequently serving as advisors to national policymakers. Since 2005 more formal policy initiatives have been created to tackle science and technology issues with national, and often global, policy dimensions. Inherently cross-disciplinary, these initiatives draw on deep MIT expertise across science and engineering disciplines, the social sciences, economics, and management. A sampling of current policy initiatives include:

Work of the Future

In the spring of 2018, MIT President L. Rafael Reif established the MIT Task Force on the Work of the Future. Its goals are to understand the relationships between emerging technologies and work, and to explore strategies to enable a future of shared prosperity. More than twenty faculty drawn from twelve departments, as well as a dozen graduate students have participated in the task force's work. The Task Force has also been advised by boards of key stakeholders from industry, academia, education, labor, and philanthropy.

The world now stands on the cusp of a technological revolution in artificial intelligence and robotics that may prove as transformative for economic growth and human potential as were electrification, mass production, and electronic telecommunications in their eras. However, people throughout the industrialized world are pessimistic about the future of work.

In September 2019, the Task force published a preliminary report (https://bit.ly/2kuR8GZ) that outlines that "new and emerging technologies will have a profound effect on the work of the future and will create new opportunities for economic growth. Whether that growth translates to higher living standards, better working conditions, greater economic security, and improved health and longevity in the United States and elsewhere, depends on institutions of governance, public investments, education, law, and public and private leadership." These preliminary insights have been offered to help frame public debate and public policy as Task Force members conduct deeper analysis.

https://workofthefuture.mit.edu

Environmental Solutions Initiative

Launched in 2014, the Environmental Solutions Initiative (ESI) advances science, engineering, policy and social science, design, the humanities, and the arts toward a people-centric and planet-positive future. ESI pursues this mission by mobilizing students, faculty, and staff across MIT in partnerships for interdisciplinary education, research, and convening.

ESI's educational mission is to prepare and equip MIT's extraordinary students to steward a healthy planet in every career path. In September 2017, ESI launched a new, multidisciplinary minor in Environment and Sustainability open to undergraduates from all majors. ESI works closely with faculty who teach required undergraduate classes (General Institute Requirements) to incorporate problem sets and material on climate and environment.

ESI's agenda for advancing research and expanding work toward environmental solutions focuses in three key domains: climate science and earth systems, cities and infrastructure, and sustainable production and consumption. These domains are multidisciplinary and promote collaboration across MIT's five schools.

http://environmentalsolutions.mit.edu/

J-Clinic

In September 2018, MIT launched the Abdul Latif Jameel Clinic for Machine Learning in Health (J-Clinic). J-Clinic's mission is to incubate research at the intersection of computer science, big data, and the life sciences, and to drive the creation and commercialization of high-precision, affordable, and scalable machine-learning technologies to health care, ranging from diagnostics to pharmaceuticals. J-Clinic focuses on three main areas: preventative medicine methods and technologies with the potential to change or stop the course of noninfectious disease; cost-effective diagnostic tests to both detect and alleviate health problems; and drug discovery and development to enable faster and cheaper discovery, development, and manufacture of new pharmaceuticals, particularly those targeted for individually customized therapies.

This is the fourth major collaborative effort between MIT and Community Jameel, the social enterprise organization founded and chaired by Mohammed Abdul Latif Jameel '78. J-Clinic is also a key part of the MIT Quest for Intelligence.

https://jclinic.mit.edu

Abdul Latif Jameel World Water and Food Security Lab

The Abdul Latif Jameel World Water and Food Security Lab (J-WAFS) serves to organize and promote food and water research around campus, emphasizing innovation and deployment of effective technologies, programs, and policies in order to have measurable impact as humankind adapts to a rapidly changing planet and combats water and food supply scarcity.

The lab addresses the collective pressures of population growth, urbanization, development, and climate change—factors that endanger food and water systems in developing and developed countries alike. To accomplish this, the lab develops broad-based approaches employing MIT's interdisciplinary strengths and expertise in science, engineering and technology, climate and hydrology, energy and urban design, business, social science, and policy. These efforts are supported in part through seed grants distributed competitively to MIT researchers from J-WAFS' endowment, established in 2014 through a generous gift by alumnus Mohammed Abdul Latif Jameel '78.

J-WAFS also seeks to partner with other institutions, foundations, industry, philanthropists, and governments to develop regionally appropriate solutions and innovations, whether for fast-growing megacities or for the rural developing world. Water supply in urban settings, for example, may benefit from conservation policies and infrastructure-scale systems, whereas rural populations may need small-scale, locally powered water purifiers. Ensuring stable food supplies requires a similarly varied approach that engages technology, biological and environment science, policy, and business innovation.

http://jwafs.mit.edu/

Internet Policy Research Initiative

The Internet Policy Research Initiative (IPRI) works with policy makers and technologists to increase the trustworthiness and effectiveness of interconnected digital systems that support our economy and society. As global interconnectedness increases there is a need to bridge the gap between the technical and policy communities who are trying to neutralize threats and seize opportunities that a more interconnected world creates.

Under the umbrella of IPRI, MIT has taken a focused interdisciplinary research approach that draws on the best of MIT's expertise in engineering, social science, and management to tackle these grand challenges. Its goal is to help guide governments and private sector institutions around the world in framing sustainable, effective Internet and cybersecurity policies.

https://internetpolicy.mit.edu

Energy

The MIT Energy Initiative (MITEI), formally launched in the fall of 2006, is widely recognized as a leader in energy policy. It is a campus-wide energy program with important educational, research, and policy components. Its policy outreach component has prospered, encompassing core MITEI activities and those under the auspices of programs such as the Tata Center for Technology and Design, Center for Energy and Environmental Policy Research (CEEPR), and the Joint Program on the Science & Policy of Global Change. MITEI, the Tata Center, CEEPR, and the Joint Program each hold workshops at least annually to bring MIT faculty, research staff, and students together with outside experts to address current technological, economic, and political challenges in energy and climate.

MITEI's best-known policy products are the in-depth, multidisciplinary "Future of..." studies addressing solar energy, the electric grid, natural gas, and other areas (see energy.mit.edu/futureof). New studies in the series will continue to inform future decisions regarding energy research, technology choices, and policy development.

Now in its second decade, MITEI has reorganized its research around specific technology areas key to addressing climate change and meeting global energy needs. Eight Low-Carbon Energy Centers support sustained collaboration across academia, industry, government, and the philanthropic and NGO communities. The eight Centers are focused on carbon capture, utilization, and storage; electric power systems; energy bioscience; energy storage; materials for energy and extreme environments; advanced nuclear energy systems; nuclear fusion; and solar.

http://energy.mit.edu/lcec

Research Initiatives

Quest for Intelligence

The MIT Quest for Intelligence was launched in 2018 to discover the foundations of human intelligence and drive the development of technological tools that can positively influence virtually every aspect of society.

Housed within the new MIT Stephen A. Schwarzman College of Computing (http://computing.mit.edu/), the MIT Quest brings together more than 200 investigators working on the science and engineering of intelligence.

MIT is leading this work through two linked entities. "The Core," advances the science and engineering of both human and machine intelligence. A key output of this work will be machine-learning algorithms. "The Core" also seeks to advance our understanding of human intelligence by using insights from computer science.

The second entity, "The Bridge," is dedicated to the application of MIT discoveries in natural and artificial intelligence to all disciplines and will host state-of-the-art tools from industry and research labs worldwide. The Bridge will provide a variety of assets to the MIT community, including intelligence technologies, platforms, and infrastructure; rich and unique data sets; technical support; and specialized hardware.

The Quest researchers are also investigating the societal and ethical implications (https://bit.ly/2mEWpgl) of advanced analytical and predictive tools. There are active projects and groups at the Institute investigating autonomous systems, media and information quality, labor markets and the work of the future, innovation and the digital economy, and the role of AI in the legal system.

https://quest.mit.edu/

AI Accelerator

In May 2019, MIT and the U.S. Air Force launched a new program, the MIT-Air Force AI Accelerator. The program, a component of the new MIT Stephen A. Schwarzman College of Computing, will leverage the expertise and resources of MIT and the Air Force to conduct fundamental research directed at enabling rapid prototyping, scaling, and application of AI algorithms and systems. The goal is to make fundamental advances in artificial intelligence that could improve Air Force operations while also addressing broader societal needs.

MIT is forming interdisciplinary teams of researchers, faculty, and students whose work focuses on topics in artificial intelligence, control theory, formal methods, machine learning, robotics, and perception, among other fields. Teams will also include leaders in technology policy, history, and ethics from a range of departments, labs, and centers across the Institute. Members of the Air Force will join and lend expertise to each team.

The MIT-Air Force program will be housed in MIT's Beaver Works facility, an innovation center located in Kendall Square. MIT Lincoln Laboratory, a U.S. Department of Defense federally funded research and development center, will make available its specialized facilities and resources to support Air Force mission requirements.

Cybersecurity Initiatives
In 2015, MIT launched three campus-wide cyber-security efforts aimed at addressing the technical, regulatory, and managerial aspects of cybersecurity. The three initiatives: Internet Policy Research Initiative (described above), Cybersecurity@CSAIL, and MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity (IC)3, are intended to provide a cohesive, cross-disciplinary strategy to tackling the complex problems involved in keeping digital information safe.

Cybersecurity@CSAIL
Cybersecurity@CSAIL aims to identify and develop technologies that address the most significant security issues confronting organizations in the next decade. Presently, approaches to system security do not give overall security guarantees, but rather attacks are fought individually—"patch and pray" style. Cyber-Security@CSAIL strives to provide an integrated and formal approach to the security of systems, combining design and analysis methods from cryptography, software, and hardware. Cybersecurity@CSAIL's approach includes three key elements: collaborate closely with industry for input to shape real-world applications and drive impact; approach the problem from a multi-disciplinary perspective; and create a test bed for our industry partners to implement and test our tools as well as have our researchers test tools developed by our partners.

https://cap.csail.mit.edu/members/initiatives/cybersecuritycsail

MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity
MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity (IC)3 addresses the important strategic, managerial, and operational issues related to the cybersecurity of the nation's critical infrastructure, ranging from energy and healthcare to financial services. An

MIT interdisciplinary team, led by Sloan along with industry partners, looks to address issues, such as cyber risk analysis, return on cybersecurity investment, cybersafety models, more effective information sharing, better organizational cybersecurity culture, disrupting the cybercrime ecosystem, and metrics and models to better protect organizations.

https://cams.mit.edu

MIT.nano—Toolset for Innovation
With nano-scale advancements, we are reimagining Health and Life Sciences, Energy, Computing, Information Technology, Manufacturing, Quantum Science, and other fields. That is because nano is not a specific technology. It does not belong to a particular industry or discipline. It is, rather, a revolutionary way of understanding and working with matter, and it is the key to launching the next Innovation Age, the Nano Age.

A new nanoscience and technology center at the heart of the MIT campus opened in the summer of 2018 to support MIT researchers' work with nano technology. It is a comprehensive, 200,000-sq ft shared facility for nano-scale advancements. It is designed to give MIT researchers and innovators, as well as our partners, access to broad and versatile toolsets that can do more—from imaging to synthesis, fabrication and prototyping—entirely within the facility's protective envelope.

MIT.nano houses hands-on learning spaces and advanced teaching tools that are integrated throughout the facility. The top floor of MIT.nano contains a new undergraduate chemistry lab teaching complex. Also, on the top floor is the set of prototyping laboratories, designed to provide tools that could translate basic advances into hand-held technologies.

http://mitnano.mit.edu

MIT Clinical Research Center and Tufts-MIT CTSI

MIT has had a Clinical Research Center (CRC) since 1962 and remains one of two non-hospital institutions nationwide with such resources. The CRC has worked closely with internal MIT resources such as the Committee on the Use of Humans as Experimental Subjects—MIT's Institutional Review Board (IRB)—to ensure the safety of human subjects in the over 700 protocols run by MIT investigators and with external agencies and institutions.

In May 2018, the MIT CRC began a new collaboration with the Tufts Clinical and Translational Science Institute (CTSI) (https://www.tuftsctsi.org/). The T.5 Capacity in Medical Devices Program, co-led by Institute for Medical Engineering and Science (IMES) (http://imes.mit.edu/) Director Elazer R. Edelman, aims is to accelerate device development for clinical studies. It focuses on the early yet critical stage of translational science, when a medical device or diagnostic tool is still in its prototype stage.

<div align="right">http://crc.mit.edu/about</div>

Section 3
Students

Students

The Institute's fall 2018 student body of 11,574 is highly diverse. Students come from all 50 states, the District of Columbia, four territories and dependencies, and 127 foreign countries. The Institute's 3,411 international students make up eleven percent of the undergraduate population and forty-two percent of the graduate population.

Student Profile, 2018–2019

Student Level	Count	Percentage
Undergraduate	4,602	40
Graduate	6,972	60
Total	**11,574**	**100**

U.S. Citizen and Permanent Resident Student Minorities, 2018–2019*

Ethnicity	Undergraduate Count	Graduate Count
Asian American	1,461	932
Hispanic or Latino	694	384
African American	398	166
American Indian or Alaskan Native	63	30
Native Hawaiian or Pacific Islander	16	9

*Students may identify with more than one race or choose not to identify with a group.

Seventy-four undergraduate and 409 graduate students chose not to identify an ethnicity or race. These figures may not precisely reflect the population because they are self-reported.

Students who identified, at least in part, as a U.S. minority group totaled 4,082—56 percent of undergraduate and 22 percent of graduate students.

Faculty and Students, 1865–2019
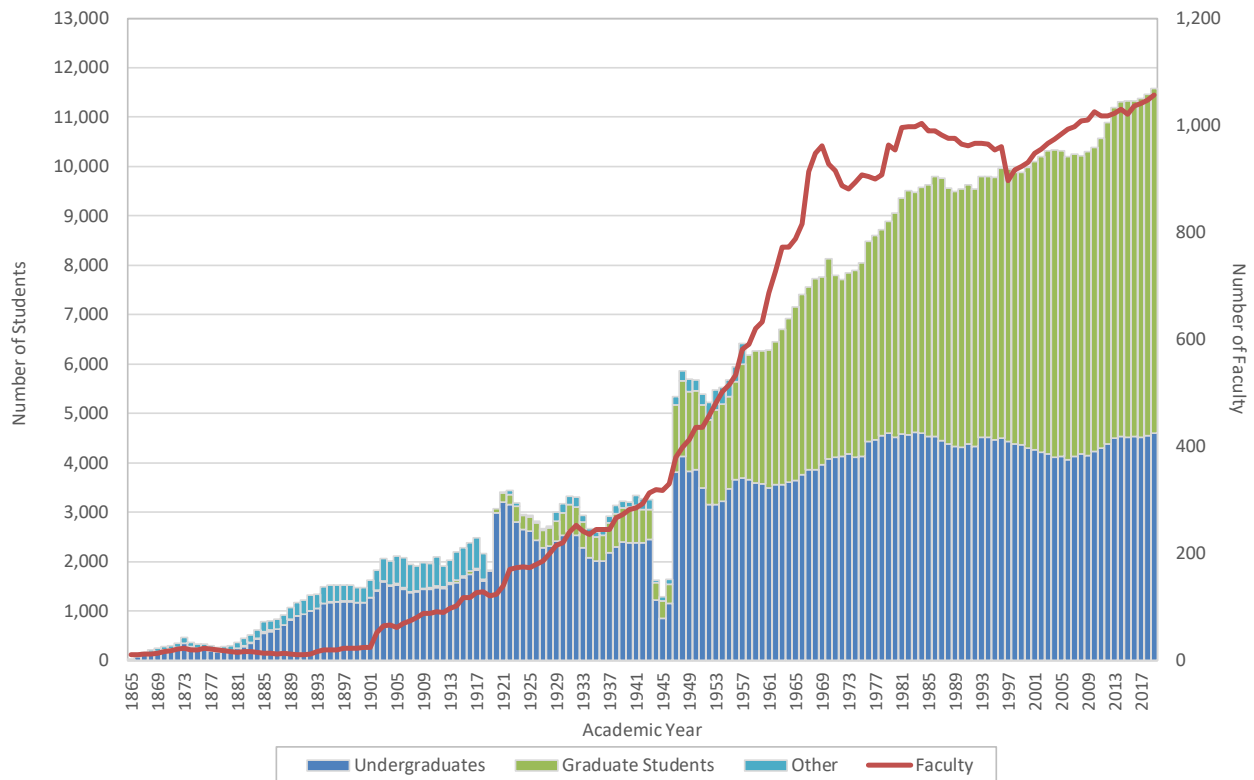
Undergraduate Students

Students first enrolled at MIT in 1865. Twenty-seven students enrolled as undergraduate students that first year. In fall 2018, there were 4,602 undergraduate students.

Undergraduate Students by Gender, 2018–2019

Undergraduate Students by Citizenship, 2018–2019

Citizenship	Count	Percentage
U.S. citizen	3,909	85
U.S. permanent resident	187	4
International	506	11
Total	**4,602**	**100**
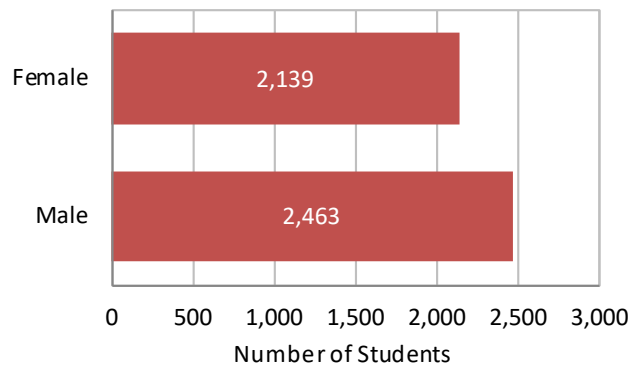
Undergraduate Students by School, 2018–2019

School	Count
Architecture and Planning	47
Engineering	2,481
Humanities, Arts, and Social Sciences	88
Management	90
Science	717
Undesignated*	1,179
Total	**4,602**
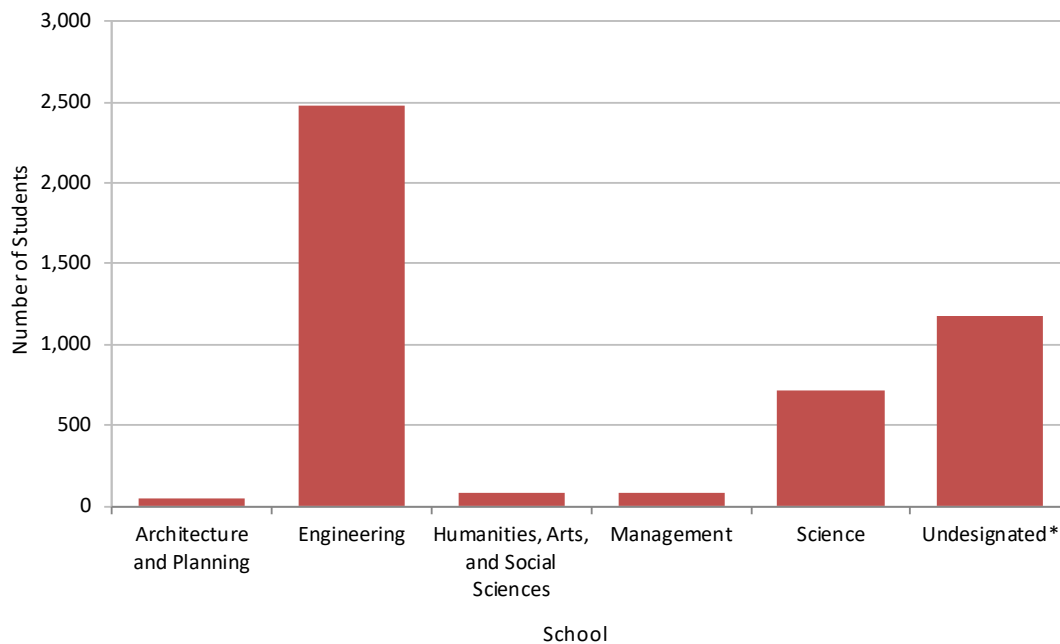
*Undesignated comprises freshman who do not enroll in a major and undesignated sophomores.

Breakdown of the Fall 2018 entering class

In 2018, MIT admitted 1,464 or 6.7% of the 21,706 first-year applications received. Forty-nine percent of the class was male and 51% was female. Of the student-reported race/ethnicity, 29% were students who identify in whole or in part with an ethnic group that is underrepresented at MIT and 18% were students who will be the first in their family to attend a four-year college. Seventy percent of the class hail from a public school education. The class is representative of all 50 states and 60 foreign countries. Of admitted students from schools that report class rank, 94% graduated in the top 5% of their high school class.

First generation students are an important part of the MIT community making up close to twenty percent of the each of the recent entering undergraduate classes. The First Generation Program (FGP) exists to enhance the academic success, professional growth, and personal development of these students at MIT.

First Generation Students as Percentage of Each Year's Entering Class
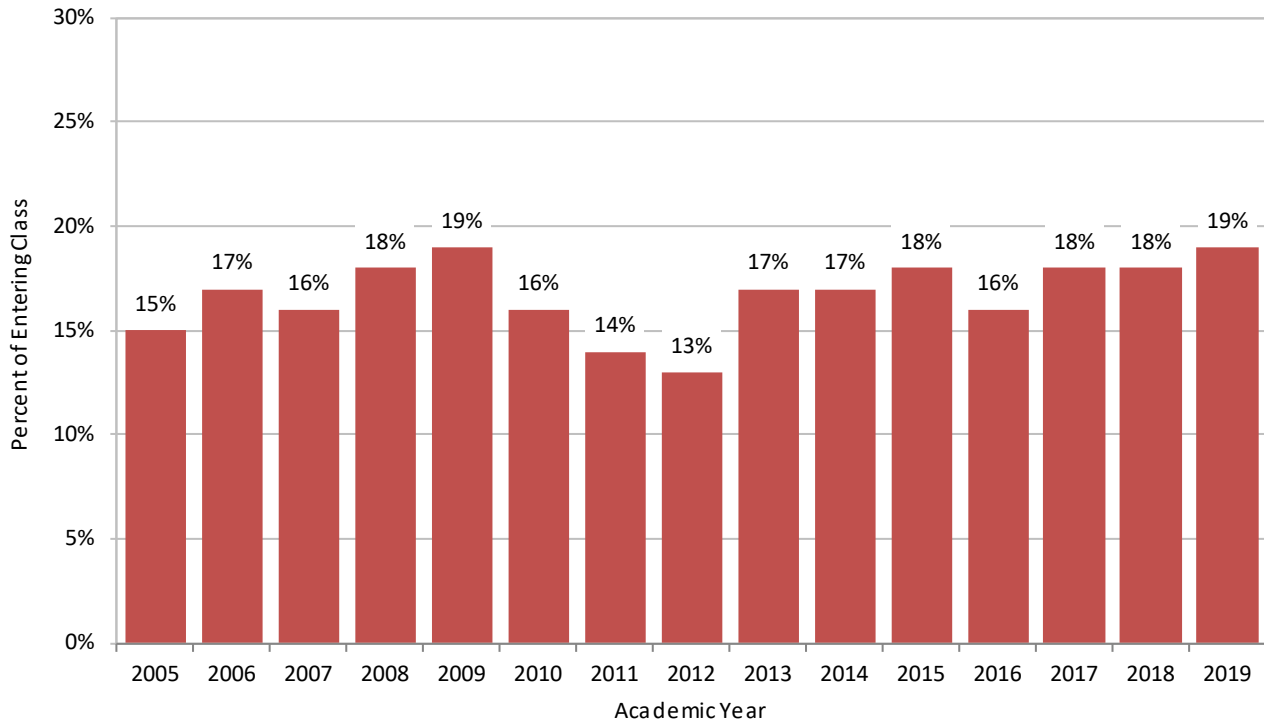
Graduate Students

Graduate students have outnumbered undergraduate students at MIT since 1980. In fall 2018, they comprised 60 percent of the student population with 6,972 students—3,002 master's students (includes 143 non-matriculating) and 3,970 doctoral students.

Graduate Students by Level and Gender, 2018–2019

Graduate Students by Citizenship, 2018–2019

Citizenship	Count	Percentage
U.S. citizen	3,824	55
U.S. permanent resident	243	3
International	2,905	42
Total	**6,972**	**100**
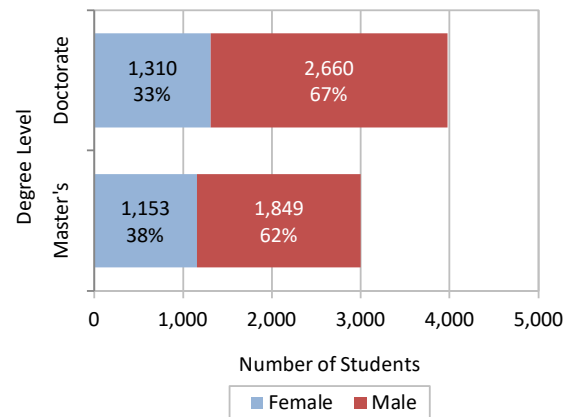
Graduate Students by School, 2018–2019

School	Master's Count*	Doctoral Count	Total
Architecture and Planning	455	199	654
Engineering	1,008	2,127	3,135
Humanities, Arts, and Social Sciences	28	299	327
Management	1,360	170	1,530
Science	8	1,175	1,183
Total	**2,859**	**3,970**	**6,829**
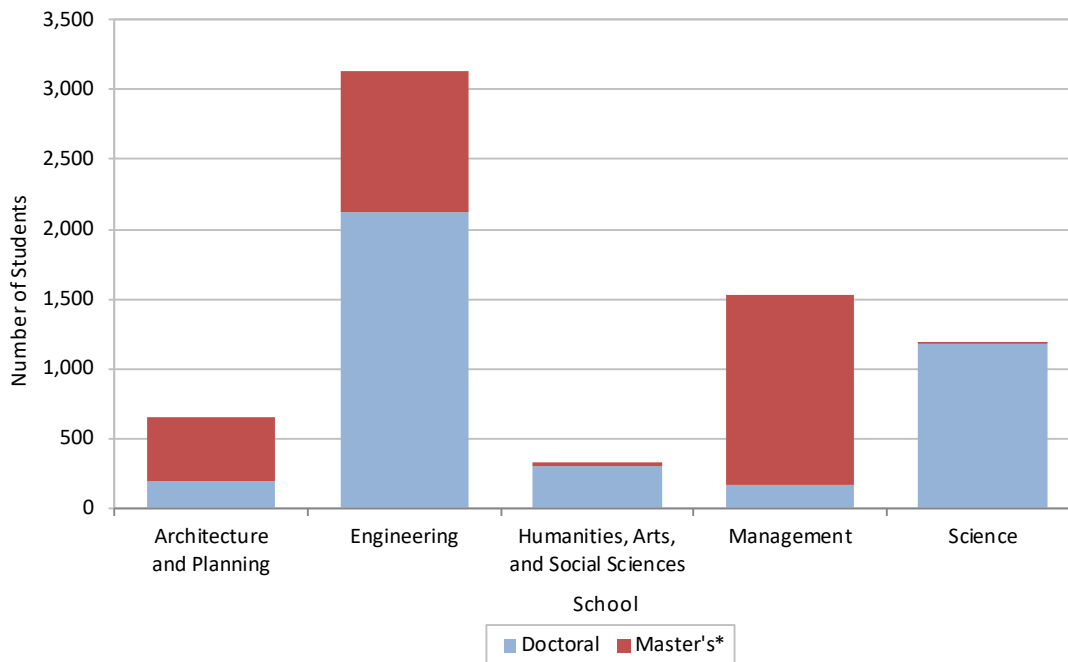
*Excludes non-matriculating students

International Students

MIT has welcomed international students essentially since its inception. The first student from Canada came to MIT in 1866, the second year that MIT offered classes. This student was followed by a steady stream of students from around the globe throughout the 19th century. By 1900, some 50 foreign-born students had traveled to Massachusetts for study; however, the number increased dramatically after World War II when an influx of these students began attending the Institute. The rapid rise of international students from East Asia, led by students from China, changed the demographics of this group beginning in the 1950s. Changes in immigration law in 1965 opened up the doors to a steadily increasing pool of international talent.

The United States has been the destination of choice for international students and scholars for the past 50 years. According to the Institute of International Education *Open Doors* 2018 report, the number of international students enrolled in U.S. colleges during the 2017–2018 academic year reached a record high of 1,094,792 students. MIT has the fourth highest number of foreign students of the institutions in Massachusetts. NAFSA: Association of International Educators produced an economic analysis based in part on *Open Doors* data that states that during the 2017–2018 academic year, international students contributed $39 billion to the U.S. economy and support 455,622 jobs.

**Total Enrollment by Citizenship
and Geographic Region of Country of Citizenship
2018–2019**
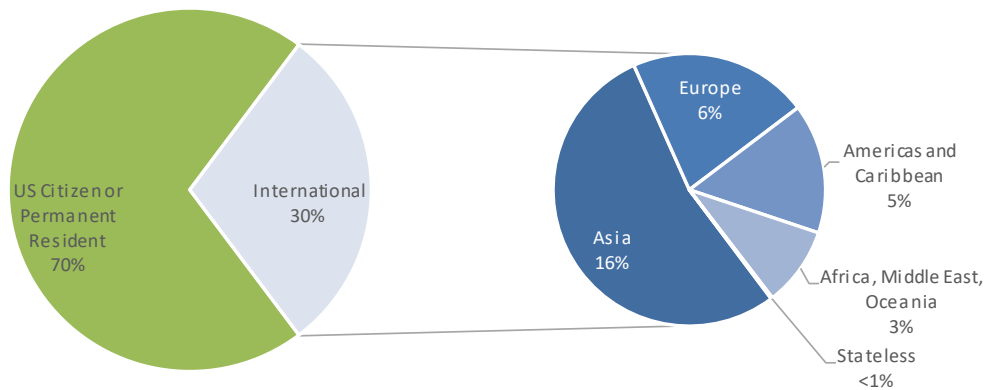
International Undergraduate Students by Country of Citizenship, 2018–2019

Country	Count
China	89
India	29
South Korea	21
Canada	19
United Kingdom	19
Thailand	18
Mexico	14
Brazil	10
Germany	10
Israel	10
Singapore	10
Vietnam	10
All other countries	247
Total	**506**

International Graduate Students by Country of Citizenship, 2018–2019

Country	Count
China	762
India	311
Canada	217
South Korea	173
France	109
Singapore	83
Spain	76
Brazil	67
Taiwan	67
Germany	64
All other countries	976
Total	**2,905**

International Students by Geographic Region of Country of Citizenship 1884–2019
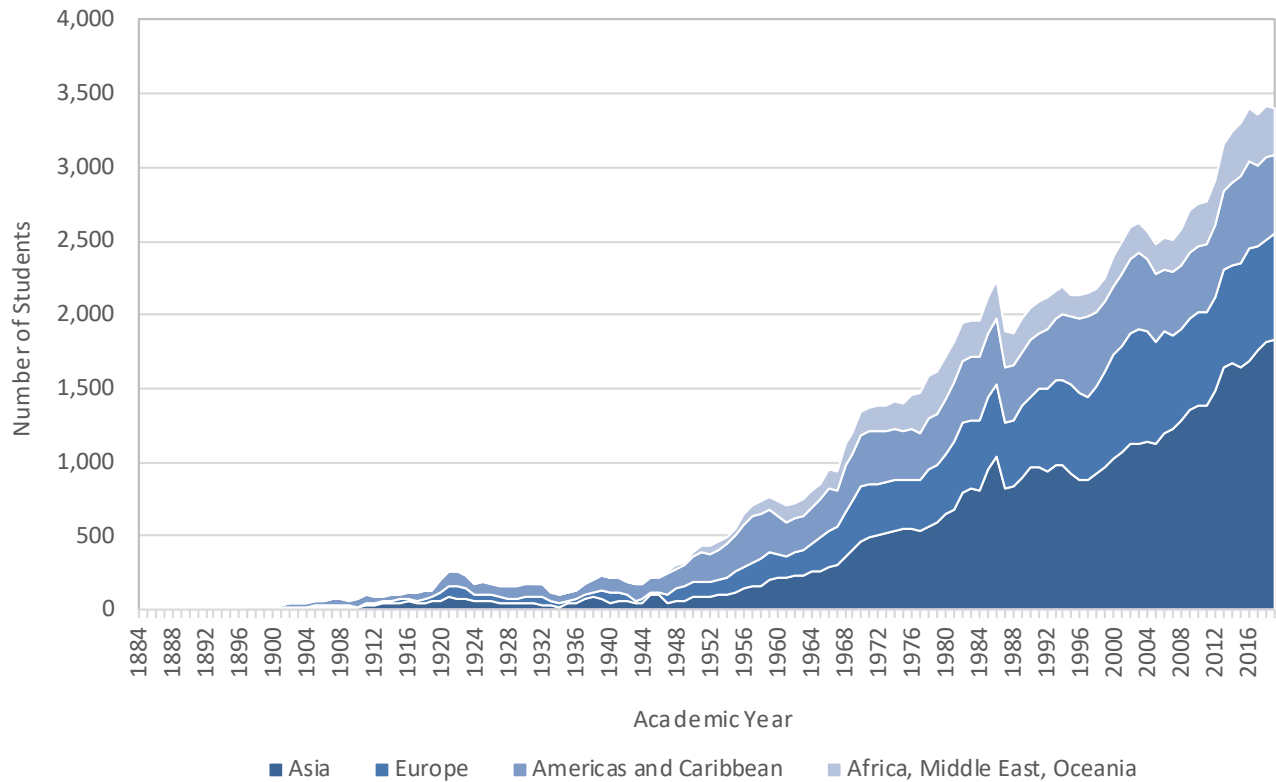
Degrees

In 2018–2019, MIT awarded 3,679 degrees.

Degrees Awarded by Type, 2018–2019

Degree Type	Count
Bachelor of Science degrees	1,142
Master of Science degrees	638
Master of Architecture, Master in City Planning, Master of Engineering, Master of Business Administration, Master of Finance, Master of Applied Science, and Master of Business Analytics degrees	1,199
Engineer's degrees	13
Doctoral degrees	687

Degrees Awarded by Gender, 2018–2019
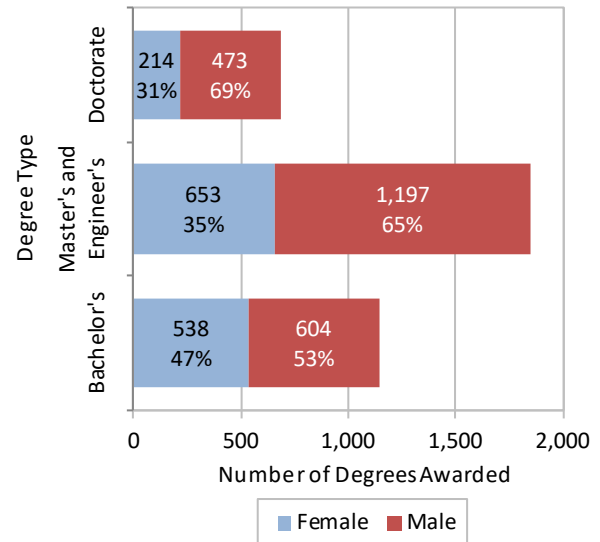
Degrees Awarded by School, 2018–2019

School	Bachelor's Count	Master's and Engineer's Count	Doctorate Count	Total
Architecture and Planning	13	203	31	247
Engineering	840	821	370	2,031
Humanities, Arts, and Social Sciences	29	16	53	98
Management	30	798	32	860
Science	230	12	201	443
Total	**1,142**	**1,850**	**687**	**3,679**
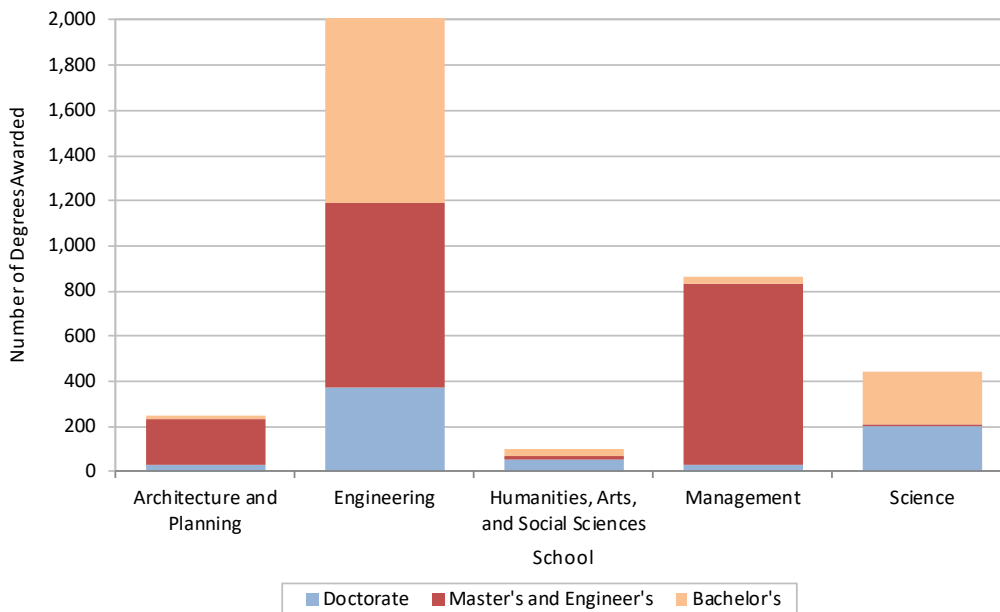
Alumni

The MIT Alumni Association works to connect the Institute's 139,318 living alumni with the Institute and with one another. It aims to engage and inspire the global MIT community to make a better world.

Alumni stay connected through their graduating-class events, departmental organizations, shared interest groups, 42 regional clubs in the United States and 41 abroad, and via regional ambassadors around the globe, among a wide variety of other face-to-face and online activities. The Association links alumni virtually through its website, alum.mit.edu, to provide Institute and alumni news, as well as through tools for connecting, such as the Online Alumni Directory and Email for Life. Nearly 17,000 alumni volunteers offer their time and service as student mentors, Educational Counselors, and fundraising volunteers, and on boards and committees; as well as on the MIT Corporation, the Institute's Board of Trustees. In FY19, 30,726 alumni contributed philanthropically to the Institute through their gifts to the MIT Annual Fund.

MIT graduates hold leadership positions in industries and organizations around the world. More than 22,000 alumni reside in Massachusetts, and about 15 percent of MIT's alumni live outside of the United States. Major markets where the most alumni reside outside of Massachusetts include New York City, Washington, D.C., and Northern California, domestically; abroad, the largest populations of alumni reside in Japan, Canada, and China.

In cooperation with the Office of Institutional Research, the Alumni Association conducts a triennial alumni attitudinal survey. Last conducted in the fall of 2016, the survey garnered an 18 percent response rate, with 69 percent of all alumni respondents reporting very positive feelings about MIT. Alumni with graduate degrees exclusively reported a slightly higher rate of satisfaction with their academics and overall experience, with 80 percent rating the academics highly satisfactory and 72 percent indicating very positive feelings about MIT. Overall, 88 percent indicated pride in their degree, and 79 percent indicated that they thought MIT was making a global impact. A large percentage of alumni indicated that they support the Institute

philanthropically, and 50 percent responded that MIT is the most important or among the most important organizations in their life today. Alumni have a desire to give back and to volunteer. Interactions with students—providing advice and mentorship—are the most popular way alumni would like to participate. Most popular among things that alumni indicated they have not done, but would like to do in the future, are taking an MITx course or visiting the library journals or OpenCourseWare. The survey will be repeated in the fall of 2019.

In May 2017, MIT invited 932 undergraduate alumni from the class of 2006 to participate in a survey that asked them about their postgraduate education, their careers, and their MIT undergraduate experience. Seventy-four percent of alumni respondents said they have enrolled in a graduate or professional degree program since graduating from MIT. Seventy-five percent of respondents said they are employed either full-time or part-time. Among those respondents who are employed, 60 percent work in the for-profit sector, 17 percent work in the nonprofit sector, 15 percent work in government or another public institution or agency, including the military, and 7 percent are self-employed. Service is a part of the lives of our alumni. Fifty-five percent of respondents have served as an officer or on a committee for a local club, organization, or place of worship in the last 10 years. Twenty-five percent have been a board member for a nonprofit organization. Sixty-two percent have done volunteer work at least once in the last year. A fall 2012 survey of graduate alumni revealed that 93 percent of respondents are employed, with just 2 percent seeking employment (others are engaged in such activities as travel and caring for family). The average annual salary was reported to be $156,793; the median was $137,500. Graduate alumni, overall, were most likely to report working in a private for-profit organization (54 percent), in a U.S. four-year college or university (13 percent), or to be self-employed (9 percent). Of those working in government in the U.S., 3.8 percent were employed by the federal government, 0.4 percent by state government, and 0.7 percent by local government. A spirit of entrepreneurship flourishes, as 28 percent of all surveyed graduate alumni have started a company. Among doctoral alumni, 41 percent report having at least one patent or invention.

Undergraduate Financial Aid

Principles of MIT Undergraduate Financial Aid

To ensure that MIT remains accessible to all qualified students regardless of their financial resources, MIT is committed to three guiding financial aid principles:

- Need-blind admissions: MIT recruits and enrolls the most talented and promising students without regard to their financial circumstances.

- Need-based financial aid: MIT awards aid only for financial need. It does not award undergraduate scholarships for academic or athletic achievements or for other non-financial criteria.

- Meeting the full need: MIT guarantees that each student's demonstrated financial need is fully met.

As a result of these guiding principles, the Institute significantly discounts tuition. The chart below shows the share of total tuition and fees MIT students pay has declined by twenty-six percentage points since 2000. In Financial Aid Year 2019, the net cost of undergraduate tuition and fees was 45% of the total tuition and fees when accounting for financial aid.

Net Undergraduate Tuition and Fees as a Percentage of Total Tuition and Fees*
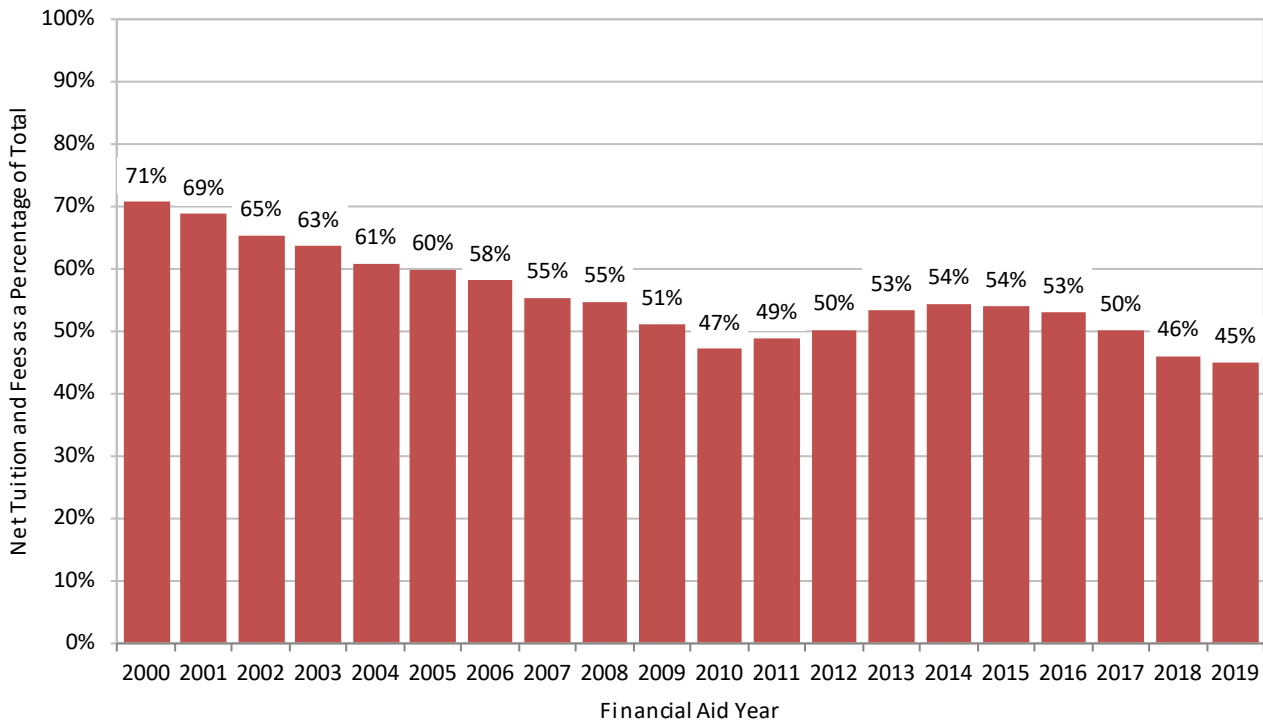
*Net tuition and fees calculated as a percentage of gross undergraduate tuition and fees. Net tuition and fees exclude MIT undergraduate scholarships.

Who Pays for an MIT Undergraduate Education

In 2018–2019, the annual price of an MIT education totaled $70,790 per student—$51,832 for tuition and fees, $15,510 for room and board, an estimated $2,898 for books, supplies, and personal expenses, and a per-student average of $550 for travel. With 4,550 undergraduates enrolled, the collective price for undergraduates was $322.1 million. Of this amount, families paid $194.2 million, or 60 percent, and financial aid covered the remaining 40 percent, or $127.9 million. Our full-need financial aid meets 100% of students demonstrated financial need. Over 70% of undergraduates graduate debt-free, and more than 30% don't pay any tuition. And, while the cost of college appears to keep rising, the cost of MIT, after financial aid, has actually gone down in constant dollars over the last few decades. For families receiving financial aid, the net cost of attending MIT is lower today by 29 percent (adjusted for inflation), than it was in 2000. These are some of the commitments we make to being financially accessible.

Since MIT subsidizes the cost of educating all undergraduates through its tuition pricing–the actual cost of educating a student is estimated to be about half of what we charge in tuition–and continues to be the largest source of financial aid to its undergraduates, the Institute is the primary source for paying for an MIT undergraduate education, and families the secondary source.

Forms of Financial Undergraduate Aid

The primary form of financial aid to MIT undergraduates is grants or scholarships—terms that at MIT are used interchangeably. Since 2005-2006 the share of undergraduate aid in the form of grants/scholarships has risen from 80.9 to 90.2 percent while the share in the form of student loans has fallen from 11.1 to 2.9 percent and student employment has decreased from 8.0 to 6.8 percent.

From the students' perspective, grants are the sole form of aid that unambiguously increases the financial accessibility of college, since they don't require repayment and don't increase the students' indebtedness. The preponderance of grant aid at MIT sets the Institute apart from many other higher education institutions.

**Types of Financial Aid for MIT Undergraduates
2018–2019**

Term-time employment 7%

Student loans 3%

Grants and Scholarships 90%
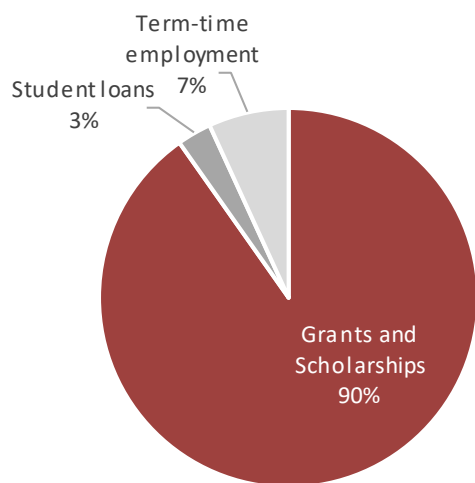
**Amounts of Financial Aid for
MIT Undergraduates, 2018–2019**

Aid Type	Amount (in U.S. Dollars)	Percent of Total*
Grants and Scholarships	144,587,273	90.2
Student Loans	4,689,241	2.9
Term-time employment	10,975,655	6.8
Total	**160,252,169**	**100.0**

*Totals may not add due to rounding.

Sources of Undergraduate Financial Aid

In 2018-2019, MIT provided 86.6 percent of undergraduate financial aid. State and private resources provided 5.4 percent, and the remaining 8.0 percent came from the federal government. MIT differs here from the national trend of relying on the federal government as the largest source of financial aid.

Approximately 59 percent of MIT undergraduates received an MIT scholarship, averaging $47,593 each. These scholarships come primarily from MIT's endowed funds, gifts from alumni and friends, and general Institute funds.

MIT participates in the Federal Pell Grant Program, the Federal Direct Loan Program and two campus-based programs: the Federal Supplemental

Educational Opportunity Grant and the Federal Work-Study Program. MIT has participated in these programs since their inception and values their role in making an MIT education accessible to all qualified students. In addition, MIT undergraduates receive federal aid for their participation in the Air Force, Army, and Navy ROTC, and some undergraduates receive benefits from the VA because they are veterans or the dependents of veterans of the U.S. Armed Forces. ROTC aid is not based on need.

Students receive private scholarships in recognition of their academic accomplishments, athletic or musical skills, career interests, and many other criteria. Two states, in addition to Massachusetts, allow their residents to receive a state grant while attending MIT: Pennsylvania and Vermont. Most state grants are need-based.

Pell Recipients as Percentage of Undergraduate MIT Population
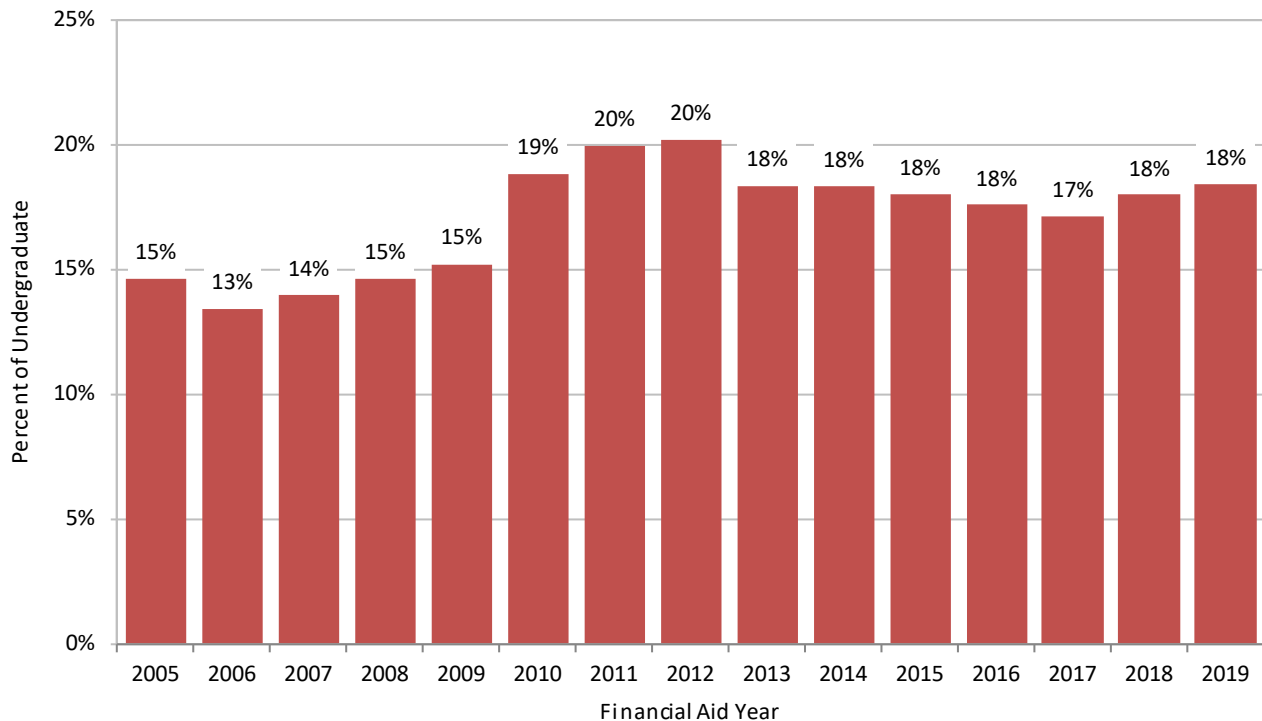
**Sources of Financial Aid for MIT Undergraduates
2018–2019**

Federal 8%
State <1%
Private 5%
MIT 87%
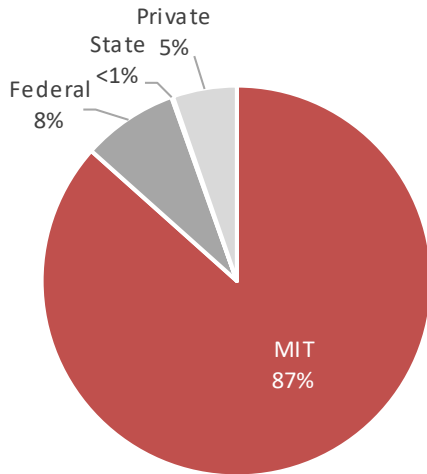
**Sources of Financial Aid for
MIT Undergraduates, 2018–2019**

Aid Source	Amount (in U.S. Dollars)	Percent of Total
MIT Financial Aid	138,779,643	86.6
Federal Financial Aid	12,741,758	8.0
State Financial Aid	204,872	0.1
Private Financial Aid	8,525,896	5.3
Total	**160,252,169**	**100.0**

The following table summarizes the sources and types of financial aid MIT undergraduates received in 2018–2019.

Undergraduate Financial Aid, 2018–2019

Source	Scholarships/Grants		Loans		Employment		Total*	
	Amount ($)	Students	Amount ($)	Students	Amount ($)	Students	Amount ($)	Students
MIT	$128,008,596	2,691	$120,550	39	$10,650,497	3,224	$138,779,643	3,947
Federal	$9,799,794	914	$2,616,806	432	$325,158	284	$12,741,758	1,445
State	$204,872	91	N/A	N/A	N/A	N/A	$204,872	91
Private	$6,574,011	1,004	$1,951,885	87	N/A	N/A	$8,525,896	1,064
Total*	**$144,587,273**	**3,047**	**$4,689,241**	**502**	**$10,975,655**	**3,230**	**$160,252,169**	**4,106**

*The total column and row are unduplicated numbers of students. Totals may not add due to rounding.

Graduate Financial Aid

Principles of MIT Graduate Financial Aid

MIT makes financial support available to graduate students from a variety of sources and in several different forms. Many forms of support are granted solely on the basis of merit (teaching and research assistantships; on-campus employment; some fellowships, scholarships, and traineeships), while others are granted on the basis of financial need (federal loans; some fellowships, scholarships, and traineeships; on-campus employment) or a combination of merit and need (some fellowships, scholarships, and traineeships; on-campus employment).

Tuition support, in particular, is provided to graduate and professional students in connection with research assistantships, teaching assistantships, and fellowship appointments. Tuition revenue support from MIT funds is considered financial aid but is not included in this report, as no single office administers these sources of support.

A typical financial support package for a graduate student includes tuition, health insurance, and stipend support. The largest part of an MIT graduate student's expenses is dedicated to tuition ($51,520 for the 2018–2019 academic year). Another portion ($3,144) is dedicated to health insurance, unless a student already has comparable coverage. General living costs, including housing, food, transportation, and books, are largely covered by a stipend (approximately $38,244 for a doctoral student). MIT houses approximately 34 percent of the graduate student body on campus, which contributes to keeping average housing costs at a reasonable level for graduate students within the context of the Boston area. The graduate residences also help foster a thriving on-campus graduate community that many graduate students cite as one of the most positive aspects of their time here.

How Graduate Students are Supported

Enrollment is determined at the department and program level, and departments and programs admit as many students as they can support based on their RA, TA, and fellowship resources as well as the number of faculty available to advise on research.

Graduate Student Financial Support, 2018–2019
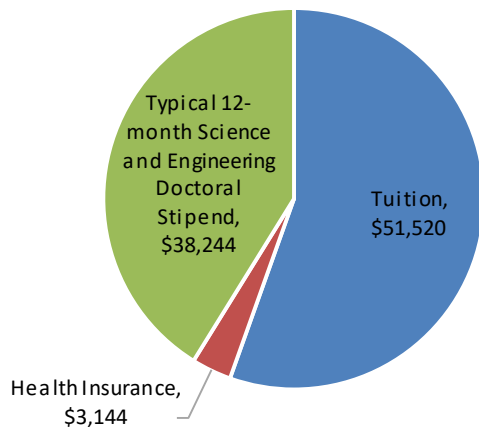
Doctoral Graduate Student Support, 2018–2019

Forms of Graduate Financial Aid
Fellowships, Traineeships, and Scholarships
At MIT, fellowships and traineeships differ from scholarships. A fellowship award to a graduate student covers full or partial tuition, and also provides a stipend to help defray living expenses. In the context of graduate study, a scholarship covers full or partial tuition only. Although most awards are made on the basis of academic merit, financial need is a factor in some instances. Recipients of graduate financial aid must be enrolled as regular resident students. The Institute annua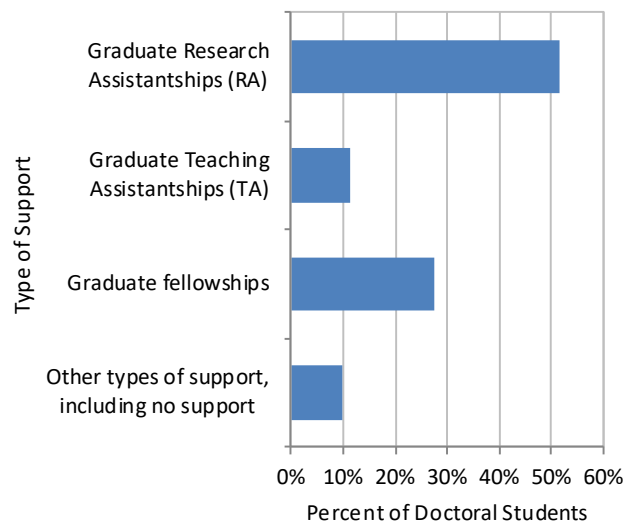lly receives funds from individual and corporate donors for the support of fellowships and scholarships. In addition, government agencies and private foundations provide grants and fellowships—often directly to outstanding students—for use at institutions of the student's choice. But occasionally these funds are directed to MIT for Institute designation of recipients.

During AY2019, students that were supported, at least in part, by fellowships were as follows:

Sponsor	Count
Department of Defense	49
Department of Energy	6
National Institutes of Health	94
NASA	17
National Science Foundation	391
Other Federal Agencies	7
Other U.S. sources	50
Non-U.S. sources	97
MIT Internal	2,394

Note, students may receive fellowships from more than one sponsor.

Teaching Assistantships
MIT employs about 1,370 graduate students each year as part-time or full-time teaching assistants to assist the faculty in grading, instructing in the classroom and laboratory, and conducting tutorials. Teaching assistants receive stipends as well as tuition support for the services that they provide.

Appointments to teaching assistantships are made upon recommendation of the head of a department. Only full-time graduate students who are candidates for advanced degrees may be appointed, and the Free Application for Federal Student Aid (FAFSA) is required for all teaching assistants who are U.S. citizens or permanent residents.

Research Assistantships
Each year, about 3,900 graduate students at MIT hold appointments as research assistants. The principal duty of a research assistant is to contribute to a program of departmental or interdepartmental research. Research assistants receive stipends as well as tuition support for the services that they provide, and are compensated on the basis of time devoted to their research.

Students who receive financial support from other sources (fellowships, scholarships, etc.) may receive supplementary stipends as teaching or research assistants in accordance with Institute and departmental guidelines.

Self-Support
Graduate and professional students are eligible for need-based financial aid, including student loans, as well as student employment under the Federal Work-Study Program, both of which are administered and reported by MIT Student Financial Services (SFS). Graduate student employment earnings under the Federal Work-Study Program, including on- and off-campus programs, totaled $0.9 million in 2018–2019, with 2.1 percent of graduate and professional students (140 students) earning $6,094 on average.

In AY2019, graduate students borrowed loans that totaled $34.5 million, a decrease of approximately $10 million from the prior year, with 8.3 percent of graduate and professional students (565 students) borrowing an average of $61,109.

Section 4
Campus Research

Research Support

MIT has historically viewed teaching and research as inseparable parts of its academic mission. Therefore, the Institute recognizes its obligation to encourage faculty to pursue research activities that hold the greatest promise for intellectual advancement. MIT maintains one of the most vigorous programs of research of any university and conducts basic and applied research principally at two Massachusetts locations, the MIT campus in Cambridge and MIT Lincoln Laboratory, a federally funded research and development center in Lexington.

MIT pioneered the federal/university research relationship, starting in World War II. Initially called upon by the federal government to serve the national war effort, that relationship has continued into the present day, helping MIT fulfill its original mission of serving the nation and the world.

Research Expenditures (MIT FY2019)

Cambridge Campus	$773.9 million
Lincoln Laboratory*	$1,066.3 million
SMART*	$45.3 million
Total	**$1,885.5 million**

*Totals do not include research performed by campus laboratories for Lincoln Laboratory and Singapore-MIT Alliance for Research and Technology (SMART).

All federal research on campus is awarded competitively based on the scientific and technical merit of the proposals. As of June 30, 2019, there were 3,237 active awards and 520 unique consortium sponsors.

Research activities range from individual projects to large-scale, collaborative, and sometimes international endeavors. Peer-reviewed research accomplishments form a basis for reviewing the qualifications of prospective faculty appointees and for evaluations related to promotion and tenure decisions.

MIT Research Expenditures 1940–2019
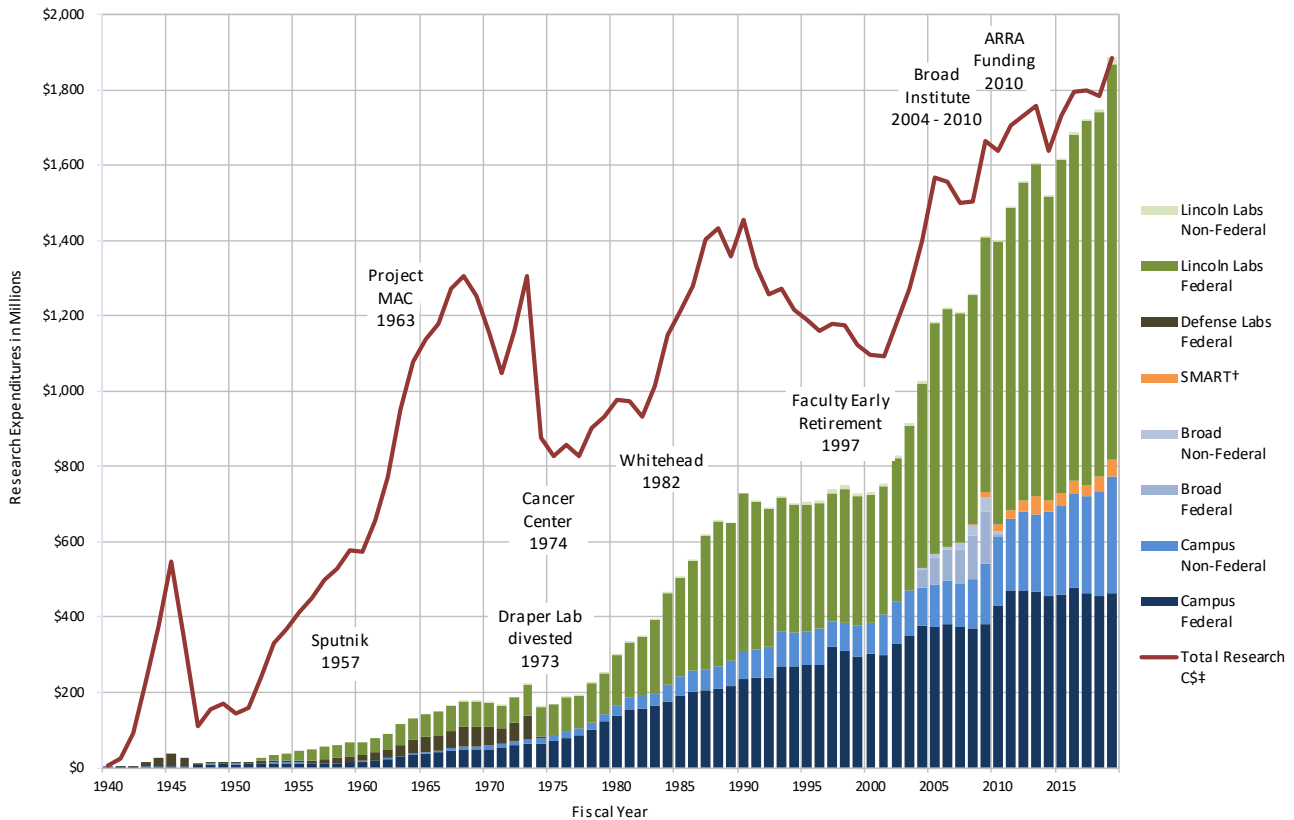
†SMART: Singapore-MIT Alliance for Research and Technology
‡The bars represent current dollars. The red line represents Total Research in constant dollars calculated using the Consumer Price Index for all Urban Consumers weighted with fiscal year 2019 equaling 100.

Campus Research Expenditures by Prime Sponsor*
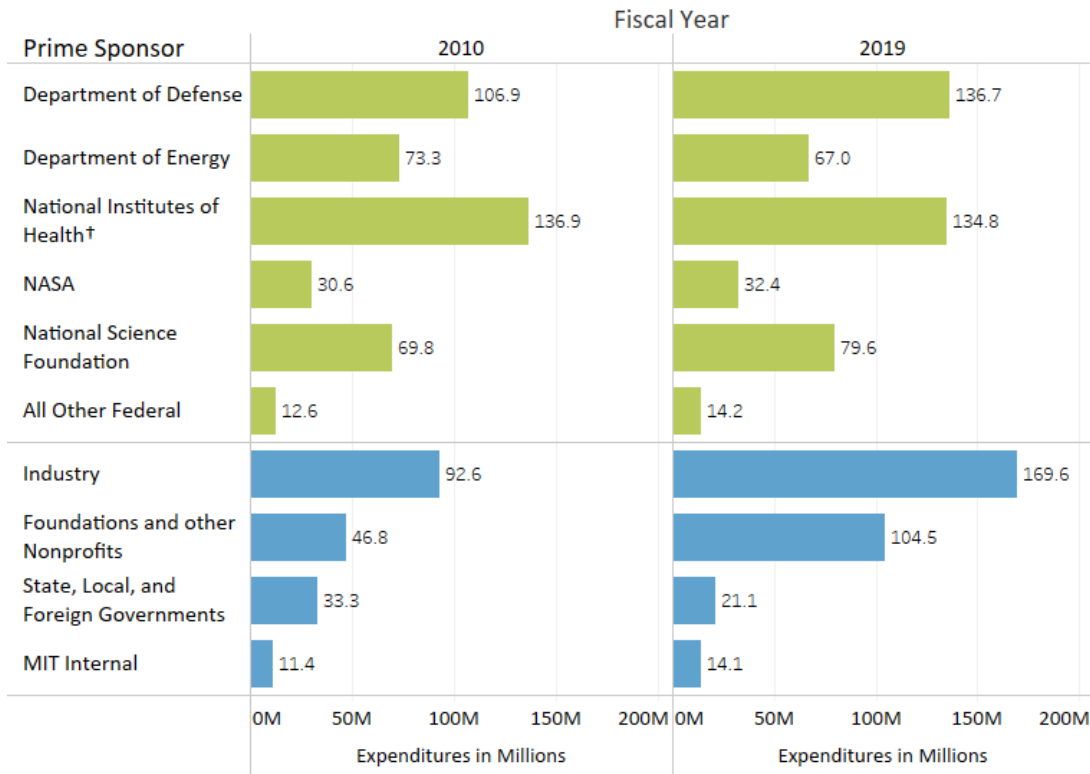
Campus Research Expenditures by Prime Sponsor

Primary Sponsor	FY2019 (In U.S. Dollars)	Percent of Campus Total
Department of Defense	136,743,404	18
Department of Energy	66,974,741	9
National Institutes of Health†	134,772,690	17
NASA	32,429,614	4
National Science Foundation	79,616,644	10
All other federal	14,180,419	2
Total Federal	**464,717,511**	**60**
Industry	169,605,879	22
Foundations and other nonprofit	104,470,528	13
State, local, and foreign governments	21,051,936	3
MIT internal	14,054,717	2
Total Non-Federal	**309,183,058**	**40**
Campus Total	**773,900,570**	**100**

*Campus based Broad Institute research expenditures are excluded.
†National Institutes of Health data includes expenditures from other Department of Health and Human Services agencies, which account for less than 2% of expenditures per year.

The Institute provides the faculty with the infrastructure and support necessary to conduct research, much of it through contracts, grants, and other arrangements with government, industry, and foundations. Research Administration Services provides central support related to the administration of sponsored research programs, and it assists faculty, other principal investigators, and their local administrators in managing and identifying resources for individual sponsored projects. In addition, a Research Council—which is chaired by the Vice President for Research and composed of the heads of all major research laboratories and centers that report to the Vice President for Research—addresses research policy and administration issues.

The Resource Development Office is available to work with faculty to generate proposals for foundation or other private support.

The Institute sees profound merit in a policy of open research and free interchange of information among scholars. At the same time, MIT is committed to acting responsibly and ethically in all its research activities. As a result, MIT has policies related to the suitability of research projects, research conduct, sources of support, use of human subjects, sponsored programs, relations with intelligence agencies, the acquisition of art and artifacts, the disposition of equipment, and collaborations with research-oriented industrial organizations. These policies are spelled out on the Policies and Procedures website and on the Vice President for Research website.

Campus Research Expenditures by Prime Sponsor and Faculty
Excluding Broad and Defense Labs
1940–2019
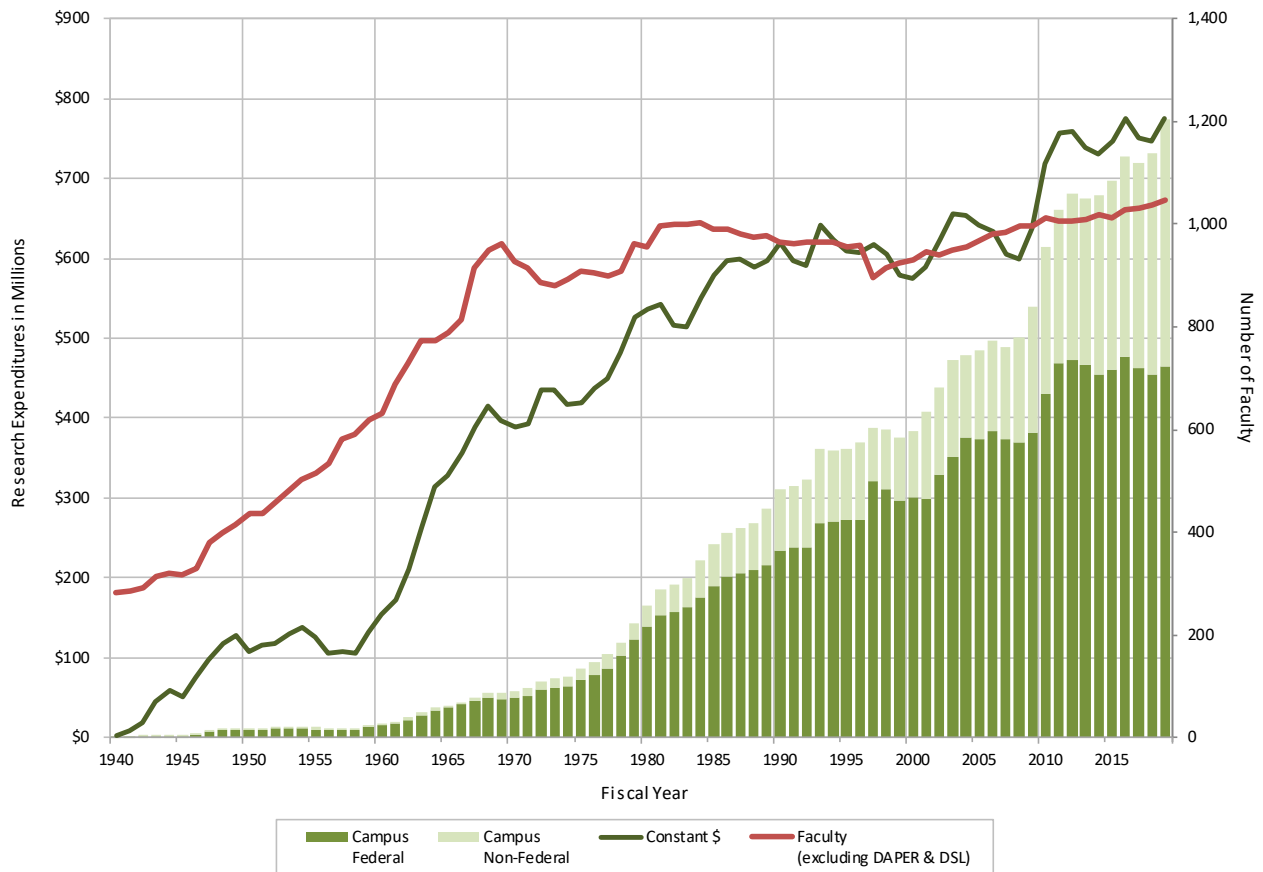
DAPER: Department of Athletics, Physical Education and Recreation
DSL: Division of Student Life

MIT subsidizes virtually every research award that it receives, even when the award includes full indirect costs because federal funding formulas never cover the full cost of research.

Research proposal budgets include direct and indirect costs. *Direct costs* are easily attributable to individual awards and include salaries and benefits for research staff and postdocs working on the project, stipends and tuition for graduate students assigned to the award, summer salary and benefits for faculty (when they get no university salary), laboratory supplies, certain research equipment including computers, and travel and publication costs. Since most faculty are paid in full by Institutional funds during the academic year, their participation in research during this time is supported by MIT.

Indirect costs (IDC) represent genuine costs of performing research that are not easily attributable to individual awards. They are recovered in part by adding a charge to each award budget proportional to certain of the direct costs of the sponsored project. These charges are based on a fixed indirect cost rate, also known as the F&A (*facilities and administrative*) rate. Think of these charges as paying for things that wouldn't need to exist or be used as extensively if MIT didn't conduct research. Examples include depreciation of research equipment and buildings, laboratory utilities (heat/cooling, power), hazardous chemical management, insurance,

administrative services, internet, and compliance with federal, state, and local regulations. The indirect cost rate is determined by dividing all the allowable indirect costs by the direct costs of all sponsored research, after excluding certain direct costs per federal regulations. The federal government defines what indirect costs can be recovered and which direct costs can be included in the total, but the indirect cost rate for research applies to all sponsors.

Each university's indirect cost rate is set based on their actual indirect costs in previous years, which are apportioned to various activities—research, instruction, or other. MIT's rates are negotiated with, and audited by, the federal government each year. MIT's IDC rate for FY2018 was 59.0%. (It was 55.0% in FY19 and is 50.6% for FY20)

A 59% indirect cost rate does not mean that 59 cents of every research dollar goes to indirect costs. The 59% rate is applied only to allowable direct costs that are subject to F&A reimbursement, not all cost. Additionally, in 1991, the government implemented a 26% rate cap applied to the administrative costs portion of the F&A rate calculations. MIT has historically been under this cap.

Figure 1 illustrates how the average federal research dollar is spent at MIT. In FY18, 72 cents of every MIT research dollar went to direct costs and 28 cents to indirect.

28¢ of each dollar is for indirect costs

72¢ of each dollar is for direct research costs

Operations and maintenance 6¢
Equipment 1¢
Utilities 3¢
Buildings 6¢
Libraries 2¢
General 4¢
Departmental 2¢
Faculty 2¢
Administration 2¢

Facilities related = 18¢
Administrative related = 10¢

Research salaries and employee benefits 39¢
Materials, services and travel 11¢
Equipment 5¢
Graduate student support 7¢
All subcontracts and other direct charges 10¢

Source: MIT Office of Sponsored Programs, FY18
Chart: MIT, November 2018

Figure 1. The MIT "Dollar Bill" that graphically explains how every dollar of an MIT federal research grant in FY18 is apportioned between direct and indirect costs.

Whenever a sponsor pays less than the federally negotiated sponsored research F&A, it generates under-recovery. Some institutions do not accept awards unless they carry full indirect costs, some write off the differential centrally, and MIT, almost uniquely, identifies internal funds to fully cover the difference on a project by project basis.

Campus Research Sponsors

The tables and charts for campus research expenditures below, and on the following pages, show the amount MIT expended by fiscal year (July 1–June 30). These figures do not include expenditures for MIT Lincoln Laboratory. Information for Lincoln Laboratory begins on page 75. Expenditures funded by industrial sponsors are shown on page 91 in the MIT and Industry section. Federal research expenditures include all primary contracts and grants, including sub-awards from other organizations where the federal government is the original funding source.

Campus Research Expenditures by Prime Sponsor (in thousands of U.S. Dollars)*
Fiscal Years 2010–2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Federal	430,154	469,521	472,583	465,947	454,939	459,979	477,169	461,626	454,497	464,718
Non-federal	184,216	191,305	208,497	208,402	223,473	236,912	250,985	257,880	277,012	309,183
Total	**614,371**	**660,825**	**681,079**	**674,348**	**678,412**	**696,891**	**728,154**	**719,506**	**731,509**	**773,901**
Constant dollars†	717,930	757,014	758,008	738,229	731,256	745,746	773,972	750,966	746,668	773,901
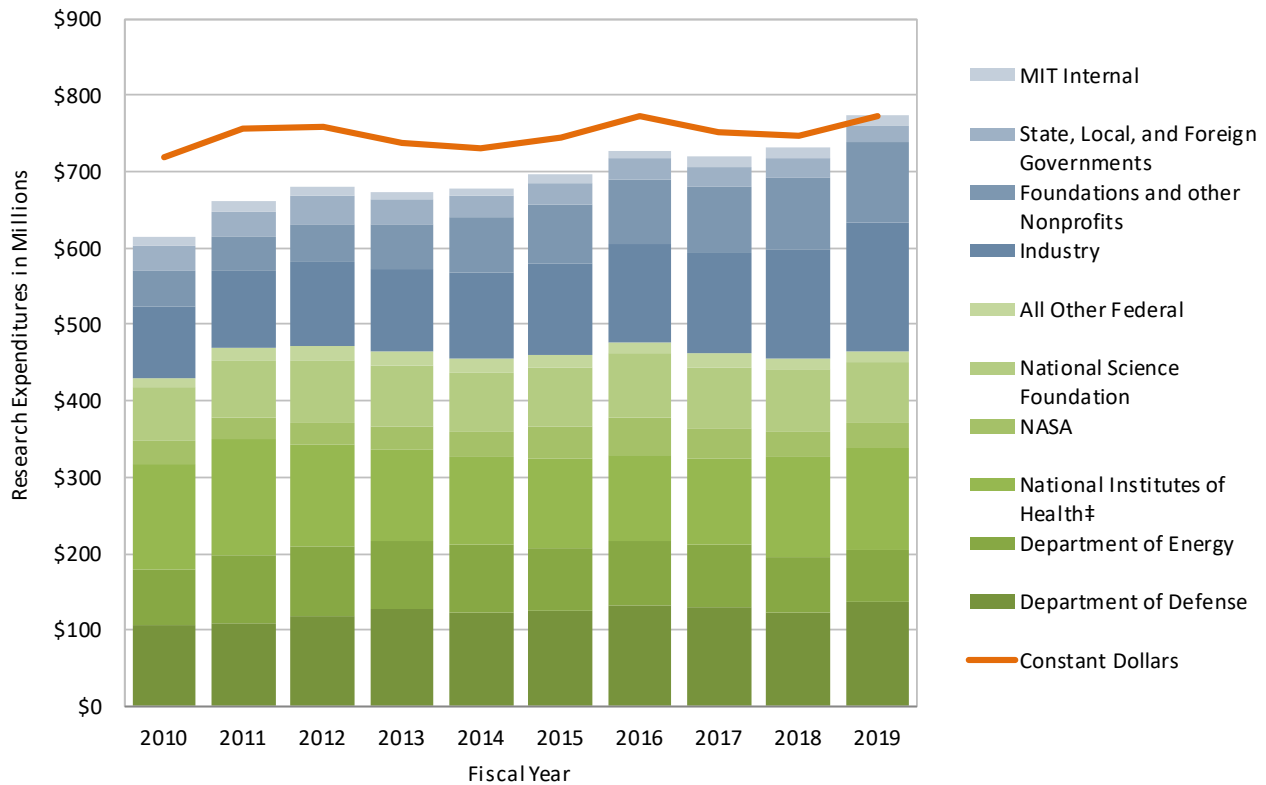
*Campus based Broad Institute research expenditures are excluded.

†Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2019 equaling 100.
‡National Institutes of Health data includes expenditures from other Department of Health and Human Services agencies which account for less than 2% of expenditures per year.

Department of Defense (DoD)

Selected projects funded by the DoD
Energy monitor can find electrical failures before they happen

A new system devised by MIT researchers can monitor the behavior of all electric devices within a building, ship, or factory, determining which ones are in use at any given time and whether any are showing signs of an imminent failure. When tested on a Coast Guard cutter, the system pinpointed a motor with burnt-out wiring that could have led to a serious onboard fire.

The new sensor, whose readings can be monitored on an easy-to-use graphic display called a NILM (non-intrusive load monitoring) dashboard, is described in *IEEE Transactions on Industrial Informatics*, in a paper by professor Steven Leeb, recent graduate Andre Aboulian MS '18, and seven others at MIT, the U.S. Coast Guard, and the U.S. Naval Academy.

The system uses a sensor that simply is attached to the outside of an electrical wire at a single point, without requiring any cutting or splicing of wires. From that single point, it can sense the flow of current in the adjacent wire, and detect the distinctive "signatures" of each motor, pump, or piece of equipment in the circuit by analyzing tiny, unique fluctuations in the voltage and current whenever a device switches on or off. The system can also be used to monitor energy usage, to identify possible efficiency improvements and determine when and where devices are in use or sitting idle.

https://bit.ly/2YfgMi0

Painting a fuller picture of how antibiotics act

Most antibiotics work by interfering with critical functions such as DNA replication or construction of the bacterial cell wall. These mechanisms represent only part of the full picture of how antibiotics act.

In a new study of antibiotic action, MIT researchers developed a new machine-learning approach to discover an additional mechanism that helps some antibiotics kill bacteria. This secondary mechanism involves activating the bacterial metabolism of nucleotides that the cells need to replicate their DNA.

Professor James Collins is senior author and research scientist Jason Yang is the lead author of the paper, which appears in *Cell*.

Many other researchers have used machine-learning models to analyze data by training an algorithm to generate predictions based on experimental data. However, these models are typically "black-box," meaning that they don't reveal the mechanisms that underlie their predictions. The MIT team took a "white-box" machine-learning approach. Before they began their computer modeling, the researchers performed hundreds of experiments to generate an array of "metabolic states" data. Then, they fed these states into a machine-learning algorithm, which was able to identify links between the different states and the outcomes of antibiotic treatment.

The "white-box" modeling approach used in this study could also be useful for studying how different types of drugs affect diseases such as cancer, diabetes, or neurodegenerative diseases, the researchers say.

https://bit.ly/2WATPVd

Spotting objects amid clutter

A new MIT-developed technique enables robots to quickly identify objects hidden in a three-dimensional cloud of data, reminiscent of how some people can make sense of a densely patterned "Magic Eye" image if they observe it in just the right way.

Robots typically "see" their environment through sensors that collect and translate a visual scene into a matrix of dots. Conventional techniques that try to pick out objects from such clouds of dots, or point clouds, can do so with either speed or accuracy, but not both. With their new technique, the researchers say a robot can accurately pick out an object within a dense cloud of dots, within seconds of receiving the visual data.

The researchers developed a three-step process to match the size, position, and orientation of the object in a point cloud with the template object, while simultaneously identifying good and bad feature associations. The team says the technique can be used to improve a host of situations in which machine perception must be both speedy and accurate, including driverless cars and robotic assistants in the factory and the home.

Assistant professor Luca Carlone and graduate student Heng Yang presented the details of the technique at the Robotics: Science and Systems conference.

https://bit.ly/33KZ4FP

Campus Research Expenditures (in U.S. Dollars)
Prime Sponsor Department of Defense
Fiscal Years 2015–2019

	2015	**2016**	**2017**	**2018**	**2019**
Campus research	125,853,521	131,624,119	130,371,698	123,512,935	136,743,404
Constant dollars*	134,676,332	139,906,450	136,072,214	126,072,575	136,743,404
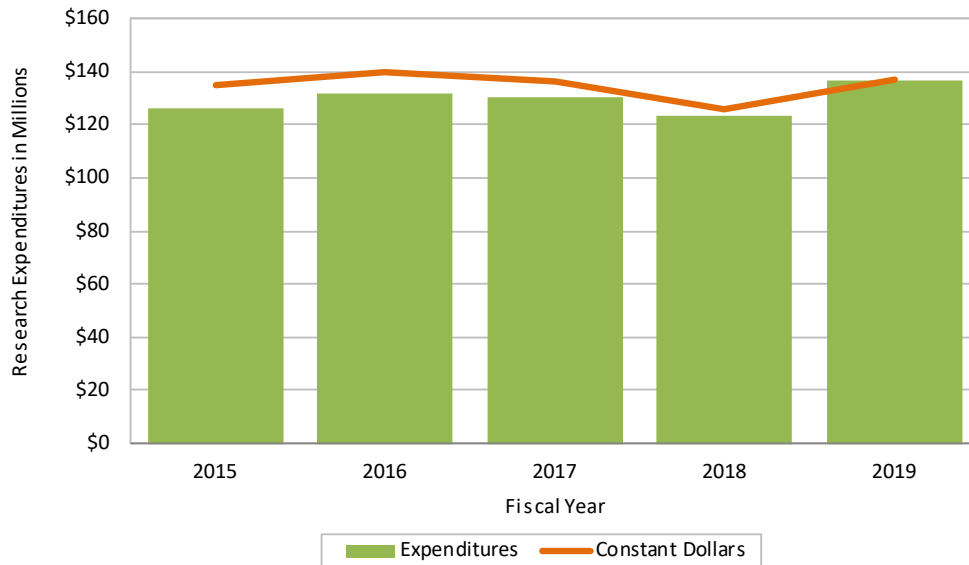
*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2019 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2019
(Shown in descending order of expenditures)

Research Laboratory of Electronics
Microsystems Technology Laboratories
Computer Science and Artificial
   Intelligence Laboratory
Biological Engineering
Institute for Soldier Nanotechnologies
Mechanical Engineering
Aeronautics and Astronautics
Media Laboratory
Chemical Engineering
Materials Research Laboratory

In fall 2018, the Department of Defense funded the primary appointments of graduate students with 312 research assistantships and 57 fellowships.

Thirty-five current faculty and staff have received the Office of Naval Research Young Investigator Program Award.

Department of Energy (DoE)

Selected projects funded by the DoE
New polymer films conduct heat instead of trapping it
Polymers are usually the go-to material for thermal insulation. Think of a silicone oven mitt, or a Styrofoam coffee cup, both manufactured from polymer materials that are excellent at trapping heat.

Now MIT engineers have flipped the picture of the standard polymer insulator, by fabricating thin polymer films that conduct heat—an ability normally associated with metals. In experiments, they found the films, which are thinner than plastic wrap, conduct heat better than ceramics and many metals, including steel.

The team's results, published in the journal *Nature Communications*, may spur the development of polymer insulators as lightweight, flexible, and corrosion-resistant alternatives to traditional metal heat conductors, for applications ranging from heat dissipating materials in laptops and cellphones, to cooling elements in cars and refrigerators.

Professor Gang Chen is a senior co-author on the paper. Other co-authors include lead author Yanfei Xu, along with Daniel Kraemer, Bai Song, Jiawei Zhou, James Loomis, Jianjian Wang, Mingda Li, Hadi Ghasemi, Xiaopeng Huang, and Xiaobo Li from MIT, and Zhang Jiang of Argonne National Laboratory.

In 2010, the team reported success in fabricating thin fibers of polyethylene that were 300 times more thermally conductive than normal polyethylene, and about as conductive as most metals. It soon became clear that, in order for polymer conductors to be used in various applications, the materials would have to be scaled up from ultrathin fibers to more manageable films. In the end, the team was able to fabricate thin films of conducting polymer, starting with a commercial polyethylene powder.

https://bit.ly/2DIvoOd

Experiments show dramatic increase in solar cell output
In any conventional silicon-based solar cell, there is an absolute limit on overall efficiency, based partly on the fact that each photon of light can only knock loose a single electron, even if that photon carried twice the energy needed to do so. But now,

researchers have demonstrated a method for getting high-energy photons striking silicon to kick out two electrons instead of one, opening the door for a new kind of solar cell with greater efficiency than was thought possible.

While conventional silicon cells have an absolute theoretical maximum efficiency of about 29.1 percent conversion of solar energy, the new approach, developed over the last several years by researchers at MIT and elsewhere, could bust through that limit, potentially adding several percentage points to that maximum output. The results are described in the journal *Nature*, in a paper by graduate student Markus Einzinger, professors Moungi Bawendi and Marc Baldo, and eight others at MIT and at Princeton University.

The basic concept behind this new technology has been known for decades, and the first demonstration that the principle could work was carried out by some members of this team six years ago. But actually translating the method into a full, operational silicon solar cell took years of hard work, Baldo says.

The key to splitting the energy of one photon into two electrons lies in a class of materials that possess "excited states" called excitons, Baldo says: In these excitonic materials, "these packets of energy propagate around like the electrons in a circuit," but with quite different properties than electrons. In this case, they were going through a process called singlet exciton fission, which is how the light's energy gets split into two separate, independently moving packets of energy. The material first absorbs a photon, forming an exciton that rapidly undergoes fission into two excited states, each with half the energy of the original state.

But the tricky part was then coupling that energy over into the silicon, a material that is not excitonic. This coupling had never been accomplished before.

As an intermediate step, the team tried coupling the energy from the excitonic layer into a material called quantum dots. What that work showed, Van Voorhis says, is that the key to these energy transfers lies in the very surface of the material, not in its bulk. That focus on the surface chemistry may have been what allowed this team to succeed where others had not, he suggests.

https://bit.ly/2P6C015

Campus Research Expenditures (in U.S. Dollars)
Prime Sponsor Department of Energy
Fiscal Years 2015–2019

	2015	2016	2017	2018	2019
Campus research	81,528,299	84,419,109	82,156,884	72,827,587	66,974,741
Constant dollars*	87,243,743	89,731,107	85,749,202	74,336,841	66,974,741
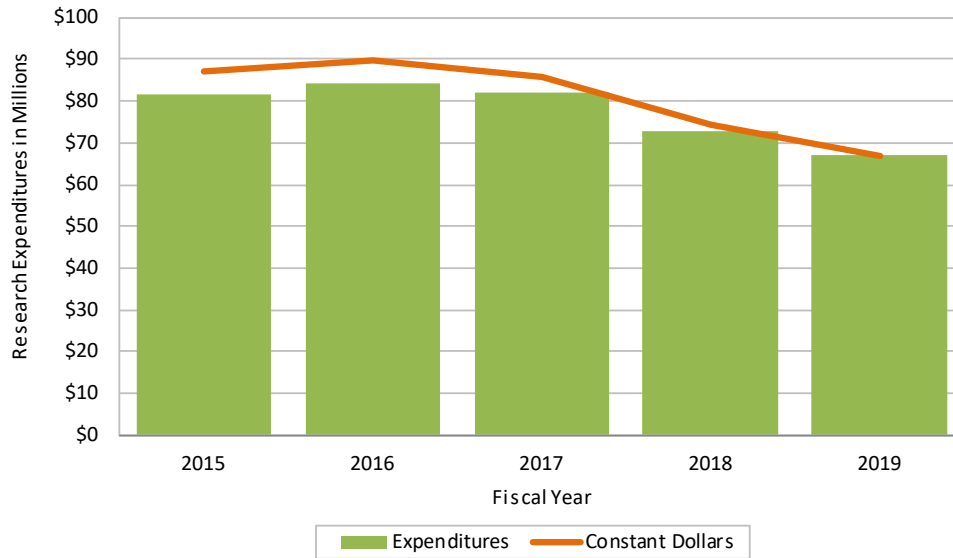
*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2019 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2019
(Shown in descending order of expenditures)

Laboratory for Nuclear Science
Plasma Science and Fusion Center
Nuclear Science and Engineering
Chemical Engineering
Materials Research Laboratory
Mechanical Engineering
Chemistry
Nuclear Reactor Laboratory
Materials Science and Engineering
Research Laboratory of Electronics

In fall 2018, the Department of Energy funded the primary appointments of graduate students with 158 research assistantships and 13 fellowships.

Twenty-eight current faculty have received the Department of Energy Outstanding Junior Investigator award or Early Career Research Program Award.

National Institutes of Health (NIH)

Selected projects funded by NIH
New pill can deliver insulin
An MIT-led research team has developed a drug capsule that could be used to deliver oral doses of insulin, potentially replacing the injections that people with type 1 diabetes have to give themselves every day.

About the size of a blueberry, the capsule contains a small needle made of compressed insulin, which is injected after the capsule reaches the stomach. In tests in animals, the researchers showed that they could deliver enough insulin to lower blood sugar to levels comparable to those produced by injections given through skin. They also demonstrated that the device can be adapted to deliver other protein drugs.

Professor Robert Langer is a senior author of the study. Giovanni Traverso, an assistant professor at Brigham and Women's Hospital, Harvard Medical School, and a MIT visiting scientist, is also a senior author of the study. The first author of the paper, which appears in *Science*, is MIT graduate student Alex Abramson. The research team also includes scientists from the pharmaceutical company Novo Nordisk.

The MIT team is now continuing to work with Novo Nordisk to further develop the technology and optimize the manufacturing process for the capsules. They believe this type of drug delivery could be useful for any protein drug that normally has to be injected, such as immunosuppressants used to treat rheumatoid arthritis or inflammatory bowel disease.
https://bit.ly/2Shl2ya

Imaging system helps surgeons remove tiny ovarian tumors
Ovarian cancer is usually diagnosed only after it has reached an advanced stage, with many tumors spread throughout the abdomen. Most patients undergo surgery to remove as many of these tumors as possible, but because some are so small and widespread, it is difficult to eradicate all of them.

Researchers at MIT, working with surgeons and oncologists at Massachusetts General Hospital, have now developed a way to improve the accuracy of this surgery. Using a fluorescence imaging system, they were able to find and remove tumors as small as

0.3 millimeters—smaller than a poppy seed—during surgery in mice. Mice that underwent this type of surgery survived 40 percent longer than those who had tumors removed without the guided system.

"What's nice about this system is that it allows for real-time information about the size, depth, and distribution of tumors," says Professor Angela Belcher. The researchers are now seeking FDA approval for a phase 1 clinical trial to test the imaging system in human patients. In the future, they hope to adapt the system for monitoring patients at risk for tumor recurrence, and eventually for early diagnosis of ovarian cancer, which is easier to treat if it is caught earlier.

Professor Angela Belcher and Michael Birrer, formerly the director of medical gynecologic oncology at MGH and now the director of the O'Neal Comprehensive Cancer Center at the University of Alabama at Birmingham, are the senior authors of the study, published online in the journal *ACS Nano*.
https://bit.ly/2IKgCuC

New material could make it easier to remove colon polyps
More than 15 million colonoscopies are performed in the United States every year, and in at least 20 percent of those, gastroenterologists end up removing precancerous growths from the colon. Eliminating these early-stage lesions, known as polyps, is the best way to prevent colon cancer from developing.

To reduce the risk of tearing the colon during this procedure, doctors often inject a saline solution into the space below the lesion, forming a "cushion" that lifts the polyp so that it's easier to remove safely. However, this cushion doesn't last long. MIT researchers have now devised an alternative—a solution that can be injected as a liquid but turns into a solid gel once it reaches the tissue, creating a more stable and longer-lasting cushion.

"That really makes a huge difference to the gastroenterologist who is performing the procedure, to ensure that there's a stable area that they can then resect using endoscopic tools," says assistant professor Giovanni Traverso and a gastroenterologist at Brigham and Women's Hospital. Traverso is the senior author of the study, which appears in *Advanced Science*.
https://bit.ly/2Mv7lZgI

Campus Research Expenditures (in U.S. Dollars)
Prime Sponsor National Institutes of Health*
Fiscal Years 2015–2019

	2015	2016	2017	2018	2019
Campus research	116,469,457	113,562,813	111,834,707	130,668,192	134,772,690
Constant dollars†	124,634,409	120,708,653	116,724,691	133,376,115	134,772,690
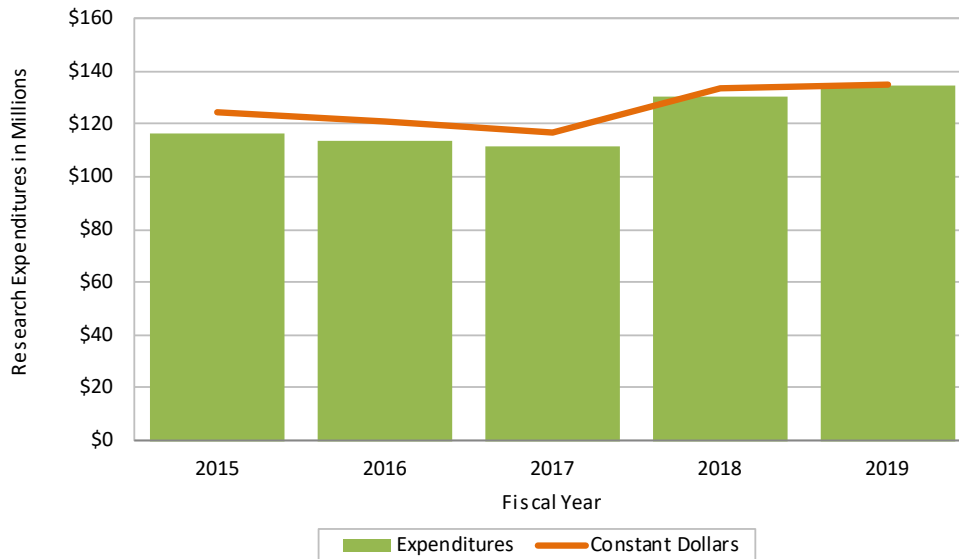
*Campus based Broad Institute research expenditures are excluded. National Institutes of Health data includes expenditures from other Department of Health and Human Services agencies which account for less than 2% of expenditures per year.
†Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2018 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2019
(Shown in descending order of expenditures)

Koch Institute for Integrative Cancer Research
Picower Institute for Learning and Memory
Biology
McGovern Institute for Brain Research
Institute for Medical Engineering and Science
Biological Engineering
Center for Environmental Health Sciences
Chemistry
Media Laboratory
Computer Science and Artificial
    Intelligence Laboratory

In fall 2018, the National Institutes of Health funded the primary appointments of graduate students with 174 research assistantships and 17 fellowships.

Eight current faculty have received the NIH Director's Pioneer Award. The recipients are Edward Boyden, Emery Brown, Arup Chakraborty, James Collins, Nancy Kanwisher, Aviv Regev, Kay Tye, and Feng Zhang.

NASA

Selected projects funded by NASA

MIT and NASA engineers demonstrate a new kind of airplane wing

A team of engineers has built and tested a radically new kind of airplane wing, assembled from hundreds of tiny identical pieces. The wing can change shape to control the plane's flight, and could provide a significant boost in aircraft production, flight, and maintenance efficiency, the researchers say.

The new approach to wing construction could afford greater flexibility in the design and manufacturing of future aircraft. The new wing design was tested in a NASA wind tunnel and is described in a paper in the journal *Smart Materials and Structures*, co-authored by research engineer Nicholas Cramer at NASA Ames in California; MIT alumnus Kenneth Cheung SM '07 PhD '12, now at NASA Ames; Benjamin Jenett, a graduate student; and eight others.

Instead of requiring separate movable surfaces such as ailerons to control the roll and pitch of the plane, as conventional wings do, the new assembly system makes it possible to deform the whole wing, or parts of it, by incorporating a mix of stiff and flexible components in its structure. The tiny subassemblies, which are bolted together to form an open, lightweight lattice framework, are then covered with a thin layer of similar polymer material as the framework.

The result is a wing that is much lighter, and thus much more energy efficient, than those with conventional designs, the researchers say. Because the structure, comprising thousands of tiny triangles of matchstick-like struts, is composed mostly of empty space, it forms a mechanical "metamaterial" that combines the structural stiffness of a rubber-like polymer and the extreme lightness and low density of an aerogel.

The same system could be used to make other structures as well, Jenett says, including the wing-like blades of wind turbines, where the ability to do on-site assembly could avoid the problems of transporting ever-longer blades. Similar assemblies are being developed to build space structures, and could eventually be useful for bridges and other high performance structures.

https://bit.ly/2FGARW1

TESS discovers three new planets nearby, including temperate "sub-Neptune"

NASA's MIT-developed Transiting Exoplanet Survey Satellite, or TESS, has discovered three new worlds that are among the smallest, nearest exoplanets known to date. The planets orbit a star just 73 light-years away and include a small, rocky super-Earth and two sub-Neptunes—planets about half the size of our own icy giant.

The sub-Neptune furthest out from the star appears to be within a "temperate" zone, meaning that the very top of the planet's atmosphere is within a temperature range that could support some forms of life. However, scientists say the planet's atmosphere is likely a thick, ultradense heat trap that renders the planet's surface too hot to host water or life.

Nevertheless, this new planetary system, which astronomers have dubbed TOI-270, is proving to have other curious qualities. For instance, all three planets appear to be relatively close in size. There's nothing in our solar system that resembles an intermediate planet, with a size and composition somewhere in the middle of Earth and Neptune. But TOI-270 appears to host two such planets: both sub-Neptunes are smaller than our own Neptune and not much larger than the rocky planet in the system.

Astronomers believe TOI-270's sub-Neptunes may be a "missing link" in planetary formation, as they are of an intermediate size and could help researchers determine whether small, rocky planets like Earth and more massive, icy worlds like Neptune follow the same formation path or evolve separately.

 "There are a lot of little pieces of the puzzle that we can solve with this system," says postdoc Maximilian Günther, lead author of a study published in *Nature Astronomy* that details the discovery. "You can really do all the things you want to do in exoplanet science, with this system."

https://bit.ly/2zcT1vS

Campus Research Expenditures (in U.S. Dollars)
Prime Sponsor NASA
Fiscal Years 2015–2019

	2015	2016	2017	2018	2019
Campus research	41,739,692	49,663,884	39,808,538	33,023,532	32,429,614
Constant dollars*	44,665,803	52,788,940	41,549,171	33,707,900	32,429,614
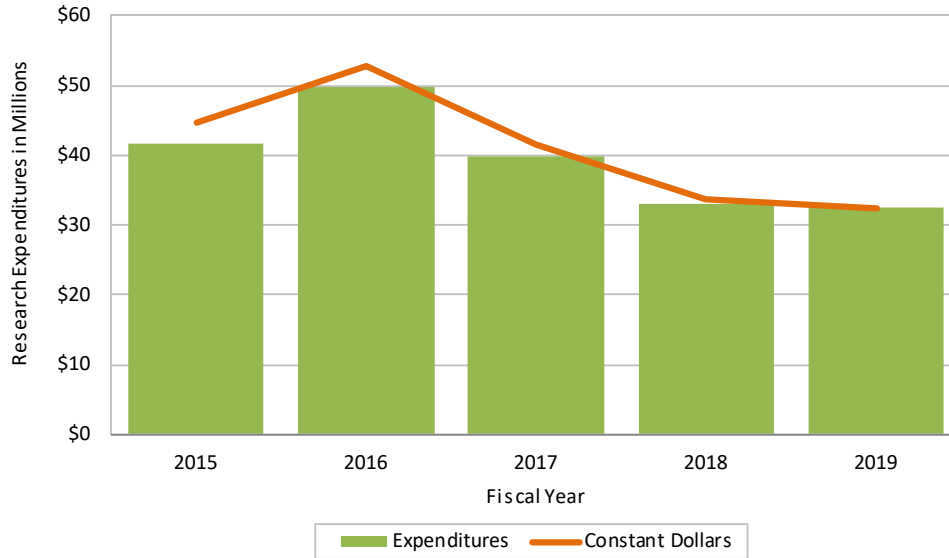
*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2019 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2019
(Shown in descending order of expenditures)

Kavli Institute for Astrophysics and Space Research
Earth, Atmospheric and Planetary Sciences
Aeronautics and Astronautics
Haystack Observatory
Center for Global Change Science
Civil and Environmental Engineering
Research Laboratory of Electronics
Mechanical Engineering
Computer Science and Artificial
   Intelligence Laboratory
Koch Institute for Integrative Cancer Research

In fall 2018, NASA funded the primary appointments of graduate students with 53 research assistantships and 16 fellowships.

National Science Foundation (NSF)

Selected projects funded by NSF
Robots track moving objects with unprecedented precision

A novel system developed at MIT uses RFID tags to help robots home in on moving objects with unprecedented speed and accuracy. The system could enable greater collaboration and precision by robots working on packaging and assembly, and by swarms of drones carrying out search-and-rescue missions.

In a paper presented at the USENIX Symposium on Networked Systems Design and Implementation, the researchers show that robots using the system can locate tagged objects within 7.5 milliseconds, on average, and with an error of less than a centimeter.

In the system, called TurboTrack, an RFID (radio-frequency identification) tag can be applied to any object. A reader sends a wireless signal that reflects off the RFID tag and other nearby objects, and rebounds to the reader. An algorithm sifts through all the reflected signals to find the RFID tag's response. Final computations then leverage the RFID tag's movement—even though this usually decreases precision—to improve its localization accuracy.

Graduate student Zhihong Luo is first author of the paper. The other Media Lab co-authors on the paper are visiting student Qiping Zhang, postdoc Yunfei Ma, and Research Assistant Manish Singh.

<div align="right">https://bit.ly/2TcqqCx</div>

Working out makes hydrogels perform more like muscle

Human skeletal muscles have a unique combination of properties that materials researchers seek for their own creations. They're strong, soft, full of water, and resistant to fatigue. A new study by MIT researchers has found one way to give synthetic hydrogels this total package of characteristics: putting them through a vigorous workout.

In particular, the scientists mechanically trained the hydrogels by stretching them in a water bath. And just as with skeletal muscles, the reps at the "gym" paid off. The training aligned nanofibers inside the hydrogels to produce a strong, soft, and hydrated material that resists breakdown or fatigue over thousands of repetitive movements.

The polyvinyl alcohol (PVA) hydrogels trained in the experiment are well-known biomaterials that researchers use for medical implants, drug coatings, and other applications, says Associate Professor Xuanhe Zhao. "But one with these four important properties has not been designed or manufactured until now."

In their paper, published in the *Proceedings of the National Academy of Sciences*, Zhao and his colleagues describe how the hydrogels also can be 3D-printed into a variety of shapes that can be trained to develop the suite of muscle-like properties.

In the future, the materials might be used in implants such as "heart valves, cartilage replacements, and spinal disks, as well as in engineering applications such as soft robots," Zhao says.

<div align="right">https://bit.ly/2NoPLpw</div>

Study demonstrates seagrass' strong potential for curbing erosion

Most people's experience with seagrass, if any, amounts to little more than a tickle on their ankles while wading in shallow coastal waters. But it turns out these ubiquitous plants, varieties of which exist around the world, could play a key role in protecting vulnerable shores as they face onslaughts from rising sea levels.

New research for the first time quantifies, through experiments and mathematical modelling, just how large and how dense a continuous meadow of seagrass must be to provide adequate damping of waves in a given geographic, climatic, and oceanographic setting.

In a pair of papers appearing in two research journals, *Coastal Engineering* and the *Journal of Fluids and Structures*, professor Heidi Nepf and doctoral student Jiarui Lei describe their findings and the significant environmental benefits seagrass offers. These include not only preventing beach erosion and protecting seawalls and other structures, but also improving water quality and sequestering carbon to help limit future climate change.

<div align="right">https://bit.ly/2H3Dzpa</div>

Campus Research Expenditures (in U.S. Dollars)
Prime Sponsor National Science Foundation
Fiscal Years 2015–2019

	2015	**2016**	**2017**	**2018**	**2019**
Campus research	78,952,919	82,160,804	80,410,343	81,563,231	79,616,644
Constant dollars*	84,487,819	87,330,700	83,926,294	83,253,519	79,616,644
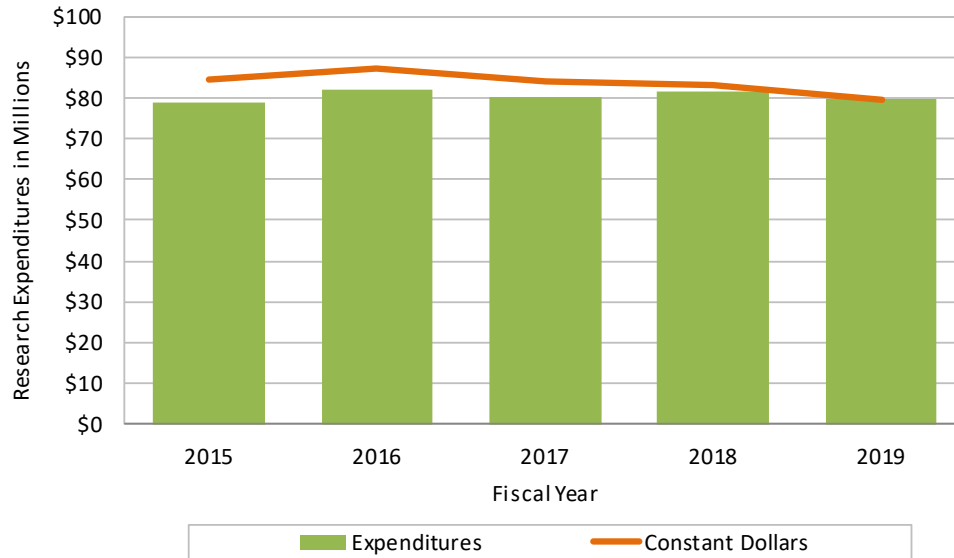
*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2019 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2019
(Shown in descending order of expenditures)

Computer Science and Artificial
   Intelligence Laboratory
Kavli Institute for Astrophysics and Space Research
Materials Research Laboratory
McGovern Institute for Brain Research
Biological Engineering
Earth, Atmospheric and Planetary Sciences
Haystack Observatory
Mathematics
Research Laboratory of Electronics
Mechanical Engineering

In fall 2018, the National Science Foundation (NSF) funded the primary appointments of graduate students with 217 research assistantships. In the 2018–2019 academic year, NSF supported, at least in part, 391 students through fellowships.

The National Science Foundation has awarded Faculty Early Career Development (CAREER) Awards to 179 current faculty and staff members.

Other Federal Agencies

Selected projects funded by other federal agencies
Deep-learning technique reveals "invisible" objects in the dark
Small imperfections in a wine glass or tiny creases in a contact lens can be tricky to make out, even in good light. In almost total darkness, images of such transparent features or objects are nearly impossible to decipher. But now, engineers at MIT have developed a technique that can reveal these "invisible" objects, in the dark.

In a study published in *Physical Review Letters*, the researchers reconstructed transparent objects from images of those objects, taken in almost pitch-black conditions. They did this using a "deep neural network," a machine-learning technique that involves training a computer to associate certain inputs with specific outputs—in this case, dark, grainy images of transparent objects and the objects themselves.

The team trained a computer to recognize more than 10,000 transparent glass-like etchings, based on extremely grainy images of those patterns. The images were taken in very low lighting conditions, with about one photon per pixel—far less light than a camera would register in a dark, sealed room. They then showed the computer a new grainy image, not included in the training data, and found that it learned to reconstruct the transparent object that the darkness had obscured.

The results demonstrate that deep neural networks may be used to illuminate transparent features such as biological tissues and cells, in images taken with very little light.

George Barbastathis is a co-author on the paper with lead author Alexandre Goy, Kwabena Arthur, and Shuai Li.

<div align="right">https://bit.ly/2Ev5XSi</div>

Shift to renewable electricity a win-win at statewide level
Amid rollbacks of the Clean Power Plan and other environmental regulations at the federal level, several U.S. states, cities, and towns have resolved to take matters into their own hands and implement policies to promote renewable energy and reduce greenhouse gas emissions. One popular approach,

now in effect in 29 states and the District of Columbia, is to set Renewable Portfolio Standards (RPS), which require electricity suppliers to source a designated percentage of electricity from available renewable-power generating technologies.

Boosting levels of renewable electric power not only helps mitigate global climate change, but also reduces local air pollution. Quantifying the extent to which this approach improves air quality could help legislators better assess the pros and cons of implementing policies such as RPS. Toward that end, a research team at MIT has developed a new modeling framework that combines economic and air-pollution models to assess the projected subnational impacts of RPS and carbon pricing on air quality and human health, as well as on the economy and on climate change. In a study focused on the U.S. Rust Belt, their assessment showed that the financial benefits associated with air quality improvements from these policies would more than pay for the cost of implementing them. The results appear in the journal *Environmental Research Letters*. The study's lead author is senior research associate Emil Dimanchev. MIT Associate Professor Noelle Selin led the study.

Burning fossil fuels for energy generation results in air pollution in the form of fine particulate matter (PM2.5). Exposure to PM2.5 can lead to adverse health effects. But avoiding those health effects—and the medical bills, lost income, and reduced productivity that comes with them—through the adoption of cleaner energy sources translates into significant cost savings, known as health co-benefits.

Applying their modeling framework, the MIT researchers estimated that existing RPS in the nation's Rust Belt region generate a health co-benefit of $94 per ton of carbon dioxide (CO_2) reduced in 2030, or 8 cents for each kilowatt hour (kWh) of renewable energy deployed in 2015 dollars. Their central estimate is 34 percent larger than total policy costs. The team also determined that carbon pricing delivers a health co-benefit of $211 per ton of CO_2 reduced in 2030, 63 percent greater than the health co-benefit of reducing the same amount of CO_2 through an RPS approach. The MIT research team's results are consistent with previous studies, which found that the health co-benefits of climate policy (including RPS and other instruments) tend to exceed policy costs.
<div align="right">https://bit.ly/2Z3NMsN</div>

Campus Research Expenditures (in U.S. Dollars)
Prime Sponsor Other Federal Agencies
Fiscal Years 2015–2019

	2015	2016	2017	2018	2019
Campus research	15,435,252	15,738,434	17,043,458	12,901,728	14,180,419
Constant dollars*	16,517,322	16,728,761	17,788,685	13,169,099	14,180,419
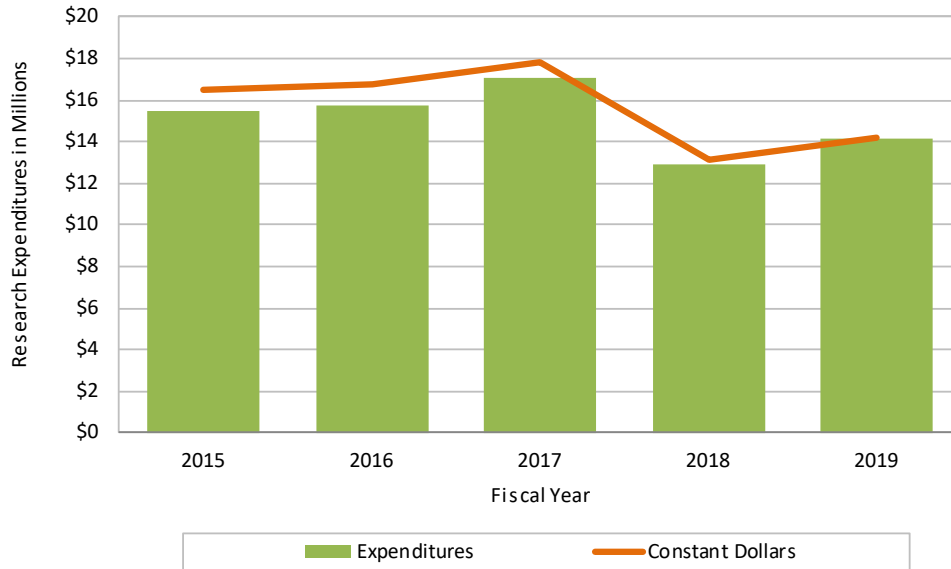
*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2019 equaling 100.

A few of the leading other federal agencies providing funding are the U.S. Department of Commerce, the U.S. Agency for International Development, the U.S. Department of Interior, the Federal Aviation Administration, the Intelligence Advanced Research Projects Activity (IARPA), and the U.S. Department of Transportation.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2019
(Shown in descending order of expenditures)

Mechanical Engineering
Center for Transportation and Logistics
Aeronautics and Astronautics
Computer Science and Artificial
   Intelligence Laboratory
Civil and Environmental Engineering
Office of Experiential Learning
Materials Research Laboratory
Center for Global Change Science
Laboratory for Information and Decision Systems
Earth, Atmospheric and Planetary Sciences

In fall 2018, other federal agencies funded the primary appointments of graduate students with 38 research assistantship.

Nonprofit Organizations

Selected projects funded by nonprofit organizations
Reducing the burden of tuberculosis treatment
Tuberculosis is one of the world's deadliest infectious diseases: One-third of the world's population is infected with TB, and more than 1 million people die from the disease every year.

One reason TB is so pervasive is that treatment requires a six-month course of daily antibiotics, which is difficult for about half of all patients to adhere to, especially in rural areas with limited access to medical facilities. To help overcome that, a team of researchers led by MIT has devised a new way to deliver antibiotics, which they hope will make it easier to cure more patients and reduce health care costs.

Using this new approach, a coiled wire loaded with antibiotics is inserted into the patient's stomach through a nasogastric tube. Once in the stomach, the device slowly releases antibiotics over one month, eliminating the need for patients to take pills every day.

Assistant professor Giovanni Traverso, a gastroenterologist at Brigham and Women's Hospital, and Professor Robert Langer are the senior authors of the study, which appears in *Science Translational Medicine*. The paper's lead author is MIT graduate student Malvika Verma; the team includes others at MIT, as well as from Harvard Medical School, Boston University School of Public Health, several hospitals in India, and the Tata Trusts of Mumbai, India.
https://bit.ly/2TKGfR3

Brain wave stimulation may improve Alzheimer's symptoms
By exposing mice to a unique combination of light and sound, MIT neuroscientists have shown that they can improve cognitive and memory impairments similar to those seen in Alzheimer's patients.

This noninvasive treatment, which works by inducing brain waves known as gamma oscillations, also greatly reduced the number of amyloid plaques found in the brains of these mice. Plaques were cleared in large swaths of the brain, including areas critical for cognitive functions such as learning and memory.

"When we combine visual and auditory stimulation for a week, we see the engagement of the prefrontal cortex and a very dramatic reduction of amyloid," says Li-Huei Tsai, director of MIT's Picower Institute for Learning and Memory and the senior author of the study.

Further study will be needed, she says, to determine if this type of treatment will work in human patients. The researchers have already performed some preliminary safety tests of this type of stimulation in healthy human subjects.

MIT graduate student Anthony Martorell and Georgia Tech graduate student Abigail Paulson are the lead authors of the study, which appears in *Cell*.
https://bit.ly/2CiAeB2

A better way to encapsulate islet cells for diabetes treatment
When medical devices are implanted in the body, the immune system often attacks them, producing scar tissue around the device, known as fibrosis, which can interfere with the device's function.

MIT researchers have now come up with a novel way to prevent fibrosis from occurring, by incorporating a crystallized immunosuppressant drug into devices. After implantation, the drug is slowly secreted to dampen the immune response in the area immediately surrounding the device.

"We developed a crystallized drug formulation that can target the key players involved in the implant rejection, suppressing them locally and allowing the device to function for more than a year," says Shady Farah, an MIT and Boston Children's Hospital postdoc and co-first author of the study.

The researchers showed that these crystals could dramatically improve the performance of encapsulated islet cells, which they are developing as a possible treatment for patients with type 1 diabetes. Such crystals could also be applied to a variety of other implantable medical devices, such as pacemakers, stents, or sensors.

Former MIT postdoc Joshua Doloff, now an assistant professor at Johns Hopkins University School of Medicine, is also a lead author of the paper, which appears in *Nature Materials*. Daniel Anderson, an MIT associate professor, is the senior author of the paper.
https://bit.ly/2L0yjof

Campus Research Expenditures (in U.S. Dollars)
Prime Sponsor Nonprofit Organizations
Fiscal Years 2015–2019

	2015	2016	2017	2018	2019
Campus research	78,666,639	84,015,000	86,752,718	94,322,337	104,470,528
Constant dollars*	84,181,469	89,301,570	90,545,990	96,277,041	104,470,528
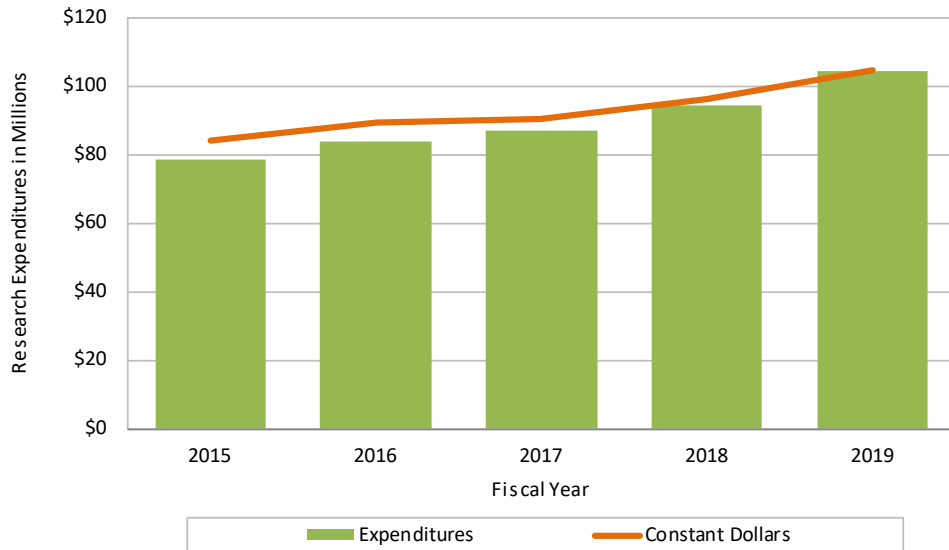
*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2019 equaling 100.

**Leading Departments, Laboratories, and Centers
Receiving Support in Fiscal Year 2019**
(Shown in descending order of expenditures)

Koch Institute for Integrative Cancer Research
Economics
Biology
Computer Science and Artificial
   Intelligence Laboratory
Mechanical Engineering
McGovern Institute for Brain Research
Civil and Environmental Engineering
Research Laboratory of Electronics
Media Laboratory
Biological Engineering

Section 5
Lincoln Laboratory

Lincoln Laboratory

MIT Lincoln Laboratory is a federally funded research and development center (FFRDC) operated by the Institute under contract with the Department of Defense (DoD). The Laboratory's core competencies are in sensors, information extraction (signal processing and embedded computing), communications, integrated sensing, and decision support, all supported by a strong program in advanced electronics technology.

Lincoln Laboratory's mission is to apply technology to problems of national security. Technology development is focused on these research areas—space control; air, missile, and maritime defense technology; communication systems; cyber security and information sciences; intelligence, surveillance, and reconnaissance systems; advanced technologies; artificial intelligence; bioengineering and biomedical research; autonomous systems; microelectronics; quantum systems; energy; tactical systems; and homeland protection; as well as nondefense projects in air traffic control and weather surveillance.

Two of our principal objectives are (1) development of components and systems for experiments, engineering measurements, and tests under field operating conditions and (2) dissemination of information to the government, academia, and industry. Program activities extend from fundamental investigations through the design process, to field demonstrations of prototype systems. Emphasis is placed on transitioning systems and technology to operational use in military deployments and to the defense industry.

MIT Lincoln Laboratory also maintains long-term competency, retains high-quality staff, provides independent perspective on critical issues, sustains strategic sponsor relationships, and develops technology for long-term interests and short-term, high-priority needs of our DoD sponsors. Significant milestones reached in several areas represent only a fraction of the technology developed over the past year.

- A novel infrared search-and-track system that was tested in maritime environments will be used to inform the design of a future naval sensor for persistent surveillance.

- The Laboratory's advanced imaging ladar system was flown over Puerto Rico to generate a baseline map of ground conditions that will be used to direct U.S. recovery efforts if a disastrous hurricane hits again.

- The Micro-sized Microwave Atmospheric Satellite CubeSat, launched into low Earth orbit in early 2018, successfully demonstrated an advanced compact microwave sounder and provided the first multiband radiometer measurements from a CubeSat payload.

- A NASA probe called the Transiting Exoplanet Survey Satellite (TESS) was launched into orbit last spring. This probe, developed with the MIT Kavli Institute for Astrophysics and Space Research, and NASA's Goddard Space Flight Center, will search for Earth-like planets that may have the possibility of harboring life.

- Through our R&D into technology to protect the nation's critical infrastructure, such as mass transit systems, against explosive attacks, we demonstrated a system to detect threats concealed on persons who are in areas of high pedestrian traffic.

- A new field-programmable imaging array integrated circuit that can be reused by multiple ladar and imaging systems greatly extends the capabilities of the widely adaptable digital focal plane array we developed.

- We successfully demonstrated the first balloon-based communications relay array, which used ten balloon-borne payloads to achieve over-the-horizon communications despite co-channel interference.

- Our energy resilience analysis methodology and software were deployed to 27 Department of Defense installations around the world and are slated to be adopted by more military installations for future energy assessments.

- We have developed architectures that allow us to integrate cyber security into small satellites.

Lincoln Laboratory—Past and Future

The Founding of MIT Lincoln Laboratory

In September 1949, President Truman announced that the rumors of a Soviet nuclear capability were well founded; the world had evidence that an atomic bomb had been tested by the Soviets in August. This news and the subsequent confirmation that the Soviet Union had developed long-range aircraft capable of reaching the United States via an Arctic route caused the Department of Defense to examine its defenses against an air attack. When the DoD determined that the nation did not have an effective, modern system that would provide timely warning of, and then engage countermeasures to, a nuclear air strike, it tasked the Air Force with improving U.S. air defenses.

A committee led by the Air Force and made up of experts in aeronautics, physics, and radar studied the problem and proposed the creation of a laboratory to develop a new air defense system. Because of the seminal, and revolutionary, work on radar systems done at MIT's Radiation Laboratory to support the Allies' efforts during World War II, this Air Defense Systems Engineering Committee proposed the laboratory be run by MIT.

The Lincoln Laboratory Site at Hanscom AFB

MIT President James Killian initially was not eager to engage the Institute in another long-term, complex, and classified military project, preferring to see MIT resources return to the mission of education and open research. However, he finally agreed to this new venture, but with the stipulation that the laboratory be located away from the MIT campus, which he wished to maintain as a research environment unencumbered by security restrictions.

The Air Force, which was the sponsor for the new air defense system, already owned the Hanscom AFB site. It had ample space for a new facility and access to Air Force consultants. So in 1951, construction began on the buildings that would be the home of R&D into the radar-based air defense system called SAGE (for Semi-Automatic Ground Environment). For the next six years, Lincoln Laboratory developed the SAGE system, which eventually digitally connected 100s of radars to an array of command centers, transformed computing by pioneering the magnetic core memory, and spawned several defense companies.

Lincoln Laboratory as an FFRDC

Lincoln Laboratory was founded as a federally funded research and development center (FFRDC). An FFRDC assists the U.S. government with scientific research and analysis, systems development, and systems acquisition to provide novel, cost-effective solutions to complex government problems. Combining the expertise and outlook of government, industry, and academia, FFRDCs are independent, nonprofit labs that are prohibited from competing with industry or working for commercial companies.

Each FFRDC is sponsored by a government agency but is privately managed by a university or another not-for-profit organization. Currently, 42 FFRDCs are providing various U.S. government agencies with R&D in fields ranging from defense to energy, space, and health and human services. Lincoln Laboratory is a Department of Defense FFRDC, managed by MIT under a contract with the U.S. Air Force.

Lincoln Laboratory's Move to the Future

After the SAGE system was completed, Lincoln Laboratory—with its technological experience, excellent technical staff, and lab and computing facilities—was positioned to tackle new DoD problems, a chief one being the advent of ballistic missiles. For 68 years, Lincoln Laboratory has found new challenges to undertake, applying its deep and broad knowledge of sensors and signal processing to developing technology for not only air and missile defense but also communication systems, space systems, advanced imaging, and more recently bioengineering, cybersecurity, and artificial intelligence.

To support the wide variety of its work that requires advanced microelectronics, Lincoln Laboratory is undertaking the construction of a Compound Semiconductor Laboratory and Microsystem Integration Facility. The new facility will be part of the research complex that still contains the four original 1951-era buildings, the Microelectronics Laboratory built in the early 1990s, and South Laboratory completed in 1995.

Breakdown of Laboratory Program Funding

Total Funding FY2018*= $1,027.1 million

Sponsor

- Non-Department of Defense 13%
- Department of Defense 87%

Mission Area

- Tactical Systems 11%
- Advanced Technology 12%
- Advanced Research Portfolio 4%
- Homeland Protection 9%
- Aviation Research—FAA 3%
- Air Defense 6%
- Ballistic Missile Defense 8%
- Communication Systems 17%
- Cyber Security and Information Sciences 7%
- Space Control 15%
- ISR Systems and Technology 8%

Total Funding
Fiscal Years 2014–2018*

Fiscal Year	Department of Defense	Other Programs
2014	851.3	80.5
2015	842.8	94.5
2016	881.0	91.8
2017	886.9	128.4
2018	889.4	137.7

Authorized Funding in Millions

■ Department of Defense   ■ Other Programs

*Lincoln Laboratory fiscal year runs concurrent with the U.S. Government fiscal year, October 1–September 30.

Major Programs/Prototypes

Early Alerts to Pathogen Exposure

Researchers at Lincoln Laboratory, in collaboration with the National Institutes of Health Integrated Research Facility (NIH-IRF) and the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), developed the Presymptomatic Agent Exposure Detection (PRESAGED) algorithm that provides early identification of pathogen exposures. The algorithm uses real-time physiological data, such as heart rate or core body temperature, to calculate the probability of a person's having been exposed to a virus or bacteria. A Laboratory team evaluated outbreak responses ranging from isolation of individuals with overt symptoms to broad quarantine of people with a probability of pathogen exposure. Through simulation and modeling, they estimated the spread of infection under different quarantine responses, and they calculated the effects of PRESAGED early warning on those estimates. Initial results show that the spread of infection could be almost halved if PRESAGED prompted early treatment and isolation of individuals identified as having been exposed to the pathogen.

TESS Cameras Will Discover Exoplanets

The Transiting Exoplanet Survey Satellite (TESS) is a NASA Astrophysics Explorer mission led and operated by MIT and managed by NASA's Goddard Space Flight Center. Aboard TESS are four identical cameras that Lincoln Laboratory developed in collaboration with the MIT Kavli Institute for Astrophysics and Space Research. Over a two-year mission, these cameras will gaze at 85% of the sky, collecting photons given off from 20 million neighboring stars and capturing any discreet dips in these stars' brightness. These dips in light indicate that an exoplanet—a planet outside of our solar system—is orbiting the star. To record the intensity and position of light, charge-coupled devices (CCDs) convert photons into electrons that are then stored in a pixel. Laboratory engineers achieved very high photon sensitivity in the CCDs, which allows the CCD to collect more light at the pixel level. Scientists expect TESS to discover thousands of new exoplanets. Through its observations, TESS will build a catalog of exoplanets that are close enough to our solar system to be studied in greater detail with ground-based telescopes.

Ladar Helps Assess Damage in Puerto Rico

In the wake of a disaster, responding agencies need to assess damage quickly to determine where to focus their efforts. Conducting damage assessments is currently a slow, manual process that requires Federal Emergency Management Agency (FEMA) personnel to walk, drive, and fly around to document and inspect damage. Lincoln Laboratory is using ladar and specialized algorithms to help FEMA automate damage assessments and speed up recovery actions.

During summer 2018, researchers scanned the entire island of Puerto Rico with the Airborne Optical Systems Testbed (AOSTB). The AOSTB uses single-photon-sensitive, time-of-flight imaging technology to collect information about the surface characteristics of the land below. This ladar system, which is 10 to 100 times more capable than any commercial system available, enabled staff to generate a high-resolution 3D ladar map of the island that showed the latest topographical conditions and debris resulting from the 2017 hurricanes.

Laboratory staff developed automated algorithms to quickly find points of interests on the map, such as buildings, roads, and powerlines. FEMA used this information to assess damages, quantify debris, inspect infrastructure, and monitor erosion and reconstruction. The data were also used for preventative purposes, for example, to model flood plains in areas where new infrastructure is being planned. Lincoln Laboratory plans to expand this work by adding additional sensors to the AOSTB and collecting data over other areas of the United States that are susceptible to natural disasters.

Major Technology Transfers

Air, Missile, and Maritime Defense Technology

Lincoln Laboratory prototyped and demonstrated automation algorithms and associated operator displays in support of wide-area passive acoustic undersea surveillance. The intellectual property was transitioned to PMS-485 and is undergoing further development to be inserted into the Integrated Undersea Surveillance System common software suite.

Air Traffic Control

Air traffic controllers in Houston, Miami, San Juan, and New York, and at the National Air Traffic Control System Command Center near Washington, D.C., are using radar-like images estimated by the Offshore Precipitation Capability that was developed by Lincoln Laboratory to help plan safe, efficient routes through airspace over oceanic regions outside the coverage of land-based radar systems.

Supercomputing

The BigDAWG polystore system, created with MIT and other universities, was released as an open-source product. Polystore systems have spurred a new field of database research, and BigDAWG as a software package is currently being evaluated by a number of organizations.

The GraphBLAS open standard that was created by a consortium led by the research team at the Lincoln Laboratory Supercomputing Center to solve large graph problems was officially released to the community. The Julia programming language, co-founded by the Lincoln Laboratory Supercomputing Center and used by millions of programmers worldwide, was successfully transitioned to a startup company.

Communication Systems

The design for a compact off-axis telescope was transitioned to industry in support of laser communication terminals being developed for NASA's Orion Crew Exploration Vehicle and the International Space Station.

Cyber Security and Information Sciences

Software developed in a project called the Scalable Cyber Analytic Processing Environment was released as open-source. The software allows researchers to explore multisource cyber defense datasets. We transferred a Security Cyber Module prototype to be used for securing communication of future ground unmanned systems, such as explosive-ordnance disposal robots. The Laboratory also transferred its high-assurance cryptographic and key management technology, called SHAMROCK, to GE Aviation in support of the Agile Resilient Embedded Systems program. In support of the U.S. Army's High Performance Computing Modernization Program, the Cyber Adversarial Scenario Modeling and Artificial Intelligence Decision Engine prototype is being transitioned to provide automated network segmentation in response to detected cyber threats.

Open-Source Analytics and Tools

Lincoln Laboratory transitioned 10 state-of-the-art open-source analytics and tools to the Defense Advanced Research Projects Agency's Memex Open Catalog:

- MIT Information Extraction Toolkit

- Lincoln Laboratory Text Classification tool

- Topic classifier

- Speech processing tool for speaker, language, and gender recognition

- VizLinc, a visual analytics platform

- TweetE, a tool for processing Twitter postings

- Lincoln Laboratory Author Classification tool

- String processing software

- Tool for efficient searching via an index of locality-sensitive hash tags

- GraphQuBE, a tool that enables graph query-by-example

Lincoln Laboratory Mission Areas

Air, Missile, and Maritime Defense Technology

Researchers in this area are investigating system architectures, prototyping pathfinder systems, and demonstrating these advanced, integrated sensor systems that are designed for use on tactical air and maritime platforms to provide defense against missiles and other threats.

Communication Systems

The work in this research area focuses on developing and demonstrating tactical network radios, radio-frequency (RF) military satellite communications, free-space laser communications, and quantum systems to expand and protect the nation's global defense networks.

Cyber Security and Information Sciences

Goals in this research area include conducting research, development, and evaluation of cyber components and systems, and developing solutions for processing large, high-dimensional datasets acquired from diverse sources, including speech, imagery, text, and network traffic.

Intelligence, Surveillance, and Reconnaissance Systems and Technology

We are conducting research and development in advanced sensing, signal and image processing, decision support technology, and high-performance embedded computing to enhance capabilities in intelligence, surveillance, and reconnaissance.

Tactical Systems

Tactical Systems researchers improve the development of tactical air and counterterrorism systems through systems analysis to assess the impact of technologies on real-world scenarios; rapidly develop prototype systems; and conduct precise instrumented testing of systems.

Space Control

Lincoln Laboratory's scientists are ensuring the resilience of the nation's Space Enterprise by designing, prototyping, operating, and assessing systems to provide space situational awareness, resilient space capability delivery, active defense, and associated cross-domain battle management.

Advanced Technology

In the Advanced Technology research area, we are Leveraging solid-state electronic and electro-optical technologies, chemistry, materials science, advanced RF technology, and quantum information science to develop innovative system applications and components.

Homeland Protection

The Homeland Protection mission area creates innovative technology and architectures to help prevent terrorist attacks within the United States, to reduce the vulnerability of the nation to terrorism, to minimize the damage from terrorist attacks, and to facilitate recovery from man-made and natural disasters.

Air Traffic Control

At Lincoln Laboratory, aviation researchers are developing advanced technologies and decision support architectures for aircraft surveillance, integrated weather sensing and processing, collaborative air traffic management, and information security to support the nation's air transportation system.

Advanced Research Portfolio

The internal research and development at Lincoln Laboratory is supported through congressionally appropriated funding, known as the Line. The Line is the primary source of relatively unconstrained funding and is used to fund the long-term strategic technology capabilities of established and emerging mission areas. Line projects form an Advanced Research portfolio focused on addressing technology gaps in critical problems facing national security.
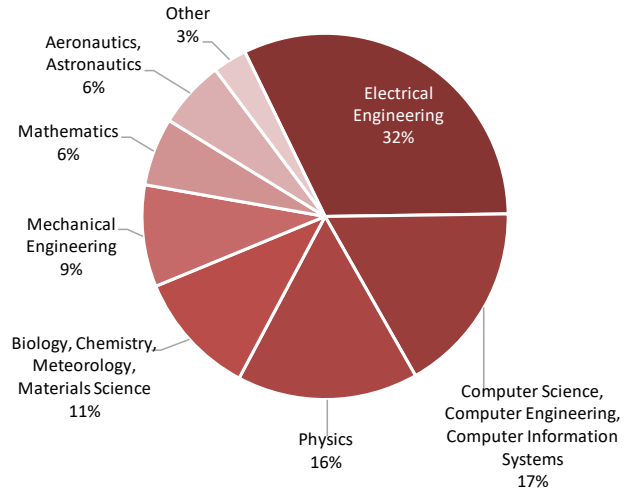
Lincoln Laboratory Technical Staff

Lincoln Laboratory employs 1,772 technical staff, 574 technical support personnel, 1,068 support personnel, and 461 subcontractors. Three-quarters of the technical staff have advanced degrees, with 41% holding doctorates. Professional development opportunities and challenging cross-disciplinary projects are responsible for the Laboratory's ability to retain highly qualified, creative staff. As employees of MIT, staff contribute in many ways to the MIT community.

Our status as a large multidisciplinary research and development center makes it a strong resource for collaborative research initiatives. Several ongoing programs connect staff at the Laboratory with researchers, faculty, and students at MIT. These initiatives focus on researching new technology, challenging students to solve interesting problems, and engaging Laboratory staff in teaching new skills. The synergy between the campus's focus on academic research and the Laboratory's experience in building prototypes has resulted in the development of innovative systems.

Lincoln Laboratory recruits at many of the nation's top technical universities, with 65 to 75% of new hires coming directly from universities. Lincoln Laboratory augments its campus recruiting by developing long-term relationships with research faculty and promoting fellowship and summer internship programs.

Academic Disciplines of Staff

- Electrical Engineering 32%
- Computer Science, Computer Engineering, Computer Information Systems 17%
- Physics 16%
- Biology, Chemistry, Meteorology, Materials Science 11%
- Mechanical Engineering 9%
- Mathematics 6%
- Aeronautics, Astronautics 6%
- Other 3%

Lincoln Laboratory's Economic Impact

During fiscal year 2018, the Laboratory issued subcontracts with a value of approximately $437 million. The Laboratory awarded subcontracts to businesses in all 50 states. Massachusetts businesses were awarded $194 million in contracts, and states as distant as Colorado and California also realized significant benefits to their economies.

Academic Degrees Held by Staff

- Doctorate 41%
- Master's 36%
- Bachelor's 20%
- No Degree 3%
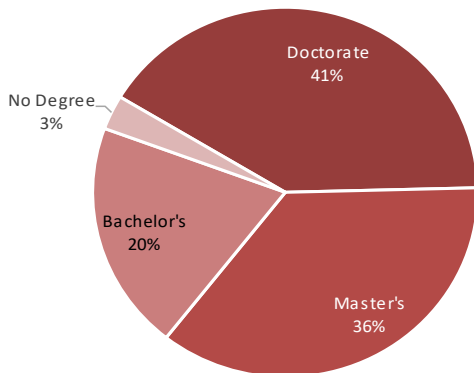
Contracted Services (FY2018)*

- Commercial Equipment and Supplies 36.3%
- Subcontractors 30.1%
- R&D 17.4%
- Construction and Real Estate 13.7%
- Utilities 2.5%
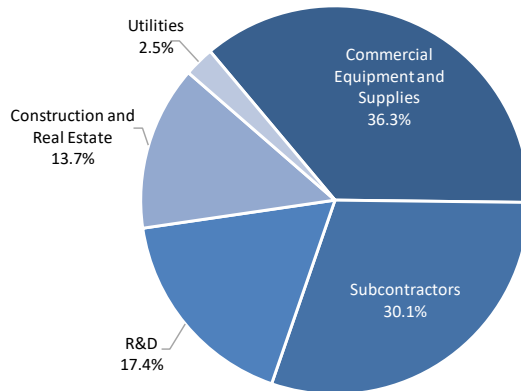
*Estimates from $436.9M, total FY2018 spend.
- Includes orders to MIT ($10.3M)
- Figures are net awards less reductions

MIT/Lincoln Laboratory Interactions

Lincoln Laboratory invests in developing and sharing the knowledge that will drive future technological advances and inform the next generation of engineers. Our educational collaborations with MIT are below.

Independent Activities Period at MIT
Lincoln Laboratory technical staff led activities offered during MIT's Independent Activity Period (IAP) in 2018. Lincoln Laboratory offered eight noncredit courses organized and led by its technical staff members. Many of this year's IAP noncredit activities were held at Beaver Works on the MIT campus.

VI-A Master of Engineering Thesis Program
Students in MIT's VI-A Master of Engineering Thesis Program spend two summers as paid interns at Lincoln Laboratory, contributing in projects related to their courses of study. Then, the students work as research assistants while developing their master of engineering theses under the supervision of both Laboratory engineers and MIT faculty. Typically, about a half-dozen students participate in the program, gaining experience in testing, design, development, research, and programming.

Research Assistantships
Lincoln Laboratory employs a limited number of research assistants from MIT. Working with engineers and scientists for three to five years, these students contribute to sponsored programs while investigating the questions that evolve into their doctoral theses.

Undergraduate Research Opportunities and Practice Opportunities Programs
Lincoln Laboratory partners with MIT's Undergraduate Research Opportunities Program (UROP) and Undergraduate Practice Opportunities Program (UPOP). Program participants at the Laboratory develop research proposals, perform experiments, and analyze data. In summer 2018, 20 undergraduates were hired as UROP interns and six as UPOP interns.

Advanced Concepts Committee
The Advanced Concepts Committee (ACC) provides funding and technical support for researchers who are investigating novel concepts that address high-priority national problems. The ACC encourages collaborative projects with MIT faculty and funds projects conducted by MIT researchers in areas pertinent to Laboratory programs.

Beaver Works
Beaver Works, a joint initiative between Lincoln Laboratory and the MIT School of Engineering, serves as a mechanism for expanding project-based learning opportunities for students. By leveraging expertise of Lincoln Laboratory staff, MIT faculty, researchers, Beaver Works is strengthening research and educational partnerships to find solutions to pressing global problems.

The signature Beaver Works collaboration is the capstone course, an MIT engineering class which involves a project to develop technology that solves a real-world problem. The fabrication areas offer access to high-tech equipment, such as 3D printers and a laser cutter, that support construction of prototypes by students from the engineering department, the MIT Robotics Club, and the MIT UAV Club. At Beaver Works, MIT undergraduate and graduate students participated in the Assistive Technologies Hackathon (ATHack), in which students prototyped engineering solutions to problems faced by the disabled.

Beaver Works extends project-based learning to K–12 schoolchildren. In 2018, eight groups were involved in programs held at the center, including a build-a-radar workshop directed by Lincoln Laboratory instructors; weekly practices for CyberPatriot teams that participate in computer-network security challenges; and the Beaver Works Summer Institute--a summer camp program that offers hands-on engineering challenges for high school students.

Beaver Works recently opened a 4,000-sq-ft auxiliary space that will facilitate collaboration between MIT Aero/Astro and Lincoln Laboratory.

Test Facilities and Field Sites

Hanscom Field Flight and Antenna Test Facility.
The Laboratory operates the main hangar on the Hanscom Air Force Base flight line. This 93,000-sq-ft building accommodates the Laboratory Flight Test Facility and a complex of state-of-the-art antenna test chambers. The Flight Test Facility houses several Lincoln Laboratory–operated aircraft used for rapid prototyping of airborne sensors and communication.

Hanscom Field Flight and Antenna Test Facility

Millstone Hill Field Site, Westford, MA
MIT operates radio astronomy and atmospheric research facilities at Millstone Hill, an MIT-owned, 1,100-acre research facility in Westford, Massachusetts. Lincoln Laboratory occupies a subset of the facilities whose primary activities involve tracking and identification of space objects.

Millstone Hill Field Site, Westford, Massachusetts

Reagan Test Site, Kwajalein, Marshall Islands
Lincoln Laboratory serves as the scientific advisor to the Reagan Test Site at the U.S. Army Kwajalein Atoll installation located about 2,500 miles WSW of Hawaii. Twenty staff members work at this site, serving two- to three-year tours of duty. The site's radars and optical and telemetry sensors support ballistic missile defense testing and space surveillance. The radar systems provide test facilities for radar technology development and for the development of ballistic missile defense techniques.

Reagan Test Site, Kwajalein, Marshall Islands

Autonomous Systems Development Facility
This new state-of-the-art facility located on Hanscom Air Force Base enables the development and testing of ground-based, aerial, and undersea autonomous systems. Infrared sensors and a motion caption system localizes reflective tags on vehicles, relaying position and orientation data in real time.
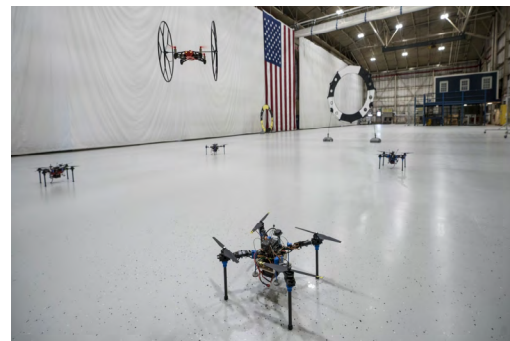
Autonomous Systems Development Facility

Lincoln Laboratory Outreach Metrics

Community outreach programs are an important component of the Laboratory's mission. Outreach initiatives are inspired by employees' desire to help people and to motivate student interest in science, technology, engineering, and mathematics (STEM). Some samples of our programs are listed below.

LLRISE

Eleven technical staff members taught various portions of the Lincoln Laboratory Radar Introduction for Student Engineers (LLRISE) Workshop and helped high-school students build their own Doppler and range radars. The students were instructed in 3D printing, circuit board assembly, electromagnetics, pulse compression, signal processing, antennas, MATLAB, and electronics. The program expanded to include two high school physics teachers in hopes that they may learn how to integrate the workshop in their own after-school curriculum. The program also offered a one-day workshop for eighth- to twelfth-graders to provide a sample of the workshop.

LLCipher

LLCipher introduces high-school students to modern cryptography—a math-based, theoretical approach to securing data. Abstract algebra, number theory, and complexity theory provide the foundational knowledge needed to understand theoretical cryptography.

Explorer Post 1776

Lincoln Laboratory sponsors a co-ed Explorer Post through the Boy Scouts of America so that high school students can build engineering systems, design prototypes, and use creative problem-solving skills.

Beaver Works Summer Institute

This program for high school students from across the country offers hands-on STEM challenges in several different areas: programming for autonomous cognitive assistants, robotics, or autonomous air vehicles; 3D printing, data science for health medicine, building a CubeSat, and unmanned air system.

LINCOLN LABORATORY COMMUNITY OUTREACH

MIT LINCOLN LABORATORY

2018 OUTREACH BY THE NUMBERS

Scientists & engineers volunteering — 575
Hours per year supporting STEM — 11,560
Donated to the American Heart Association — 6,000
Military Fellows at Lincoln Laboratory — 42
Care packages sent to troops — 137
Dollars contributed to the Jimmy Fund by Laboratory cyclists in the Pan-Mass Challenge — 16,600
Dollars raised for Alzheimer Support Community since 2009 — 401,500
Dollars raised by Laboratory employees in 2018 — 108,546
Lincoln Laboratory K-12 STEM programs — 35
Students seeing STEM demonstrations — 18,000
Students touring Lincoln Laboratory — 3,600
Charities receiving donations — 33
Toys donated to Toys for Tots drive — 518
Summer Internships — 246
Staff in Lincoln Scholars — 200

Section 6
MIT and Industry

MIT and Industry

MIT welcomes all industry partners who seek practicable and pragmatic solutions, and who share and celebrate the entrepreneurial spirit that brings new ideas to life. Together, MIT and industry can make great progress in creating new knowledge, in shaping new leaders, and in bringing important, new technologies to market.

- Direct industry sponsored R&D at MIT totaled $180 million in FY2019.

- Over 800 companies provided R&D/gift support to MIT; 54 companies funded $1 million+, 271 companies funded $100 thousand–$1 million.

- MIT consistently tops the National Science Foundation rankings in industry-financed R&D expenditures among all universities and colleges without a medical school.

Office of Strategic Alliances and Technology Transfer
In September 2019, the MIT Office of Strategic Alliances and Technology Transfer (OSATT) was launched to bolster faculty leaders who are pursuing alliances, collaborations and other research engagements with sponsors.

The OSATT team is led by MIT's Associate Provost, Krystyn Van Vliet, in coordination with three directors, who bring deep experience in academic research agreements, technology transfer, and engagement with external sponsors and collaborators. Lesley Millar-Nicholson serves as director of catalysts, responsible for faculty engagement and agreement development, while continuing to serve as director of the Technology LIcensing Office. Meghan McCollum Fenno serves as director of strategic transactions, responsible for negotiations, while continuing to serve as counsel in the Office of the General Counsel. Karl Koster serves as director of alliance management and continues to serve as executive director of Corporate Relations.

OSATT's new services assist faculty in catalyzing potential agreements and in managing the important next steps for establishing operations at MIT that meet the shared goals and expectations. OSATT, along with Research Administrative Services (RAS), replace the former Office of Sponsored Programs (OSP). RAS, reporting to the Office of the Vice President for Research, Maria Zuber, manages pre-award administration of grants and contracts sponsored by the federal, state, and local governments, as well as some philanthropic foundations, and post-award activities for all sponsored programs.

OSATT Organization
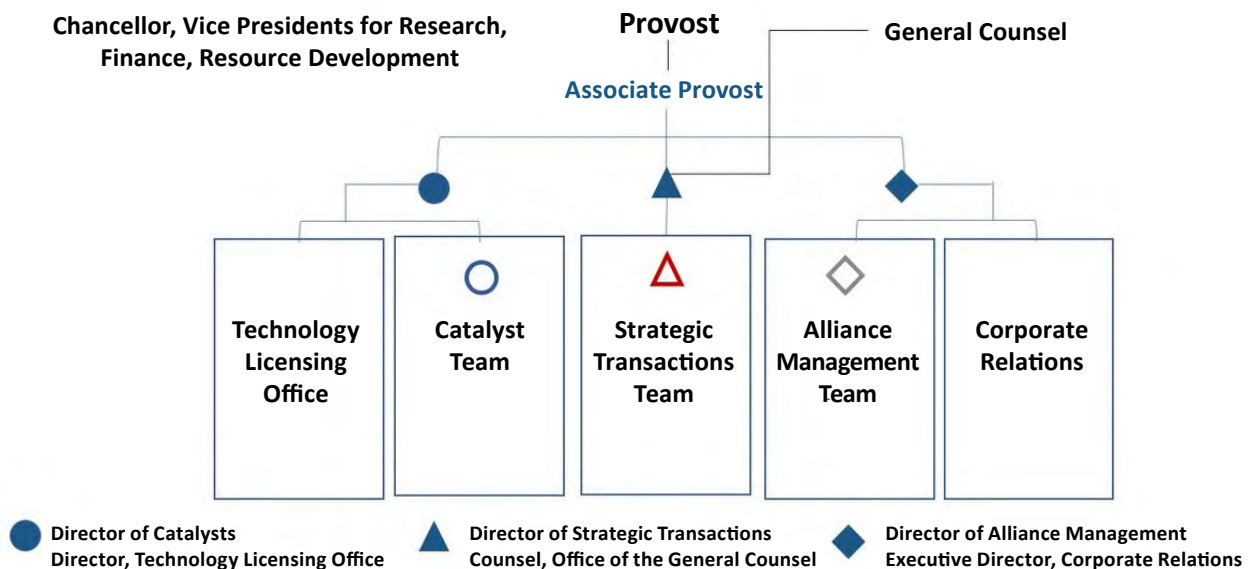
Industrial Liaison Program

MIT is the first research university to have formal and systematic liaisons with firms. Today, its Industrial Liaison Program (ILP) helps company managers by scheduling and facilitating face-to-face meetings with MIT faculty, coordinating on-campus networking activities, and advising company managers on how to navigate, adapt and benefit from the dynamic, interdisciplinary MIT environment. Over 260 of the world's leading companies partner with the Industrial Liaison Program to advance their research agendas at MIT.

MIT Differentiators

Real World Impact

MIT is dedicated to research that is animated, if not inspired, by application to industry. Considering viable paths to commercialization from the outset expedites solving real-word challenges/problems.

Interdisciplinary Culture

An interdisciplinary environment and holistic approach to technological development avoids silos, and allows thought leaders from multiple disciplines and fields to collaborate freely and reach for the previously unimaginable.

Out of the Box Thinking

MIT's prowess at ideation and its ability to speed groundbreaking technologies to commercialization makes the Institute the first place industry turns to for the next big idea.

Fearlessly Entrepreneurial

The MIT ethos champions extraordinary individuals who are eager to pursue new high-risk startups that will potentially change the world. Faculty, researchers and students relish their status as outliers—techies, geeks, and dreamers—and thrive in this 24/7 domain of science and technology exploration.

Hub of Innovation Ecosystem

The Cambridge innovation ecosystem is synonymous with MIT. Many startups born at MIT choose to stay close to home, leveraging the community's random, informal interactions that catalyze idea generation and growth.

Industry Partners

A selection of these partnerships are described below.

Commonwealth Fusions Systems

In March 2018, MIT partnered with new private company, Commonwealth Fusion Systems (CFS) to fast track progress toward the dream of fusion power—potentially an inexhaustible and zero-carbon source of energy. CFS will join with MIT to carry out rapid, staged research leading to a new generation of fusion experiments and power plants based on advances in high-temperature superconductors—work made possible by decades of federal government funding for basic research.

IBM

In September 2017, IBM announced a 10-year, $240 million investment to create the MIT–IBM Watson AI Lab in partnership with MIT. The collaboration aims to advance AI hardware, software, and algorithms related to deep learning and other areas; increase AI's impact on industries, such as health care and cybersecurity; and explore the economic and ethical implications of AI on society.

Philips

In May 2015, Philips announced an alliance with MIT that will ultimately support MIT research in the company's core areas of health care and lighting solutions technology. The agreement follows the company's recent decision to move its North American research headquarters to Kendall Square, citing the area's concentration of startups and research labs—especially in the biomedical area—and for its proximity to MIT.

Liberty Mutual

In April 2019, Liberty Mutual announced a $25 million, five-year collaboration to support artificial intelligence research in computer vision, computer language understanding, data privacy and security, and risk-aware decision making, among other topics. With the Quest, MIT is working to accelerate progress on techniques and technologies that can help countless industries seize the transformative opportunities of AI.

Selected Projects funded by Industry

Flexible Piezoelectric Devices for Gastrointestinal Motility Sensing

Improvements in ingestible electronics with the capacity to sense physiological and pathophysiological states have transformed the standard of care for patients. Yet, despite advances in device development, significant risks associated with solid, non-flexible gastrointestinal transiting systems remain. Here, we report the design and use of an ingestible, flexible piezoelectric device that senses mechanical deformation within the gastric cavity. We demonstrate the capabilities of the sensor in both in vitro and ex vivo simulated gastric models, quantify its key behaviours in the gastrointestinal tract using computational modelling and validate its functionality in awake and ambulating swine. The proof-of-concept device may lead to the development of ingestible piezoelectric devices that might safely sense mechanical variations and harvest mechanical energy inside the gastrointestinal tract for the diagnosis and treatment of motility disorders, as well as for monitoring ingestion in bariatric applications.

<div align="right">http://ilp.mit.edu/newsstory.jsp?id=25541</div>

Boosting Energy Storage for Smartphones, Cars, and the Electrical Grid

In the grand global march toward clean energy, batteries bring up the rear—constraining the performance of everything from tiny sensors to smartphones to electric cars to the electrical grid. That's a challenge taken on by Ju Li, MIT professor of materials science engineering and of nuclear science and engineering. Supported by corporate partnerships, his battery research ranges from fundamental chemical and mechanical studies to creating prototypes for commercial systems.

<div align="right">http://ilp.mit.edu/newsstory.jsp?id=25062</div>

Nanolayered Thin Films for Wound Treatments

Paula Hammond's current research work exploits layering techniques that uses water to create multi-layer thin film that contains multiple drugs. The process allows introduction of proteins and DNA into layered films without denaturing and destroying their function, and means higher amounts can reach the treatment area than is possible in traditional polymer materials. Hammond has used the technology to introduce proteins into bandages that help stop bleeding and eliminate infection, and one of her latest projects, supported in part by the U.S. Army through the Institute for Soldier Nanotechnologies, includes coating bandages with systems containing nucleic acids called siRNA which silence genes that can cause scarring.

<div align="right">ilp.mit.edu/newsstory.jsp?id=22491</div>

Transforming Healthcare Decisions with Analytics

Dimitris Bertsimas is harnessing analytics and computational power to make predictive and prescriptive algorithms for healthcare. With a data footprint that went back to the 1990s, Bertsimas has created a system that predicts outcomes for new drugs with high accuracy, allowing pharmaceutical companies to identify promising trials, and avoid significant early investment costs. He is also developing presumptive analytics, taking what is already known, combining it with modeling, and being able to predict and propose the next 10 drug trials. The result is better delivery of care. Bertsimas hopes over the next decade to see the medical industry incorporate algorithms that continually learn from data in order to propose more targeted recommendations.

<div align="right">http://ilp.mit.edu/newsstory.jsp?id=23363</div>

Design, Planning and Operation of Highly Responsive and Sustainable Urban Last-mile Delivery Networks

This project aims to understand the impact of rapid urbanization and the growing importance of highly responsive/on-demand last-mile delivery services in e-commerce and omni-channel retailing on the design, planning, and operation of urban last-mile distribution networks. Here, omni-channel retailing refers to the integrated operation of offline (i.e., brick-and-mortar) and online retail channels and their underlying logistics. Understanding the implications of urbanization and the growth in e-commerce on the optimal structure of distribution facility networks and fleets further allows us to analyze the economic, social and environmental viability and impact of various innovative approaches to the design and operation of future urban last-mile distribution systems.

<div align="right">http://ilp.mit.edu/newsstory.jsp?id=24118</div>

Campus Research Sponsored by Industry

Campus Research Expenditures (in U.S. Dollars)
Prime Sponsor Industry
Fiscal Years 2015–2019

	2015	**2016**	**2017**	**2018**	**2019**
Campus research	119,238,077	128,308,988	132,914,760	144,126,295	169,605,879
Constant dollars*	127,597,120	136,382,718	138,726,472	147,113,118	169,605,879
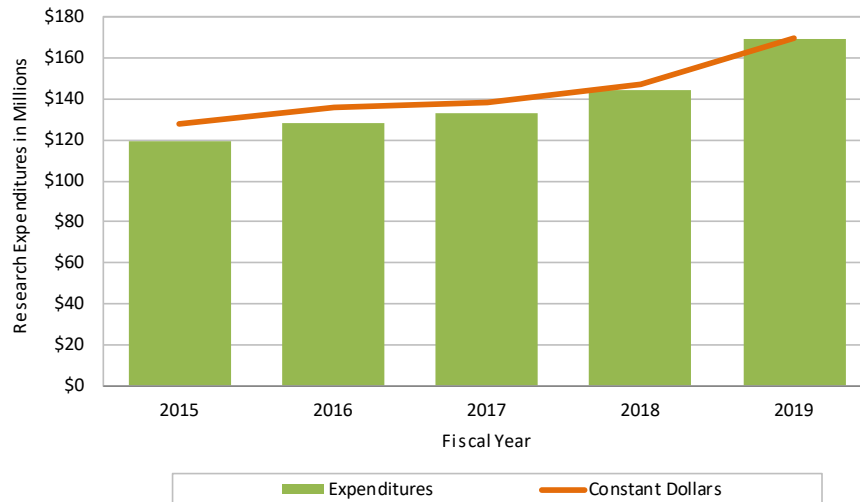
*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2019 equaling 100.

Technology Licensing Office Statistics for FY2019

Total number of invention disclosures:	789
Number of U.S. new utility patent applications filed:	439
Number of U.S. patents issued:	381
Number of licenses granted (not including trademarks and end-use software):	82
Number of options granted (not including options as part of research agreements):	31
Number of software end-use licenses granted:	63
Number of companies started (number of new license or option agreement to MIT technologies that serve as the foundation for a start-up company):	25

Entrepreneurship

MIT is recognized as one of the most entrepreneurial universities in the world. Its faculty ranks include hundreds of serial startup founders, and its hands-on approach to education encourages students to make a difference in the world by discovering and exploiting new technologies. The science-based ventures coming out of MIT helped transform Kendall Square into a major hub of biotech innovation, and the area thrives today with startups representing an array of industries from energy, to healthcare, to nanotech to advanced manufacturing.

$100K Entrepreneurship Competition

The MIT $100K Entrepreneurship Competition (student group) is the leading business plan competition in the world. The competition was founded in 1990 to encourage students and researchers in the MIT community to act on their talent, ideas, and energy to produce tomorrow's leading firms. Entirely student-managed, the competition has produced hundreds of successful ventures that have created value and employment.

The Engine

In October 2016, MIT announced "The Engine," a startup accelerator that will assist startups engaged in scientific and technological innovation, i.e. tough tech, with the potential to transform society in such areas as biotechnology, robotics, manufacturing, medical devices and energy. MIT is the Engine's anchor limited partner, contributing $25 million to the Engine Fund which had reached $200 million by October 2017. The accelerator, which will be open to startups not otherwise affiliated with MIT, includes a dedicated high-tech workspace of 26,000 square feet of space at 501 Massachusetts Avenue with the aim of growing to 200,000 square feet in the next several years.

Deshpande Center for Technological Innovation

The Deshpande Center for Technological Innovation was established at the MIT School of Engineering in 2002 to increase the impact of MIT technologies in the marketplace, and support a wide range of emerging technologies including biotechnology, biomedical devices, information technology, new materials, tiny tech, and energy innovations. Since 2002, the Deshpande Center has funded more than 80 projects with over $9 million in grants. Eighteen projects have spun out of the center into commercial ventures, having collectively raised over $140 million in outside financing. Thirteen venture capital firms have invested in these ventures.

Martin Trust Center for MIT Entrepreneurship

The Martin Trust Center for MIT Entrepreneurship is committed to fostering and developing MIT's entrepreneurial activities and interests in three primary areas: education and research, alliance, and community. The Center educates and nurtures students from across the Institute who are interested in learning the skills to design, launch, and grow innovation-based ventures. The Center facilitates business and technology partnerships by combining breakthrough academic research with practical, proven experience. The people of the Center cultivate and nourish a thriving network that unifies academic, government, and industry leaders around the vision of entrepreneurial success.

MIT Sloan's Action Learning Labs

MIT Sloan's Action Learning Labs take the idea of learning-by-doing to a whole new level. These Labs aren't run-of-the-mill practicums; they are a total immersion into MIT Sloan's signature experiential learning model—Think-Act-Reflect. Action Learning Labs enable students to translate classroom knowledge and theory into practical solutions for real organizations across the globe. The breadth of opportunities provided by a diverse selection of labs allows students to pursue their specific interests and passions—or explore something totally new—while developing and strengthening their problem-solving and leadership capabilities.

MIT Startup Exchange

MIT Startup Exchange actively promotes collaboration and partnerships between MIT-connected startups and industry. Qualified startups are those founded and/or led by MIT faculty, staff, or alumni, or are based on MIT-licensed technology. Industry participants are principally members of MIT's Industrial Liaison Program (ILP). MIT Startup Exchange maintains a propriety database of over 1,800 MIT-connected startups with roots across MIT departments, labs and centers; it hosts a robust schedule of startup workshops and showcases, and facilitates networking and introductions between startups and corporate executives. MIT Startup Exchange and ILP are integrated programs of MIT Corporate Relations.

MIT Regional Entrepreneurship Acceleration Program

The MIT Regional Entrepreneurship Acceleration Program (reap.mit.edu) provides opportunities for communities around the world to engage with MIT in an evidence-based, practical approach to strengthening innovation-driven entrepreneurial (IDE) ecosystems. The program achieves this by translating research insights into practical frameworks, convening stakeholders focused on IDE, and educating regional leaders through team-based interaction to achieve economic and social impact. REAP is an MIT Executive Education capstone global initiative designed to help regions accelerate economic growth and social progress through innovation-driven entrepreneurship.

Venture Mentoring Service

Venture Mentoring Service (VMS) supports innovation and entrepreneurial activity throughout the MIT community by matching both prospective and experienced entrepreneurs with skilled volunteer mentors. VMS uses a team mentoring approach with groups of 3 to 4 mentors sitting with the entrepreneur(s) in sessions that provide practical, day-to-day professional advice and coaching. VMS mentors are selected for their experience in areas relevant to the needs of new entrepreneurs and for their enthusiasm for the program. VMS assistance is given across a broad range of business activity, including product development, marketing, intellectual property law, finance, human resources, and founders issues. VMS services are offered without charge to MIT students, alumni, faculty and staff in the Boston area.

Learning

Leaders for Global Operations

The Leaders for Global Operations (LGO) program is an educational and research partnership among global operations companies and MIT's School of Engineering and Sloan School of Management. Its objective is to discover, codify, teach, and otherwise disseminate guiding principles for world-class manufacturing and operations. The 24-month LGO program combines graduate education in engineering and management for those with two or more years of full-time work experience who aspire to leadership positions in manufacturing or operations companies. A required six-month internship comprising a research project at one of LGO's partner companies leads to a dual-degree thesis, culminating in two master's degrees—an MBA (or SM in management) and an SM in engineering.

Professional Education

MIT Professional Education provides short courses, semester or longer learning programs and customized corporate programs for science and engineering professionals at all levels. Taught by renowned faculty from across the Institute, MIT Professional Education programs offer professionals the opportunity to gain crucial knowledge in specialized fields to advance their careers, help their companies, and have an impact on the world.

- Short Programs. Over 40 courses, in two-to-five day sessions, spanning the range of disciplines at MIT, are taught on the MIT campus each summer by MIT faculty/researchers and experts from industry and academia. Participants earn Continuing Education Units (CEUs) and certificates of completion.

- Digital Programs. These online programs address topics of high interest to industry, delivering timely, expert knowledge of MIT faculty and researchers to a global audience. The benefits of online learning include the ability of busy professionals to gain advanced knowledge at their own pace and convenience, without the need to travel to the MIT campus.

- **Advanced Study Program.** A unique, non-degree program at MIT that enables professionals to take regular, semester-long MIT courses, to gain specific knowledge and skills needed to advance their careers and take innovative ideas back to their employers. Participants earn grades, MIT course credit, and an Advanced Study Program certificate.

- **Custom Programs.** Professional Education offers customized programs tailored to meet the specific training needs of corporations. These MIT faculty-led programs can be a single week or several weeks over a year, with interrelated on-the-ground projects. These specialized programs can be delivered at MIT and/or at company sites.

- **International Programs.** Select courses from Professional Education's Short Programs can be brought to international locations in Asia, the Middle East, Europe and Latin America. These globally-relevant courses enable professionals who cannot easily come to the MIT campus access to MIT knowledge and expertise in high interest topics, often with a local focus.

Sloan Fellows Program in Innovation and Global Leadership

This full-time, 12-month (June–June) immersive MBA program is designed for high-performing mid-career professionals. The program typically enrolls more than 100 outstanding individuals with 10–20 years of professional experience from at least two dozen nations, representing a wide variety of for-profit and nonprofit industries, organizations, and functional areas. Many participants are sponsored by or have the strong support of their employers, but the program also admits independent participants, many with unique entrepreneurial experiences and perspectives. The program is characterized by a rigorous academic curriculum, frequent interactions with international business and government leaders, and a valuable exchange of global perspectives.

Sloan Executive Education

MIT Sloan Executive Education programs are designed for senior executives and high-potential managers from around the world. From intensive two-day courses focused on a particular area of interest, to executive certificates covering a range of management topics, to custom engagements addressing the specific business challenges of a particular organization, their portfolio of non-degree, executive education and management programs provides business professionals with a targeted and flexible means to advance their career development goals and position their organizations for future growth.

System Design and Management

System Design and Management (SDM) is a master's program in engineering and management. Jointly offered by MIT's School of Engineering and the Sloan School of Management, SDM educates mid-career professionals to lead effectively and creatively by using systems thinking to solve large-scale, complex challenges in product design, development, and innovation.

Recruiting

Global Education and Career Development

The MIT Global Education and Career Development center assists employers in coordinating successful on- and off-campus recruitment of MIT students and provides students with opportunities to interact and network with professionals and obtain quality internships and full-time positions. MIT is proud to serve the needs of undergraduates (including Sloan), graduates and MIT alumni. (Departments that conduct their own recruiting include Chemistry, Chemical Engineering, and Sloan School of Management.)

Sloan's Career Development Office

Sloan's Career Development Office (CDO) serves a vital role in connecting MIT Sloan's innovative master's students and alumni with the world's leading firms. The CDO is dedicated to supporting employer recruiting goals and helping them identify the best candidates for their organization.

Section 7
Global Engagement

Global Engagement

International activities are central to MIT's mission of educating tomorrow's global leaders, advancing the frontiers of knowledge, and bringing forefront knowledge to bear on solving the world's great problems. Our faculty and students are active in more than 75 countries. These activities include faculty research collaborations; opportunities for students to participate in research, problem-solving projects in the field, and study abroad; and major Institute projects to help build new educational and research institutions and strengthen national and local innovation systems around the world. International projects and collaborations can also present a distinctive set of risks and questions. MIT cannot protect itself fully from these risks but can take actions to mitigate them.

A Global Strategy for MIT

A Global Strategy for MIT (http://web.mit.edu/global-strategy/) was published by the Associate Provost for International Activities in May 2017. MIT's strategic plan is designed to create a more robust and durable platform to support the international initiatives of individual faculty, while also establishing a principled framework for selecting and undertaking larger-scale activities to increase MIT's impact in the world. The plan identifies eight core principles to help guide the Institute's future international activities, and proposes seven new initiatives in support of our global engagement objectives.

Among its recommendations, the plan calls for building new MIT Partnerships for a Better World to promote and coordinate faculty and Institute-level collaborations in different regions of the world, and calls for an increased focus on China, Latin America, and Africa.

Working across borders, collaborating with international partners, and tackling some of the world's most difficult problems are fundamental to MIT's institutional values, and the plan calls for MIT to remain steadfast in our commitment to international engagement. The plan also proposes several mitigating measures to help protect MIT against new risks in the international arena.

New Review Process for 'Elevated-Risk' International Proposals

In April 2019, the Vice President for Research and the Associate Provost for International Activities announced a new review process for 'elevated-risk' international proposals. Given the increase in quantity and scope of global collaborations, this new effort was launched to strengthen MIT's internal processes for evaluating and structuring international agreements. Currently, engagements with China, Russia, and Saudi Arabia have been identified as meriting additional faculty and administrative review by the International Coordinating Committee, the International Advisory Committee, and the newly created Senior Risk Group. This new review process is designed to enable MIT to engage with the world effectively, with responsible management of risks and in keeping with the values of the MIT community.

International Initiatives

The following are some of MIT's many international activities.

Singapore-MIT Alliance for Research and Technology Centre, Singapore

The Singapore-MIT Alliance for Research and Technology (SMART) Centre is a research enterprise established by MIT in partnership with the National Research Foundation of Singapore. The SMART Centre serves as an intellectual hub for research interactions between MIT and Singapore at the frontiers of science and technology. This partnership allows faculty, researchers, graduate students, and undergraduate students from MIT to collaborate with their counterparts from universities, polytechnics, research institutes, and industry in Singapore and throughout Asia. The SMART Centre is MIT's first research center outside of Cambridge, Massachusetts, and its largest international research endeavor. For more information: http://smart.mit.edu/

MIT Skoltech Initiative, Russia

In 2011, MIT and Russia initiated a multi-year collaboration to help conceive and launch the Skolkovo Institute of Science and Technology (Skoltech), a new graduate research university in Moscow. The first phase of this joint effort between MIT, Skoltech, and the Skolkovo Foundation comprised a wide span of agreed activities leading to the launch and early growth of Skoltech. The second phase of the MIT-Skoltech relationship, known as the MIT Skoltech Program, began in March 2016 and was oriented around a narrower set of collaborative activities promoting the continued development of Skoltech and the Skolkovo ecosystem. The Program featured a focused set of core research and advisory activities, including an MIT faculty advisory committee, a joint annual conference, and multiple collaborative research projects. This phase of the collaboration ended in February 2019. For more information about the initiative: http://skoltech.mit.edu/

Asia School of Business (ASB)

In 2015, MIT Sloan announced a partnership with Bank Negara Malaysia, the nation's central bank, to establish the Asia School of Business (ASB) in Kuala Lumpur. ASB offers a full-time, 20-month MBA program based on the rigor of MIT Sloan's curriculum and focused on Asia's dynamic business environment. The inaugural class of ASB students earned their MBA degrees in 2018. MIT Sloan professor Charles Fine leads ASB as president and founding dean. This collaboration comprises the following components: MIT Sloan faculty teach courses at ASB; International Faculty Fellows Program enables ASB faculty to spend time on MIT campus; ASB students visit MIT for one month to take courses and learn about MIT's innovation ecosystem; and, MIT Sloan senior administrators share best practices with ASB counterparts.

Center for Excellence in Energy, Egypt

MIT received a $30 million award in February 2019 from the U.S. Agency for International Development (USAID) to support the development of a Center of Excellence in Energy at Ain Shams University, Mansoura University, and Aswan University, in Egypt. Over the next five years, MIT will work to build the research, education, and entrepreneurial capacity of the universities to address the country's most pressing energy-related problems. The USAID award will also enable MIT to bring faculty and graduate students from Egypt to the Institute, to learn how to approach large, energy-related challenges from an MIT perspective. The Center of Excellence in Energy will be led by Ahmed Ghoniem, the Ronald C. Crane Professor in MIT's Department of Mechanical Engineering, and Daniel Frey, a professor of mechanical engineering and the faculty research director for MIT D-Lab.

Centers for Mechanical Engineering Research and Education

MIT and the Southern University of Science and Technology (SUSTech) in Shenzhen, China launched the Centers for Mechanical Engineering Research and Education in June 2018. The two centers aim to inspire intellectual dialogue, innovative research and development, and new approaches to teaching and learning between experts in China and at MIT. The five-year collaboration will enable faculty and students from MIT to observe the innovation system in Shenzhen, and will enable SUSTECH faculty and students to visit MIT to conduct research and observe education practices. Gang Chen, the Carl Richard Soderberg Professor of Power Engineering, serves as the faculty director for the MIT center.

Dubai Institute for Design and Innovation, United Arab Emirates

The MIT School of Architecture and Planning (SA+P) has collaborated with the Dubai Design and Fashion Council (DDFC) to develop the Dubai Institute for Design and Innovation (DIDI). Faculty from MIT SA+P—led by the Department of Architecture but drawn from disciplines across the school—have helped to develop the curriculum for the new institute. The agreement reflects the increasing importance placed by industry, government, and educational institutions on design as a mode of inquiry and a critical skill for innovation and economic development. Opened in fall 2018 as a private, nonprofit education institution accredited by the Dubai Ministry of Higher Education, DIDI offers the region's first-ever Bachelor of Design degree with concentrations in Product Design, Strategic Design Management, Media, Visual Art, and Fashion Design.

European Council for Nuclear Research, Switzerland

Several MIT research groups in particle and nuclear physics are active at the European Council for Nuclear Research (CERN) in Geneva, Switzerland. CERN has a number of particle accelerators and detectors to study the constituents of matter and the fundamental laws of nature. MIT researchers use the Large Hadron Collider (LHC), the world's most powerful particle accelerator, which collides protons and/or heavy ions. Particles from these collisions are detected in several experiments; MIT participates in both the CMS (Compact Muon Solenoid) and LHCb (LHC beauty) experiments. MIT leads another effort that is based at CERN, although the detector is located on the International Space Station. The Alpha Magnetic Spectrometer (AMS) detects cosmic ray events in a precision search for dark matter, antimatter and the origin of cosmic rays. The payload operations control center for AMS is located at CERN. Altogether, approximately 70-80 people affiliated with MIT either work at CERN or work on CERN-related research.

Global Supply Chain and Logistics Excellence Network

The MIT Center for Transportation and Logistics (MIT CTL) created the MIT Global Supply Chain and Logistics Excellence (SCALE) Network in 2003 as an international alliance of leading research and education centers dedicated to the development and dissemination of supply chain and logistics innovation. This international network consists of six Centers spanning four continents: North America (MIT CTL), Europe (Spain and Luxembourg), South America (Colombia), and Asia (Malaysia and China). Each Center fosters relationships between its local students, faculty, and businesses as well as those across the network. More than 250 graduate students are enrolled annually in the various SCALE supply chain educational programs. The network also features partnerships with over a hundred global corporations that sponsor research, participate in events, and recruit students. Research projects recently undertaken by the network include projects on decision making under uncertainty, supply chain resilience, humanitarian logistics, sustainable supply chains, and global transportation reliability.

Laser Interferometer Gravitational-wave Observatory

The Laser Interferometer Gravitational-wave Observatory (LIGO) gives scientists insights into ripples in space-time caused more than a billion years ago by immense cosmic phenomena such as the merging of black holes and dense neutron stars. LIGO is funded by the National Science Foundation and operated by Caltech and MIT, which conceived of LIGO and led the Initial and Advanced LIGO projects. Financial support for the Advanced LIGO project was led by the NSF with Germany (Max Planck Society), the U.K. (Science and Technology Facilities Council) and Australia (Australian Research Council-OzGrav) making significant commitments and contributions to the project. Approximately 1,300 scientists from around the world participate in the effort through the LIGO Scientific Collaboration. In total, since making history with the first-ever direct detection of gravitational waves in 2015, the network, including Virgo, located at the European Gravitational Observatory (EGO) in Italy, has spotted evidence for four neutron star mergers; 16 black hole mergers; and one possible black hole-neutron star merger.

Hong Kong Innovation Node, Hong Kong

Since 2015, the Hong Kong Innovation Node has focused on cultivating the innovation capabilities of MIT students, increasing opportunities for students and faculty to participate in the innovation process, and accelerating the path from idea to impact to help strengthen the region's innovation ecosystem. The Node is deepening MIT's links to the Greater Bay Area and is working to enrich the educational experiences of MIT and Hong Kong students in key areas of innovation practice, including entrepreneurship, making, and rapid scale-up of prototypes. The Node has created an engaging physical space for collaboration, connection, and making that has enabled MIT students, faculty, and alumni to connect with local universities, entrepreneurs, and companies. In 2019, the Node is offering 15 different programs that will engage more than 30 MIT faculty, 100 MIT students, 300 alumni, and 60 start-up companies from MIT and the Greater Bay Area.

MIT Norman B. Leventhal Center for Advanced Urbanism

The mission of the MIT Norman B. Leventhal Center of Advanced Urbanism (LCAU) is to establish a new theoretical and applied research platform to create knowledge that can be used to transform the quality of life throughout the urbanized world. LCAU is committed to achieving this goal both domestically and internationally, through collaborative interdisciplinary research projects using design as a mode of inquiry, intellectual discourse, and dissemination through leadership forums, conferences, publications, and teaching. In addition to ongoing research in Australia, Canada, China, India, Spain, Turkey, China, the UAE, and Ukraine, the LCAU is also undertaking a multi-year research effort on equitable resilience, which brings to the forefront questions of equity when designing for urban resilience. Research is currently underway in Argentina, Boston, Colombia, Florida, India, Philippines, Puerto Rico, South Africa, and Tajikistan.

MIT Portugal Program, Portugal

The MIT Portugal Program (MPP) is a strategic partnership between Portuguese universities and research centers, MIT, and the Portuguese government. The program is in its third phase of funding, the MIT Portugal Partnership 2030 (MPP2030). MPP2030's goal is to strengthen Portugal's knowledge base and international competitiveness through strategic investments in people, knowledge, and innovative ideas. Program funding is provided by the Portuguese Science and Technology Foundation (FCT). MPP2030 has shifted the program's focus to research in the areas of Climate Science & Climate Change, Earth Systems, Digital Transformation in Manufacturing and Sustainable Cities. Despite this shift in focus from education to research, the program is proud of its educational impact in Portugal. Phases 1 and 2 yielded over 500 students from partner universities in Portugal and engaged over 270 Portuguese and 70 MIT faculty members. MPP is widely recognized as a model for international alliances involving universities, industry, and governmental agencies. For more information about the program: http://www.mitportugal.org/

MIT Regional Entrepreneurship Acceleration Program

Since 2012, MIT Regional Entrepreneurship Acceleration Program (REAP) has provided opportunities for communities around the world to engage with MIT in an evidence-based, practical approach to strengthening innovation-driven entrepreneurial (IDE) ecosystems. Eight teams from regions around the world annually participate in this 2-year program. Each team is led by a regional team champion and comprises leaders from five major groups of stakeholders: government, corporate, academia, risk capital, and the entrepreneurial community. The program seeks to educate regional IDE ecosystem leaders through team-based learning, and impact regions through the development of new programmatic and policy interventions tailored to their IDE ecosystems. MIT REAP includes four workshops and interspersed action phases. Over the past seven years, the program has engaged with over 52 regions worldwide.

MIT Sloan Latin America Office, Chile

In 2013, MIT Sloan established its first physical presence outside the United States in Santiago, Chile. The mission of the MIT Sloan Latin America Office (MSLAO) is to develop and nurture meaningful activities throughout Latin America that benefit the region, the School, and the Institute, and support the creation and transfer of knowledge and the advancement of management education and practice. MIT Sloan's presence in the region has provided opportunities in five primary areas: Knowledge Creation; Regional Awareness; Admissions; Action Learning; and Strengthen the Alumni Network. The office supports research, teaching, and knowledge-sharing opportunities for MIT Sloan and MIT faculty and has focused its efforts on three main themes that are relevant to the region: Energy, Water, and Sustainability; Innovation and Entrepreneurship; Growth and Productivity. This is being achieved by enhancing connections with local alumni and creating avenues for potential corporate, governmental, and academic partnerships and research collaborations for MIT faculty and researchers.

MIT-Africa Initiative

The MIT-Africa Initiative seeks mutually beneficial engagement in research, education, and innovation, contributing to economic and intellectual trajectories of African countries, while advancing MIT scholarship and research. The Initiative communicates activities across MIT related to Africa, while inviting new connections. MIT faculty, staff, and students are engaged in projects in half the countries of Africa, including research collaborations, projects that promote educational excellence, entrepreneurship workshops and competitions. A growing number of MIT students travel to Africa for internships with universities, schools, corporations and governments. The Initiative welcomes dignitaries to campus through the MIT-Africa Forum, and celebrates achievements of MIT personnel and alumni in a monthly Newsletter and at africa.mit.edu. An eminent faculty Working Group, and a Team including staff and students advance MIT-Africa organization.

Transiting Exoplanet Survey Satellite

The Transiting Exoplanet Survey Satellite (TESS) is the newest planet hunting mission led and operated by MIT and managed by NASA's Goddard Space Flight Center. George Ricker of MIT's Kavli Institute for Astrophysics and Space Research serves as principal investigator for the mission and Professor Sara Seager acts as deputy science director for TESS. More than a dozen universities, research institutes, and observatories worldwide are participants in the mission, which in its first year of scientific operations, has discovered 28 planets outside of our solar system that are orbiting bright, nearby stars. MIT scientists, including Seager and Julien de Wit can determine these exoplanets' characteristics, such as atmospheres and chemical compositions, leveraging international observatories such as the SPECULOOS project (Search for habitable Planets EClipsing ULtra-cOOl Stars) based in Spain.

International Education Opportunities

There is a broad range of global activities for students to choose from. These run the gamut from varied study-abroad programs to innovative short-term projects, but most are infused with the Institute's philosophy of *mens et manus*. Based on the results of the 2018 Graduating Student Survey, 54.4% of graduating seniors and 40.2% of students graduating with a master's degree reported completing at least one global experience while at MIT.

The following are examples of programs that provide students with experiences abroad:

IAP Faculty-led Programs

Six for-credit courses taught by MIT faculty will be offered this coming IAP (including two new offerings). Three literature courses (in Madrid, London, and Sao Paulo) will allow students to focus on topics in literature for the month of January, and three foreign language courses (two courses in Spain and one course in China) will help them hone foreign language skills.

Semester Study Abroad Options

During academic semesters, students can study abroad through exchange programs and by enrolling directly at foreign universities who offer this option. Some exchanges span several departments and others are focused in one department only. The Exchange with Imperial College London includes eight departments: Materials Science and Engineering; Chemistry; Electrical Engineering and Computer Science; Chemical Engineering; Earth, Atmospheric and Planetary Sciences; Aeronautics and Astronautics; Mathematics; and Nuclear Science and Engineering. The Exchange with ETH Zurich involves two departments: Mechanical Engineering, and Electrical Engineering and Computer Science. The Exchange with the University of Tokyo spans two departments: Mechanical Engineering and Materials Science and Engineering. The Exchange with Sciences Po allows students from any major to participate if they plan to take courses in political science and related fields. The Exchange with the University of Oxford is focused in one department: Materials Science and Engineering. The Department of Aeronautics and Astronautics offers study at the University of Pretoria in South Africa through an exchange. Beyond the exchange program in Materials Science and Engineering, University of Oxford receives our students from other majors through a direct enrollment option. Examples of other universities that offer a direct enrollment option for our students include: National University of Singapore, University of Hong Kong, Seoul National University, University of Manchester, University of New South Wales and University of Melbourne.

UROP Overseas

Resources are available for MIT undergraduates pursuing UROP research mentored by MIT faculty and requiring overseas travel. Such opportunities can provide many of the same benefits offered through conventional study abroad experiences—including the chance to connect with individuals from diverse cultural backgrounds who share similar intellectual goals. In addition, these experiences can help students enhance communication and leadership skills and refine collaborative and decision-making skills, while increasing understanding and awareness of ethical issues.

Singapore-MIT Undergraduate Research Fellowships

The SMART Centre has established a summer research internship programme: the SMURF programme (Singapore-MIT Undergraduate Research Fellows programme). It is open to all undergraduates at MIT, NTU, NUS, and SUTD and gives them the opportunity, during the summer break, to engage in research at the SMART Centre. The SMURFs work in MIT faculty supervisors' labs, actively participate in the research projects, and engage with postdoctoral scholars, graduate students, and other researchers. The programme provides undergraduates an international experience and inspire then to consider a career in research. Their research experiences are supplemented with numerous social activities and weekend trips to other South East Asia countries. Based on feedback from the students, the SMURFs greatly value their experiences at SMART and the community that forms among them.

Digital Learning

MITx and MIT OpenCourseWare represent MIT's largest and most far-reaching international educational outreach programs. MITx on edX is the Institute's interactive learning initiative that offers online versions of MIT courses on edX, a university collaboration in online education founded by MIT and Harvard University. MIT instructors teach these MITx courses to learners around the world. As of July 2019, MITx had built 176 massive open online courses (MOOCs), corresponding to more than 120 semester-long on-campus MIT courses, from 23 departments in all 5 schools. MITx also offers 4 (and soon 5) MicroMasters programs. The MicroMasters is a valuable professional credential earned by completing 4 or 5 online courses at the MIT Masters level, as well as a new path to a Master's degree at MIT and other universities.

Since the first MITx course was offered in August 2012, more than 3.8 million unique learners have enrolled 8.2 million times in MITx courses. Learners come from more than 200 different countries. Anyone in the world can explore and learn from MITx for free. Those who wish to earn an MITx certificate must verify their identity and pay a small fee. As of July 2019, MITx had awarded 195,000 certificates on edX.

MIT OpenCourseWare (OCW) is a free, open, publicly accessible web-based resource that offers high-quality educational materials from more than 2,450 MIT courses, reflecting the undergraduate- and graduate-level teaching in all five MIT schools and 33 academic units. This coverage in all disciplines makes OCW unique among open education offerings around the world. MIT continually updates OCW, adding new courses as they become available and refreshing existing courses with new materials. OCW Educator helps education professionals around the globe to navigate this vast library of MIT teaching materials by sharing insights from MIT faculty about how they teach with these materials on campus.

On average OCW attracts about 2 million visits per month, and to date more than 300 million people from almost every country on earth have accessed MIT academic content through these resources. Learners also find OCW content on other platforms like YouTube, where OCW's 2 million subscribers make it the largest college/university channel. Please see http://ocw.mit.edu/about/ocw-stories/ for inspiring examples.

MIT International Science and Technology Initiatives

MIT International Science and Technology Initiatives (MISTI) works with MIT students, faculty, and international partners and sponsors to build strong intercultural connections, advance crucial research with global implications, and help MIT students develop into true world leaders capable of shaping the future.

Student programs

Rooted in the *mens et manus* tradition, MISTI creates tailored internship, research and teaching opportunities abroad for MIT undergraduate and graduate students. MISTI's internship program matches students with rigorous, hands-on projects in companies and labs around the world. Through MISTI's teaching programs, students learn how to communicate with international peers by teaching STEM and entrepreneurship in foreign high schools and universities.

To prepare for their experiences abroad, MISTI students complete coursework in the language, culture, history and politics of their host country. Students also participate in a series of location-specific training modules covering topics such as cross-cultural communication, current events, technology and innovation in the host country, navigating the workplace, logistics, and safety.

MISTI student programs are available in Africa, the Arab world, Australia, Belgium, Brazil, Chile, China, Denmark, France, Germany, India, Israel, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Peru, Portugal, Russia/Eurasia, Singapore, Spain, Switzerland, and the United Kingdom. Over 1,200 student placements are made through MISTI each year.

Here are a few examples from the more than 10,000 students MISTI has placed since it began by sending a handful of interns to Japan over 35 years ago:

- In Chile, undergrad Maria Tou developed fog-harvesting technology to provide clean water to local communities as part of a faculty-led MISTI seed fund project.

- Chemical Engineering student Nathalia Rodriguez worked on gene therapy for muscular dystrophy at Genpole, a French biotech cluster.

- Postdoc Wiljeana Glover explored healthcare reform with peers at Technion-Israel Institute of Technology in Haifa through an MIT-Israel Seed Fund project.

- Matthew Zedler, a Mechanical Engineering graduate, examined Chinese auto growth and energy at Cambridge Energy Research Associates in Beijing.

- Physics major Jason Bryslawskyj designed superconducting magnetic bearings for electric motors at Siemens in German. He wrote two patents at Siemens.

- Ammar Ammar, an EECS undergrad, designed and tested a Google/YouTube project at Google Israel.

Faculty seed funds

The MISTI Global Seed Funds (GSF) grant program promotes and supports early-stage collaborations between MIT researchers and their counterparts around the globe. Many of the joint projects lead to additional grant awards and the development of valuable long-term relationships between international researchers and MIT faculty and students.

MISTI GSF grants enable participating teams to travel to collaborate with international peers, either at MIT or abroad, with the aim of developing and launching joint research projects. Grantees are encouraged to include both undergraduate and graduate students in their projects. The program comprises a general fund for projects in any country and several funds for projects in specific countries.

Since the launch of GSF in 2008, MISTI has received 2,105 proposals. Of these, 841 faculty projects were awarded $17.7 million for projects in 52 countries. More than 650 MIT faculty members and 175 research scientists have applied for a MISTI GSF grant at least once. Seed funds are currently offered in Africa, Belgium, Brazil, Chile, China, Colombia, France, Germany, India, Israel, Italy, Japan, Korea, Peru, Spain, and the United Kingdom. The MISTI GSF General Fund accepts proposals for projects in any country with priority consideration for proposals from Africa and Latin America.

MISTI Programs and Start Year

- Japan, 1983
- China, 1995
- Germany, 1997
- India, 1998
- Italy, 1999
- France, 2001
- Singapore, 2002
- Switzerland, 2002
- Mexico, 2004
- Spain, 2007
- Israel, 2008
- Belgium, 2009
- Brazil, 2010
- MEET, 2011
- Netherlands, 2011
- Chile, 2012

- Korea, 2012
- Russia, 2012
- Global Startup Labs, 2012
- Global Teaching Labs, 2012
- Turkey, 2013
- Argentina, 2013
- Africa, 2013
- ANZ, 2014
- UK, 2015
- Arab World, 2015
- Portugal, 2015
- Peru, 2015
- Denmark, 2018

MISTI Global Seed Fund Projects by Country 2018–2019
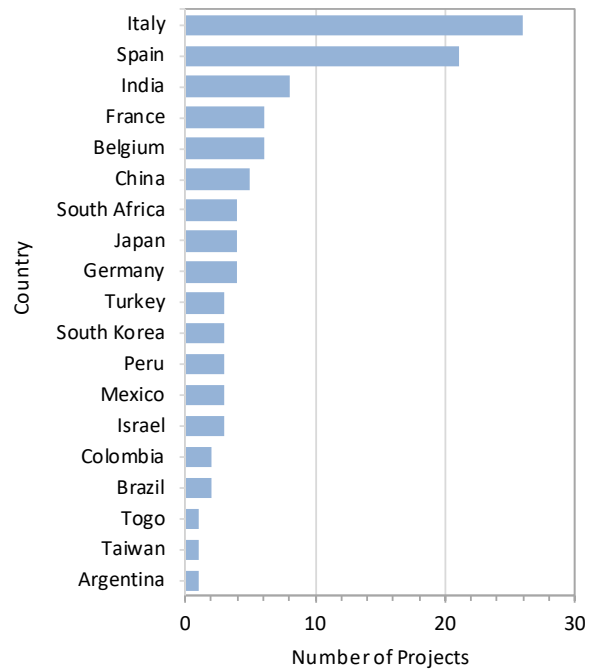
MISTI Annual Internship Placements 1994–2019*
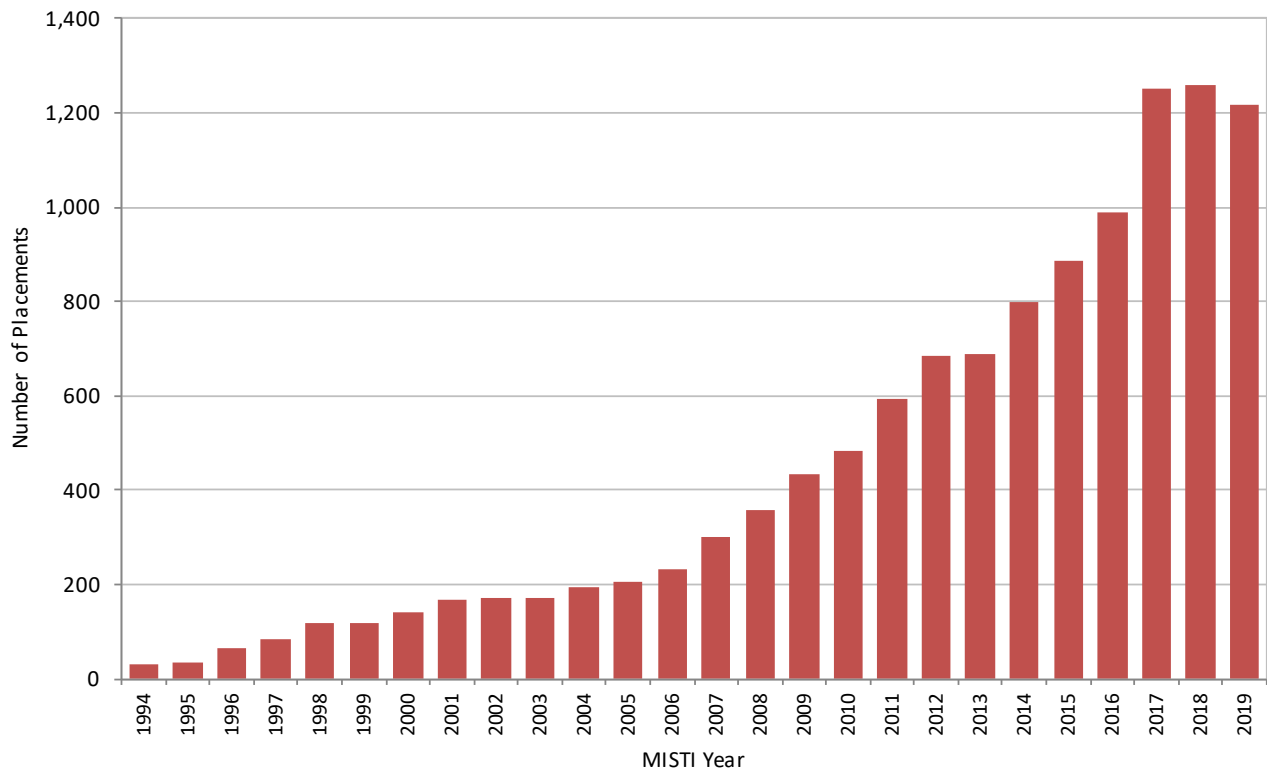
*MISTI year runs from September 1–August 31. 2019 represents the 2018–2019 year.

Section 8
Service to Local
and World Communities

Service to Local and World Communities

Founded with the mission of advancing knowledge to serve the nation and the world, MIT has been strongly committed to public service from its start. While MIT faculty, students, and staff regularly engage in conventional projects such as raising money for hurricane victims, renovating old housing, or restoring local nature reserves, MIT's scientific and technological orientation gives much of its public service outreach a particular emphasis. Many of its public service programs are specifically devoted to inventing new technologies and applying new knowledge that will advance social well-being.

Priscilla King Gray Public Service Center

The Priscilla King Gray Public Service Center (PKG Center) helps MIT achieve its mission of working wisely, creatively, and effectively for the betterment of humankind. Through its programs, they provide encouragement, advice, logistical support, and funding to help students engage in meaningful and effective public service projects, working with communities in the greater Boston area, throughout the United States, and around the world.

PKG Center's goal is to enrich the MIT education for students through hands-on, real-world opportunities that complement the innovative culture of MIT. Their programs (described below) are designed to help students apply classroom learning, develop new skills, and understand the complexities of resolving community challenges.

http://studentlife.mit.edu/pkgcenter

Public Service Fellowships Program
MIT students tackle a great variety of human and environmental challenges in communities around the world through this program. Participating students build their skills and reflect on their experiences to enhance classroom learning. Students can work individually or as part of a team on projects during IAP, summer, and the academic year. Fellows tackle some of the most pressing issues in the United States and abroad, working in sectors such as agriculture, water and sanitation, climate change, community development, assistive technology, education, environmental sustainability, food and agriculture, health and health technology, technology dissemination, and urban planning.

IDEAS Global Challenge
Through this annual innovation and social entrepreneurship competition, students form teams to work with a community partner to design and implement innovative projects that improve the quality of life in communities around the world. Teams work in many sectors, including energy, mobile technology, health and medical devices, water and sanitation, education, and agriculture.

ReachOut Tim Tutors
The ReachOut Tim Tutors program recruits, trains, and matches MIT students, faculty, staff, spouses, and partners with children at a local community center to engage and challenge them with reading and math activities. The program currently partners with three local community centers. In addition, ReachOut Tim Tutors is a Federal Work-Study eligible program. Students who are eligible for Federal Work-Study as part of their financial aid package can be paid for providing this valuable community service.

Community Service Work-Study

This program enables MIT students to give back to the community while earning a paycheck during the semester, summer, or winter break. Students who qualify for Federal Work-Study are able to add to their work experience while assisting nonprofit organizations with finding creative solutions to the problems they face. For instance, Work-Study students might help staff a local homeless shelter, create communication materials for a lead-poisoning prevention program, serve as advocates for low-income clients, or tutor Boston high school athletes. Through a partnership between Community Service Work-Study and the Externship program, four students traveled to Los Angeles to design material for a STEM program with the i.am.angel Foundation.

CityDays

CityDays is a series of one-day volunteer opportunities for all members of the MIT community. All students, faculty, and staff are encouraged to engage with the Cambridge and greater Boston community by devoting a few hours to volunteer with CityDays throughout the year. In conjunction with MIT's mission, the CityDays campaign aims to work for the "betterment of humankind" by connecting those who are a part of the MIT community with local organizations who need volunteers.

Four Weeks for America

This program enables MIT students to spend IAP working with Teach for America teachers on science and math projects in classrooms in small rural areas or big inner cities while learning about educational change and policy. Participating students might develop hands-on science curriculum, perform data analysis of classroom performance, or research tools that improve learning.

Alternative Spring Break

Alternative Spring Break enables MIT students to spend spring break participating in service in our local region. The PKG Center typically arranges week-long group experiences with community agencies in Greater Boston and New Jersey. Students combine hands-on service activities with learning about local issues and exploring societal challenges. They also offer grants to service groups who plan their own alternative spring break trips combining service and reflection.

LEAP Grants

Learn, Explore, Act, & Prepare (LEAP) Grants provide MIT students with funding to carry out a service project, volunteer day, or philanthropy event in the United States. LEAP grants also help students learn about service and social responsibility or build their skills to tackle a community challenge.

Freshman Urban Program

Through this week-long freshman pre-orientation program, incoming MIT students can help others while exploring their new neighborhood, learning about community challenges, and making friends. Freshman Urban Program participants volunteer with local agencies such as the Charles River Conservancy and Bridge over Troubled Waters and explore how issues like hunger and homelessness affect our community.

Office of Government and Community Relations

Since its founding, MIT has maintained a commitment to serving the local community as both a resource for education and technology and as a good neighbor. Through the Office of Government and Community Relations (OGCR), MIT works collaboratively with dozens of Cambridge nonprofits that address local challenges and opportunities such as meeting the needs of underserved populations, youth programs, and environmental sustainability. The Institute supports these organizations by providing direct financial support as well as in-kind resources including facility use, faculty & staff expertise, and volunteer engagement. In addition, OGCR collaborates with the MIT PKG Center and MIT Community Giving to oversee the MIT Community Service Fund (CSF). The CSF provides support for nonprofits where MIT volunteers are at work and encourages the creation of new community service projects by providing grants to MIT affiliates.

In addition to working with nonprofits to serve the local community, the Institute's various departments, labs, and centers (DLCs) coordinate outreach programs to educate and inspire K–12 students. OGCR works with these outreach programs to facilitate their relationships to educators and leaders in the local educational ecosystem.

Service to the community is embedded into the culture of MIT—the Institute's various DLCs have a diverse array of programs that support our host community.

Abdul Latif Jameel Poverty Action Lab

The Abdul Latif Jameel Poverty Action Lab (J-PAL) is a global research center based at MIT working to reduce poverty by ensuring that policy is informed by scientific evidence. Anchored by a network of more than 180 affiliated professors at universities around the world, J-PAL conducts large-scale randomized impact evaluations of social programs to answer critical questions in the fight against poverty. J-PAL builds partnerships with governments, multilateral organizations, NGOs, and others to share this knowledge, scale up effective programs, and advance evidence-informed decision-making.

J-PAL was launched at the Department of Economics at MIT in 2003 by professors Abhijit Banerjee, Esther Duflo, and Sendhil Mullainathan and now has regional centers at leading research universities in Cape Town, Jakarta, New Delhi, Paris, and Santiago. With more than 400 research associates, policy experts, and training staff around the world, J-PAL's work spans ten broad sectors: Agriculture; Crime, Violence, and Conflict; Education; Environment and Energy; Finance; Firms; Health; Gender; Labor Markets; and Political Economy and Governance.

Research

At J-PAL we believe investing in rigorous research is essential to finding solutions to the world's greatest challenges. Working with governments, NGOs, donors, and private firms, J-PAL affiliates have conducted more than 900 randomized evaluations across a diverse range of topics, from clean water to microfinance to crime prevention.

J-PAL's research group works with affiliates to forge relationships with implementers on the ground and contributes to the design of survey instruments, data collection and survey efforts, statistical analysis, and data publication. J-PAL also creates practical research resources designed to help people develop and carry out high-quality randomized evaluations. Its comprehensive online library features evaluation manuals, analysis and survey tools, coding tools, and guidelines on ethics and transparency in research.

Education and Training

The education and training group at J-PAL works to build the capacity of researchers who produce evidence, policymakers and donors who use it, and advocates of evidence-informed policy. J-PAL's training offerings include half-day workshops, five-day Executive Education courses, and full-year degree programs, and cover topics from applied statistical analysis to ethics and responsible decision-making.

To make this capacity building more accessible, J-PAL partnered with MITx to develop a series of free open online courses for students and professionals. These twelve-week courses are taught by J-PAL's affiliated professors and are open to all who are interested in using evidence to promote effective policies and programs.

Policy Expertise
The policy group at J-PAL bridges gaps between researchers and policymakers. J-PAL's policy experts work with its affiliated professors to distill research results into practical lessons that are clear, concise, and relevant to policymakers. Through trusted government partnerships spanning the globe, J-PAL provides funding, technical assistance, and embedded staff to help shape programs and policies that deliver results. J-PAL's research and policy outreach work has contributed to cost-effective programs being scaled up to reach more than 400 million people.

J-PAL North America
J-PAL North America, one of J-PAL's six regional research centers, is also based at MIT. To address the complex causes and consequences of poverty, J-PAL North America's work spans a range of sectors including health care, housing, criminal justice, education, and labor markets. J-PAL North America works with decisionmakers at the local, state, and federal level to conduct randomized evaluations of social policy, share research results, and train policymakers and practitioners to generate and use evidence.

J-PAL North America runs five major initiatives to support randomized evaluations and evidence-informed policymaking: the Education, Technology, and Opportunity Initiative; the State and Local Innovation Initiative; the Health Care Delivery Initiative; the Social Policy and Research Initiative; and, in partnership with MIT's Task Force on Work of the Future, the Work of the Future Initiative. Amy Finkelstein (MIT) and Lawrence Katz (Harvard University) lead J-PAL North America as its scientific directors. J-PAL affiliates have carried out more than 250 randomized evaluations in the region.

MIT D-Lab

MIT D-Lab works with people around the world to develop and advance collaborative approaches and practical solutions to global poverty challenges. The program's mission is pursued through interdisciplinary courses, research in collaboration with global partners, social entrepreneurship, capacity building, humanitarian intervention, technology development, and community initiatives—all of which emphasize experiential learning, real-world projects, community-led development, and scalability.

D-Lab classes and projects are connected to communities around the world in countries including Bangladesh, Botswana, Brazil, Burkina Faso, Colombia, El Salvador, Ethiopia, Ghana, Guatemala, Greece, Haiti, India, Indonesia, Kenya, Lesotho, Mali, Mexico, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Peru, Rwanda, Senegal, Tanzania, Uganda, the United States (Puerto Rico), Zambia, and others.

Programs & Opportunities
Education
Through hands-on projects in real-world settings, D-Lab students can make a difference in the lives of people living in poverty. They give real substance to the MIT commitment to solve hard problems in service to the world. In D-Lab's 20+ MIT classes, D-Lab students acquire competency in the participatory design process, understand and apply principles of engineering and design, engage in hands-on shop work, learn to think critically about theories of development, and obtain meaningful experiences in the field—all preparing you to continue socially and environmentally conscious work that addresses issues of global poverty.

http://d-lab.mit.edu/education

Research

D-Lab's lean, collaborative, and interdisciplinary research team creates, shares, and uses collaborative research practices, actionable findings, and practical solutions to address global poverty challenges. The team designs and implements a variety of studies (such as needs assessment and asset mapping, technology evaluations, technology development projects, assessing the outcomes and impacts of local innovation, and understanding innovation processes) in collaboration with organizations and local community members around the world in several sectors (evaporative cooling, biomass fuels and cookstoves, water treatment, digital financial services, and mobile technologies). The research program is integrated with the other programs within D-Lab and its findings inform the continual development of the D-Lab Education and Innovation Practice programs.

D-Lab is also home to the Comprehensive Initiative on Technology Evaluation (CITE), launched with USAID funding by D-Lab and a consortium of MIT partners in 2012. This past year, D-Lab received USAID funding to take on six projects under the auspices of CITE: 1) Assessing the Impact of Evaporative Cooling Technologies for Improved Vegetable Preservation (Mali); 2) Investigating Inclusive Systems Innovation; 3) Designing an Evaluation Methodology to Assess Capacity Development for Local Innovation; 4) Fairness, Bias, and Appropriate Use of Machine Learning; 5) Internet of Things: Low Cost Sensors for Agriculture (Kenya and India); 6) Digital Financial Services for Smallholder Farmers (Senegal, Guatemala, and Burkina Faso).

Ongoing research in evaporative cooling for fruit and vegetable preservation (Burkina Faso, Rwanda, India, Mali, Kenya), xylem water filter development (India), local innovation (Mexico and Morocco), a green products evaluation (India), and mobile health technologies (multiple countries) continued throughout the year. In the fall of 2018, MIT D-Lab received a grant from the National Science Foundation to create and evaluate a co-creation toolkit for graduate students working in humanitarian settings.

http://d-lab.mit.edu/research

Innovation Practice

The third pillar of D-Lab, Innovation Practice, was formed in spring 2017 to develop, advance, and apply participatory innovation as a methodology for tackling poverty. To achieve this, the Innovation Practice team conducts design trainings, fosters global communities of practice, and partners with other development actors to implement local innovation programs in complex settings. This year, the Innovation Practice team began to tackle a new question across all of its programs: how can we support local innovators by strengthening the innovation ecosystems they inhabit? The programs that make up the Innovation Practice pillar include:

- The **D-Lab Scale-Ups Fellowship**, which supports social entrepreneurs to bring poverty-alleviating products and services to emerging markets at scale. This past year, six new fellows were selected—all founders of homegrown, high-impact ventures in underserved markets in Kenya, Tanzania, and Uganda. To date, the fellowship has supported 39 fellows who have reached 1.5 million people with goods and services.

- **Humanitarian Innovation**, which is spearheaded by D-Lab Founding Director Amy Smith and humanitarian relief expert Martha Thompson. The team engages refugees and displaced persons in the design process so that they can create the things they need to improve their lives and ultimately improve the way humanitarian work is delivered. The program has delivered workshops in Sudan, Uganda, El Salvador, and Greece with multiyear projects in Greece and El Salvador, where Innovations Centers run by local staff have been established. A new program, working with Rohingya refugees in Bangladesh, is just getting under way.

- The **Inclusive Markets** program engages with regional and community leaders to develop inclusive businesses, markets, and economies that promote equity, resourcefulness, and resilience for people living in poverty. This year, this program has leveraged D-Lab's Creative Capacity Building and Co-Design methodologies to engage with wastepickers in Ghana and artisanal miners in Colombia, facilitating opportunities for these workers to co-create new market systems alongside government and industry leaders.

- **Innovation Ecosystem Building** at D-Lab seeks to support grassroots informal sector entrepreneurs addressing local and global challenges by bringing together diverse regional actors to support innovation and entrepreneurship. This year, D-Lab held catalytic innovation ecosystem convenings through the NEXTi2i program in Accra, Ghana; the OC3 program in Oaxaca, Mexico; and at the PIA Co-Design Summit in Laayoune, Western Sahara/Southern Morocco.

- The **Practical Impact Alliance** (PIA), a membership organization of leaders from diverse organizations with aligned missions who learn, collaborate, and develop best practices together. 2019 members included Danone, Johnson & Johnson, OCP Phosboucraa Foundation, PACT, SC Johnson, Siemens Stiftung, USAID, and World Vision.

Local Programs

Amphibious Achievement
Amphibious Achievement is an MIT undergraduate student run group that mentors high school students in the greater Boston area in athletics and academics. Under the guidance of MIT student coaches/tutors, Amphibious Achievers train to row and swim competitively while also working on college-preparatory academics. It is free of cost to all students who participate.

http://amphibious.mit.edu/

Cambridge Science Festival
The annual Cambridge Science Festival, the first of its kind in the United States, is a 10-day (and night!) celebration showcasing Cambridge as a leader in science, technology, engineering, and math. The festival is presented to the public by the MIT Museum in collaboration with the City of Cambridge, community organizations, schools, universities, and businesses. A multifaceted, multicultural event held every spring, Cambridge Science Festival celebrates curiosity and makes science accessible, interactive, and fun for everyone through 225+ engaging events across the city.

http://www.CambridgeScienceFestival.org/

Edgerton Center—K–12 Programs
The Edgerton Center continues the learning-by-doing legacy of "Doc" Edgerton. The Center's K–12 programs educate, inspire, and motivate primarily middle school through 12th grade students through hands-on science and engineering challenges. Concentrating in the Greater Boston area, with selected out-of-state and foreign endeavors, the Edgerton Center's multifaceted approach supports over 150 on-campus classroom workshops annually, intensive summer programs, innovative curriculum, and professional development workshops for teachers. MIT students are closely involved in many of the programs, and all programs are provided at no or minimal cost.

Educational Studies Program
The MIT Educational Studies Program (ESP) was created by MIT students in 1957 to make a difference in the community by sharing their knowledge and creativity with local high school students. Since then, they have grown to support well over three thousand students each year with the help of hundreds of MIT students. Through an extensive offering of academic and non-academic classes, ESP is dedicated to providing a unique, affordable educational experience for motivated middle school and high school students. ESP courses are developed and taught by MIT students, alumni, faculty, and members of the community.

http://esp.mit.edu/

Giving Tree

The MIT Giving Tree allows students, alumni, faculty, staff, and friends to provide gifts to local children and families each holiday season. The MIT PKG Center works with several campus groups, along with hundreds of individuals across campus to collect gifts for 12 local agencies serving low-income children. This program provides MIT a means to expand our ethic of caring to local children and families.

Graduate Student Council External Affairs Board

Part of the broader MIT Graduate Student Council (GSC) student government, the External Affairs Board (EAB) coordinates relationships with organizations outside MIT; political advocacy at all levels of government; community outreach, education, and service; and the writing of statements of the positions of the GSC or the graduate student body on issues of significance to the welfare of graduate students at MIT, all in line with the GSC Policy Platform, which can be found on the GSC website. Examples of EAB's work include biannual U.S. Congressional advocacy trips, regular Massachusetts statehouse advocacy visits, outreach efforts to the hometown schools and newspapers of MIT graduate students, and regular participation in multi-university collaborations at the Boston, regional, and national levels.

MIT Integrated Learning Initiative

Launched in 2016, MIT Integrated Learning Initiative's (MITili) mission is to transform learning through research and applied practice. This initiative studies learning the MIT way: through rigorous, interdisciplinary research on the fundamental mechanisms of learning and how we can improve it. MITili draws from fields as wide-ranging as cognitive psychology, neuroscience, economics, health, design, engineering, architecture and discipline-based education research to study learning from several perspectives.

MITili projects include work in pK–12 education, such as "Reach Every Reader" which leverages neuroscience to develop digital screening tools that detect potential learning difficulties, so that intervention can begin before the child falls behind; a project that leverages artificial intelligence to support low socioeconomic status families in fostering early language development; development and assessment of learning games to increase early mathematics readiness; and partnering with school districts to create more effective and equitable school choice mechanisms. In higher education, MITili supports creation of visualization tools to enhance understanding of physics and identifying ways to increase learner completion in online courses. In the workforce learning space, MITili has researched ways to enhance professional education, from evaluating pedagogical structure of training classes to reduce mind wandering and increase retention, to assessing the neuroscience of inserting novelty videos to enhance engagement and learning.

Teaching Systems Labs

MIT's Teaching Systems Labs (TSL) helps prepare pK–12 teachers for the complex, technology-driven classrooms of the future, by developing games, simulations and other tools for teaching, offering practice spaces for teachers to design and test new pedagogies, and offering online and in person training for teachers on innovative content.

Playful Journey Lab

The MIT Playful Journey Lab explores frontiers in lifelong, lifewide learning with the goal of understanding the ways we can strengthen future-ready skills. With a focus on learner-centered assessment and playful exploration, researchers and educators in the lab design and investigate new ways to prepare schools, teachers, students, and members of society to thrive in a rapidly-changing world. Through the design of both digital and non-digital tools, design-based research with learners and practitioners, and a growing community of passionate educators, this work will map out new pathways for the future of learning.

World Programs

MIT has a strong commitment to service. There are programs that are active both domestically and abroad while others cover more than service. Below are a couple of examples of work abroad. Please see descriptions of J-PAL and D-Lab on pages 108–110, and the Global Engagement section beginning on page 95 for additional work.

Abdul Latif Jameel World Education Laboratory

Founded in 2017, the Abdul Latif Jameel Education Laboratory (J-WEL) is an incubator for change in education at MIT and around the world. It brings together educators, technologists, policymakers, and societal leaders to address global challenges in education through online and in-person collaborations, workshops, and conferences. It consists of three collaboratives that address these challenges across all levels of education: pK–12, higher-ed, and workforce learning.

Legatum Center for Development and Entrepreneurship

The Legatum Center for Development and Entrepreneurship at MIT was founded on the belief that economic progress and good governance in low-income countries emerge from entrepreneurship and innovations that empower ordinary citizens. The center administers a highly competitive fellowship program for MIT graduate students who intend to launch innovative and inclusive for-profit enterprises in developing countries. In addition to supporting the Legatum Fellows, the Legatum Center aims to catalyze entrepreneurship for broad-based prosperity by administering programs including case writing, research, articles, lectures, conferences, and seed grants.

http://legatum.mit.edu/