MIT Briefing Book

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## MIT Senior Leadership

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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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Section 1
Facts and History
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 longstanding 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.

MIT Campaign for a Better World

Launched to the public in May 2016, the MIT Campaign for a Better World is a $5 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—is focusing MIT’s distinctive strengths in education, research, and innovation on six key priority areas: defining the future of human health through advances from the laboratory to the clinic; transforming our world through fundamental scientific research; addressing mankind’s critical environmental and sustainability challenges; reimagining education for the 21st-century learner; accelerating the journey from idea to investment and investment 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; transforming MIT’s presence in the innovation hub of Kendall Square; and developing leading-edge research facilities such as MIT.nano.

Early support for the Campaign from MIT’s alumni and friends has been directed toward such areas as education, water and food security, autism research, and urbanization. Across campus, new teaching, learning, and research spaces are providing MIT’s faculty and students with the advanced facilities they need. Donor support is also providing MIT with funds to invest in the daring, high-risk research that is the Institute’s hallmark and sustain support for students, faculty, and the physical campus.
Fields of Study
MIT supports a large variety of fields of study, from science and engineering to the arts. MIT’s five academic schools 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
Data, Systems, and Society
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

Interdisciplinary Undergraduate Programs
Chemistry and Biology
Computer Science and Molecular Biology
Computer Science, Economics, and Data Science
Humanities
Humanities and Engineering
Humanities and Science

Interdisciplinary Graduate Programs
Computation for Design and Optimization
Computational and Systems Biology
Computational Science and Engineering
Computer Science and Molecular Biology
Design and Management (Integrated Design and Management & System Design and Management)
Harvard-MIT Health Sciences and Technology Program
Joint Program with Woods Hole Oceanographic Institution
Leaders for Global Operations
Microbiology
Operations Research
Polymers and Soft Matter
Social and Engineering Systems
Statistics
Supply Chain Management
Technology and Policy
Transportation
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
Abdul Latif Jameel World Water and Food Security Lab
Center for Archaeological Materials
Center for Bits and Atoms
Center for Collective Intelligence
Center for Computational Engineering
Center for Computational Research in Economics and Management Science
Center for Energy and Environmental Policy Research
Center for Environmental Health Sciences
Center for Global Change Science
Center for International Studies
Center for Information Systems Research
Center for Real Estate
Center for Transportation and Logistics
Clinical Research Center
Computer Science and Artificial Intelligence Laboratory
Concrete Sustainability Hub
Deshpande Center for Technological Innovation
Division of Comparative Medicine
Edgerton Center/D-Lab
Haystack Observatory
Initiative on the Digital Economy
Institute for Data, Systems, and Society
Institute for Medical Engineering and Science
Institute for Soldier Nanotechnologies
Institute for Work and Employment Research
Joint Program on the Science and Policy of Global Change
Knight Science Journalism Program
Koch Institute for Integrative Cancer Research
Laboratory for Financial Engineering
Laboratory for Information and Decision Systems
Laboratory for Manufacturing and Productivity
Laboratory for Nuclear Science
Legatum Center for Development and Entrepreneurship
Leventhal Center for Advanced Urbanism
Lincoln Laboratory
Martin Trust Center for MIT Entrepreneurship
Materials Research Laboratory
McGovern Institute for Brain Research
Microsystems Technology Laboratories
MIT Center for Art, Science, and Technology
MIT Energy Initiative
MIT Environmental Solutions Initiative
MIT Innovation Initiative
MIT Kavli Institute for Astrophysics and Space Research
MIT Media Lab
MIT Portugal Program
MIT Program in Art, Culture, and Technology
MIT Sea Grant College Program
MIT/Woods Hole Oceanographic Institution Joint Program in Oceanography/Applied Ocean Science and Engineering
Nuclear Reactor Laboratory
Operations Research Center
Picower Institute for Learning and Memory
Plasma Science and Fusion Center
Research Laboratory of Electronics
Sloan School of Management-Research Centers
Simons Center for the Social Brain
Singapore–MIT Alliance for Research and Technology
Sociotechnical Systems Research Center
Women’s and Gender Studies Program

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

Since the advent of digital computing, MIT has been at the forefront of innovation in educational technology. Individual faculty initiatives, departmental projects, or Institute-wide programs have helped transform education at MIT and around the world. In the last few years, technology-enabled change in how we teach and learn has been accelerating. Remarkable educational experiments throughout higher education are resulting in unprecedented breakthroughs:

- New pedagogies and tools. Digital technologies enable students to do more outside the class: consume lecture content, receive rapid feedback, and access adaptive hints to foster learning. This means that class time can focus on discussion, hands-on experiments and other forms of active learning. Technologies, such as the Residential MITx platform, provide flexibility in course delivery, enabling students to access content anytime, anywhere. New tools such as internet labs, 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 project—and since joined by hundreds more institutions worldwide—lowers financial, geographical, and political barriers to accessing quality educational content. Robust learning management platforms like edX (originally an MIT-Harvard alliance) make it possible to increase student cohort size from a campus classroom to tens of thousands around the globe via the Internet. MITx brings MIT faculty and their MOOCs to thousands of learners everywhere via the edX platform. MicroMasters programs offer an online credential to learners and a new path to a Master’s degree at MIT and other universities.

- 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. In the aggregate, these data can be used to model student learning approaches. Launched in 2016, the MIT Integrated Learning Initiative (MITili) is a cross-disciplinary, Institute-wide effort that will foster rigorous, quantitative research on how people learn; investigate what methods and approaches to education work best for different people and subjects; and improve learning and teaching from K–12 through college through continuing education.

MIT Open Learning 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; and the Jameel World Education Lab (J-WEL), which convenes a global community to spread research and best practice in teaching and learning. 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
- Partners with companies, universities, governments, and organizations that wish to develop new learning capabilities and enhance the competencies of their students, workforce, and citizens
- Extends MIT’s knowledge and classrooms to the world.

http://odl.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 25 U.S. 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/nucc

**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/

**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.

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/

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, Air Force, Army, 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. https://due.mit.edu/rotc/rotc-programs/

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.

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/
**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** The Whitaker College of Health Sciences, Technology, and Management is established to strengthen MIT’s ability to engage in health related research and education.

**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.

**1983–1990** MIT language and computer science faculty join in the Athena Language Learning Project to develop interactive videos that immerse students in the language and character of other cultures. The work pioneers a new generation of language learning tools.

**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.

1991 The Department of Mechanical Engineering’s course 2.70 (2.007) design contest goes international, with students competing from Japan, England and Germany.

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.

1994 The MIT-China Program is created within MISTI to send MIT students to China for internships.

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. MIT’s Political Science Department establishes the Washington Summer Internship Program to provide undergraduates the opportunity to apply their scientific and technical training to public policy issues.

1997 The MIT-Germany Program is created within MISTI to send MIT students to Germany for internships.

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 MIT-India Program is created within MISTI to send MIT students to India for internships.

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.

1999 The MIT-Italy Program is created within MISTI to send MIT students to Italy for internships.

1999 The University of Cambridge and MIT establish the Cambridge-MIT Institute, whose programs include student and faculty exchanges, an integrated research program, professional practice education, and a national competitiveness network in Britain.

1999 MIT establishes the Society of Presidential Fellows to honor the most outstanding students worldwide entering the Institute’s graduate programs. With gifts provided by lead donors, presidential fellows are awarded fellowships that fund first year tuition and living expenses.

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 The MIT-France Program is created within MISTI to send MIT students to France for internships and enhance research collaboration between faculty at MIT and in France through the MIT-France Seed Fund.

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’s Program in Computational and Systems Biology (CSBi), an Institute-wide program linking biology, engineering, and computer science in a systems biology approach to the study of cell-to-cell signaling, tissue formation, and cancer, begins accepting students for a new Ph.D. program that will give them the tools for treating biological entities as complex living systems.

2004 The MIT-Mexico Program is created within MISTI to send MIT students to Mexico for internships.

2005 Combining courses from engineering, mathematics, and management, MIT launches its master’s program in Computation for Design and Optimization, one of the first curriculums in the country to focus on the computational modeling and design of complex engineered systems. The program prepares engineers for the challenges of making systems ranging from computational biology to airline scheduling to telecommunications design and operations run with maximum effectiveness and efficiency.

2006 MIT creates the Campaign for Students, a fundraising effort dedicated to enhancing the educational experience at MIT through creating scholarships and fellowships, and supporting multidisciplinary education and student life.

2006 The MIT-Spain Program is created within MISTI to send MIT students to Spain for internships.

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.

2008 The MIT-Israel Program is created within MISTI to send MIT students to Israel for internships; strengthen collaborations between MIT and Israel; and organize workshops, conferences, symposia and lectures at MIT and in Israel.

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 The MIT-Brazil Program is created within MISTI to send MIT students to Brazil for internships and encourage research collaboration between faculty at MIT and in Brazil through the MIT-Brazil Seed Fund.

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. It can be combined with any major subject. The minor aims to allow students to develop expertise and depth in their major disciplines, but then complement that with the breadth of understanding offered by the energy minor.

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 Lincoln Laboratory debuts a new outreach program—a two-week summer residential program for high-school students. The program, Lincoln Laboratory Radar Introduction for Student Engineers (LLRISE), focuses on radar technology. The project-based curriculum is based on a popular class offered during MIT’s Independent Activities Period (IAP) and taught by Laboratory technical staff. While the instructors adapted the IAP course to suit high-school students, they retained the challenging nature of the original class. The goal of the program is that students take away not only an understanding of radar systems but also the realization that engineering is about problem-solving and applying knowledge in innovative ways.

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.
2013 OCW inaugurates “OCW Educator” with the first “This Course at MIT” page. This feature offers educational ideas, practices, and pedagogical expertise from MIT faculty in order to inspire teachers around the world with innovations that they may use in their own teaching.

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

2014 The Office of Digital Learning pilots the MITx Global Entrepreneurship Bootcamp, an innovative “blended learning” program that combines online education with an intensive, immersive one-week on-campus experience.

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 Lincoln Laboratory offers LLCipher, a one-week workshop providing an introduction to cryptography. Lessons provide high-school students the foundational knowledge to understand a math-based theoretical approach to securing data. Students construct provably secure encryption and digital signature schemes, and then learn about zero-knowledge proofs and multiparty computation. The workshop’s success warrants an expansion in future years.

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.
Research Highlights

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

1967 Joel Moses, William A. Martin, and others develop MACSYMA, a computer program that manipulates algebraic quantities and performs symbolic integration and differentiation.

1968 Radar-based lunar studies are performed by Lincoln Laboratory. The use of radar to map the surface of the moon becomes possible when the radar beam is made small enough to discriminate between two points on the surface that would contribute echoes at the same range and Doppler shift. Altitude data is added to the two-dimensional radar reflectivity data by the use of interferometry. In addition, from the strength of radar reflections, it is estimated that the lunar surface has weight-bearing properties similar to that of terrestrial sand.

1969 Ioannis V. Yannas begins to develop artificial skin—a material used successfully to treat burn victims.

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 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/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/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 The high frame rate required for airborne laser radar demands an array of photomixers, and Lincoln Laboratory begins a design study in binary optics for a solution. A hologram is proposed to generate an array of beams with the amplitude and phase distributions necessary to ensure efficient photomixing.

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.

1982 Lincoln Laboratory utilizes a new generation of digital signal processing chips to develop a compact linear predictive coding (LPC) vocoder small and inexpensive enough for wide distribution. A vocoder analyzes and synthesizes speech using parameters that can be encrypted and transmitted at a much lower bit rate than the original speech waveform. The LPC vocoder is important in the U.S. development of secure voice systems.

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/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/Medicine for his work.

1988 Project Daedalus sets distance and endurance records for human-powered aircraft in a flight over the Aegean Sea.

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

1989 The Airport Surveillance Radar (ASR)-9, developed at Lincoln Laboratory, provides air traffic control (ATC) personnel with a display free of clutter and a telephone bandwidth data stream for transmitting information to ATC facilities. The technology is later transferred to Westinghouse Corporation, which deploys the ASR-9 at 137 sites in the U.S. for the Federal Aviation Administration.

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.

1991 Cleveland heart doctors begin clinical trials of a laser catheter system for microsurgery on the arteries that is largely the work of Michael Feld and his MIT associates.

1992 The Lincoln Laboratory Microelectronics Laboratory becomes operational. It is a 70,000 sq ft state-of-the-art semiconductor research and fabrication facility supporting a wide range of programs: flight-quality gigapixel charge-coupled device (CCD) imager focal planes, photon-counting avalanche photodiode arrays, and niobium-based superconducting circuits, to name a few. The Microelectronics Laboratory also supports advanced packaging with a precision multichip module technology and an advanced three-dimensional circuit stacking technology.

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 Alexander Rich and postdoctoral fellow Shuguang Zhang report the discovery of a small protein fragment that spontaneously forms into membranes. This research will lead to advances in drug development, biomedical research, and the understanding of Alzheimer’s and other diseases.

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.

1994 MIT engineers develop a robot that can “learn” exercises from a physical therapist, guide a patient through them, and, for the first time, record biomedical data on the patient’s condition and progress.

1995 The Advanced Land Imager (ALI) is developed at Lincoln Laboratory to validate new technologies that could be utilized in future land-observing satellites and would reduce mass, size, and power consumption while improving instrument sensitivity and image resolution.

1995 Scientists at the Whitehead Institute for Biomedical Research and MIT create a map of the human genome and begin the final phase of the Human Genome Project. This powerful map contains more than 15,000 distinct markers and covers virtually all of the human genome.

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 MIT biologists, led by Leonard Guarente, identify a mechanism of aging in yeast cells that suggests researchers may one day be able to intervene in, and possibly inhibit, the aging process in certain human cells.

1998 Lincoln Near Earth Asteroid Research (LINEAR) is developed by Lincoln Laboratory to detect and catalogue near-Earth asteroids that may threaten Earth. Applying technology originally developed for the surveillance of Earth-orbiting satellites, LINEAR uses two ground-based electro-optical deep-space surveillance telescopes.

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) 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. He 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.

2000 Researchers develop a device that uses ultrasound to extract a number of important molecules noninvasively and painlessly through the skin. They expect that the first application will be a portable device for noninvasive glucose monitoring for diabetics.
2000 Researchers from the MIT Sloan School of Management launch the Social and Economic Explorations of Information Technology (SeeIT) Project, the first empirical study of the effects of information technology (IT) on organizational and work practices. Examining IT’s relationship to changes in these models, SeeIT provides practical data for understanding and evaluating IT’s business and economic effects, which will enable us to take full advantage of its opportunities and better control its risks.

2001 In a step toward creating energy from sunlight as plants do, Daniel Nocera and a team of researchers invent a compound that, with the help of a catalyst and energy from light, produces hydrogen.

2002 MIT researchers create the first acrobatic robotic bird—a small, highly agile helicopter for military use in mountain and urban combat.

2002–2005 Scientists at MIT, the Whitehead Institute for Biomedical Research, and the Broad Institute complete the genomes of the mouse, the dog, and four strains of phytoplankton, photosynthetic organisms that are critical for the regulation of atmospheric carbon dioxide. They also identify the genes required to create a zebrafish embryo. In collaboration with scientists from other institutions, they map the genomes of chimpanzees, humans’ closest genetic relative, and the smallest known vertebrate, the puffer fish.

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 will provide 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.

2004 MIT’s Levitated Dipole Experiment, a collaboration among scientists at MIT and Columbia, generates a strong dipole magnetic field that enables them to experiment with plasma fusion, the source of energy that powers the sun and stars, with the goal of producing it on Earth. Because the hydrogen that fuels plasma fusion is practically limitless and the energy it produces is clean and doesn’t contribute to global warming, fusion power will be of enormous benefit to humankind and to earth systems in general.

2004 A team, led by neuroscientist Mark Bear, illuminates the molecular mechanisms underlying Fragile X Syndrome and shows that it might be possible to develop drugs that treat the symptoms of this leading known inherited cause of mental retardation, whose effects range from mild learning disabilities to severe autism.

2004 Shuguang Zhang, Marc A. Baldo, and recent graduate Patrick Kiley, first figure out how to stabilize spinach proteins—which, like all plants, produce energy when exposed to light—so they can survive without water and salt. Then, they devise a way to attach them to a piece of glass coated with a thin layer of gold. The resulting spinach-based solar cell, the world’s first solid-state photosynthetic solar cell, has the potential to power laptops and cell phones with sunlight.

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

2005 Vladimir Bulovic and Tim Swager develop lasing sensors based on a semiconducting polymer that is able to detect the presence of TNT vapor subparts per billion concentrations.

2006 MIT launches the MIT Energy Initiative (MITEI) to address world energy problems. Led by Ernest J. Moniz and Robert C. Armstrong, MITEI coordinates energy research, education, campus energy management, and outreach activities across the Institute.
2007 Rudolf Jaenisch, of the Whitehead Institute for Biomedical Research, conducts the first proof-of-principle experiment of the therapeutic potential of induced pluripotent stem cells (iPS cells), using iPS cells reprogrammed from mouse skin cells to cure a mouse model of human sickle-cell anemia. Jaenisch would then use a similar approach to treat a model of Parkinson’s disease in rats.

2007 Marin Soljačić and his colleagues develop a new form of wireless power transmission they call WITricity. It is based on a strongly coupled magnetic resonance and can be used to transfer power over distances of a few meters with high efficiency. The technique could be used commercially to wirelessly power laptops, cell phones, and other devices.


2007 Tim Jamison discovers that cascades of epoxide-opening reactions that were long thought to be impossible can very rapidly assemble the Red Tide marine toxins when they are induced by water. Such processes may be emulating how these toxins are made in nature and may lead to a better understanding of what causes devastating Red Tide phenomena. These methods also open up an environmentally green synthesis of new classes of complex highly biologically active compounds.

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 A team, led by Marc A. Baldo, designs a solar concentrator that focuses light at the edges of a solar power cell. The technology can increase the efficiency of solar panels by up to 50 percent, substantially reducing the cost of generating solar electricity.

2009 Lincoln Laboratory develops and demonstrates the Lincoln Distributed Disaster Response System, which enables information from airborne platforms, distributed weather stations, GPS-enabled devices, and other sources to be shared by responders at the emergency command centers and by those equipped with ruggedized laptops at the front lines. The system design initially focuses on fighting a large-scale fire but is also applicable for any large-scale disaster response.

2009 A team of MIT researchers, led by Angela Belcher, reports that it is able to genetically engineer viruses to produce both the positively and negatively charged ends of a lithium-ion battery. The battery has the same energy capacity as those being considered for use in hybrid cars, but is produced using a cheaper, less environmentally hazardous process. MIT President Susan Hockfield presents a prototype battery to President Barack Obama at a press briefing at the White House.

2009 Researchers at MIT’s Picower Institute for Learning and Memory show for the first time that multiple interacting genetic risk factors may influence the severity of autism symptoms. The finding could lead to therapies and diagnostic tools that target the interacting genes.

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.

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 Li-Huei Tsai’s laboratory describes mechanisms that underlie Alzheimer’s disease and propose that inhibition of histone deacetylases is therapeutic for degenerative disorders of learning and memory. Her laboratory also discovers the mechanisms of action of the gene Disrupted-in-Schizophrenia 1 and demonstrates why drugs such as lithium are effective in certain instances of schizophrenia. This research opens up pathways to discovering novel classes of drugs for devastating neuropsychiatric conditions.

2010 A new approach to desalination is being developed by researchers at MIT and in Korea that could lead to small, portable desalination units that could be powered by solar cells or batteries and could deliver enough fresh water to supply the needs of a family or small village. As an added bonus, the system would remove many contaminants, viruses, and bacteria at the same time.

2010 Yang Shao-Horn, with some of her students, and visiting professor Hubert Gasteiger report that lithium-oxygen (also known as lithium-air) batteries with electrodes with either gold or platinum as a catalyst have a higher efficiency than simple carbon electrodes. Lithium-air batteries are lighter than the conventional lithium-ion batteries.

2010 A team at the Media Lab, including Ramesh Raskar, visiting professor Manuel Oliveira, student Vitor Pamplona, and postdoctoral research associate Ankit Mohan, create a new system to determine a prescription for eyeglasses. In its simplest form, the test can be carried out using a small plastic device clipped onto the front of a cellphone’s screen.

2010 MIT releases The Future of Natural Gas report. The two-year study, managed by the MIT Energy Initiative, examines the scale of U.S. natural gas reserves and the potential of this fuel to reduce greenhouse-gas emissions. While the report emphasizes the great potential for natural gas as a transitional fuel to help curb greenhouse gases and dependence on oil, it also stresses that it is important as a matter of national policy not to favor any one fuel or energy source in a way that puts others at a disadvantage.

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 just by adding or removing an additional solution.

2010 Lincoln Laboratory developed 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. The system is installed at the Atom Site on the White Sands Missile Range in New Mexico to evaluate its detection and tracking of microsatellites before being transitioned to Space Surveillance Network.

2011 Elazer Edelman, graduate student Joseph Franses, and former postdoctoral fellows Aaron Baker and Vipul Chitalia show that cells lining blood vessels secrete molecules that suppress tumor growth and prevent cancer cells from invading other tissues, a finding that could lead to a new cancer treatment.

2011 The Alpha Magnetic Spectrometer (AMS)—an instrument designed to use the unique environment of space to search for antimatter and dark matter and to measure cosmic rays—is delivered to the International Space Station. The AMS experiment, led by Samuel C. C. Ting, is designed to study high-energy particles; such study could lead to new theories about the formation and evolution of the universe.

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** By combining a physical interface with computer-vision algorithms, researchers in the Department of Brain and Cognitive Sciences create a simple, portable imaging system that can achieve resolutions previously possible only with large and expensive lab equipment. The device could allow manufacturers to inspect products too large to fit under a microscope and could also have applications in medicine, forensics, and biometrics. Moreover, because the design uses multiple cameras, it can produce 3D models of an object, which can be manipulated on a computer screen for examination from multiple angles.

**2011** Researchers, led by Daniel Nocera, have produced 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 will construct a detailed gravitational model of the moon that will be used to answer fundamental questions about the moon’s evolution and its internal composition. GRAIL’s principal investigator is Maria T. Zuber.

**2012** Researchers, including Jeffrey Grossman, discover that building cubes or towers of solar cells—to extend the cells upward in three-dimensional configurations—generates two to 20 times the power produced by fixed flat panels with the same base area.

**2012** Researchers, led by Ian Hunter, have engineered a device that delivers a tiny, high-pressure jet of medicine through the skin without the use of a hypodermic needle. The device can be programmed to deliver a range of doses to various depths—an improvement over similar jet-injection systems that are now commercially available.

**2012** A clinical trial of an Alzheimer’s disease treatment developed at MIT finds that a nutrient cocktail can improve memory in patients with early Alzheimer’s. Richard Wurtman invented the supplement mixture, known as Souvenaid, which appears to stimulate growth of new synapses.

**2012** Researchers, including Young Lee and PhD graduate Tianheng Han, have followed up on earlier theoretical predictions and demonstrated experimentally the existence of a fundamentally new magnetic state called a quantum spin liquid (QSL), adding to the two previously known states of magnetism. The QSL is a solid crystal, but its magnetic state is described as liquid: Unlike the other two kinds of magnetism, the magnetic orientations of the individual particles within it fluctuate constantly, resembling the constant motion of molecules within a true liquid.

**2012** Lincoln Laboratory develops a laser communications system to demonstrate high-data-rate communications between a lunar-orbiting NASA satellite and a ground site in the United States. The Lunar Laser Communications Demonstration addresses NASA’s need for very-high-rate, very-long-distance communications systems small enough to fly in space. It transmits over 600 megabits per second using only a 4-inch telescope and a 1/2-watt laser installed on the satellite. The ground receiver is nearly ten times more efficient than any optical receiver ever demonstrated at these high rates.

**2013** A new steelsmaking process developed by researchers, Donald Sadoway, Antoine Allanore, and former postdoc Lan Yin, produces no emissions other than pure oxygen and carries nice side benefits: The resulting steel should be of higher purity, and eventually, once the process is scaled up, cheaper.

**2013** A research team, led by Yuriy Román, has devised a cheaper way to synthesize a key biofuel component, which could make its industrial production much more cost-effective. The compound, known as gamma-valerolactone (GVL), has more energy than ethanol and could be used on its own or as an additive to other fuels. GVL could also be useful as a “green” solvent or a building block for creating renewable polymers from sustainable materials.

**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.
2013 Hydrophobic materials—water-shedding surfaces—have a theoretical limit on the time it takes for a water droplet to bounce away from such a surface. Researchers, led by Kripa Varanasi, have found a way to burst through that perceived barrier, reducing the contact time by at least 40 percent. This research could aid ice prevention, wing efficiency, and more.

2014 Lincoln Laboratory develops PANDA (Platform for Architecture-Neutral Dynamic Analysis) enabling software analysts to simplify the analysis and understanding of complex software systems for cyber analysis and threat protection. PANDA allows analysts to quickly develop instrumentation that can help answer complex questions about software and inform appropriate responses. Software developers and analysts can move toward automating tasks that would otherwise be manual, tedious, time-consuming, and costly.

2014 Platinum-group metals can be considered unsustainable resources that are needed catalysts to enable renewable energy technologies. Graduate student Sean Hunt, postdoc Tarit Nimmandwudipong, and Yuriy Román have devised a process of synthesizing renewable alternative catalysts.

2014 Engineers at MIT and Lawrence Livermore National Laboratory (LLNL) have devised a way to translate that airy, yet remarkably strong, structure style of the Eiffel Tower down to the microscale—designing a system that could be fabricated from a variety of materials, such as metals or polymers, and that may set new records for stiffness for a given weight. Nicholas Fang, former postdoc Howon Lee, visiting research fellow Qi “Kevin” Ge, LLNL’s Christopher Spadaccini and Xiaoyu “Rayne” Zheng are among the researchers involved in the project.

2014 Researchers, including Gang Chen and postdoc Hadi Ghasemi, have developed a new material structure—a layer of graphite flakes and an underlying carbon foam—that generates steam by soaking up the sun. The material is able to convert 85 percent of incoming solar energy into steam—a significant improvement over recent approaches to solar-powered steam generation. The setup loses very little heat in the process, and can produce steam at relatively low solar intensity.

2014 Bryan Hsu PhD ’14 and Paula Hammond, working with Myoung-Hwan Park of Shamyook University in South Korea and Samantha Hagerman ’14, have developed 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 have found there’s a hard limit to how close ultrarelativistic electrons can get to the Earth. The team found 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.

2015 Natalie Artzi and Elazer Edelman, working with other researchers, found that a tissue adhesive they had previously developed worked much differently in cancerous colon tissue than in colon tissue inflamed with colitis. The finding suggests that scientists must take into account the environment in which the material will be used, instead of using a “one-size fits all” approach for this sealant, or any other kind of biomaterial, designed to work inside the human body.

2015 MACHETE, a state-of-the-art airborne lidar system that performs high-resolution, 3D imaging at an area collection rate an order of magnitude higher than other lidar systems, is developed by Lincoln Laboratory. The system is highly optimized for foliage-penetration applications; it can image through dense canopy to reveal structures at and near ground level. The system employs advanced single-photon-counting Geiger-mode avalanche detector array technology, and an ultra-short pulsed laser and gimbaled pointing system to deliver high-altitude, high-resolution 3D imaging.
2015 Kimberly Hamad-Schifferli and Lee Gehrke are among the researchers that have devised a new diagnostic test that is a simple paper strip similar to a pregnancy test, that can rapidly diagnose Ebola, as well as other viral hemorrhagic fevers such as yellow fever and dengue fever. Unlike most existing paper diagnostics, which test for only one disease, the new MIT strips are color-coded so they can be used to distinguish among several diseases.

2015 Research conducted by Polina Anikeeva, graduate student Ritchie Chen, postdoc Gabriela Romero, graduate student Michael Christiansen, and undergraduate Alan Mohr has developed a method to stimulate brain tissue using external magnetic fields and injected magnetic nanoparticles—a technique allowing direct stimulation of neurons, which could be an effective treatment for a variety of neurological diseases, without the need for implants or external connections.

2015 Plants achieve efficient energy transport by making use of the exotic effects of quantum mechanics—effects sometimes known as “quantum weirdness.” These effects, which include the ability of a particle to exist in more than one place at a time, have now been used by engineers to achieve a significant efficiency boost in a light-harvesting system. Researchers at MIT, including Angela Belcher and Seth Lloyd, and Eni, the Italian energy company, use engineered viruses to provide quantum-based enhancement of energy transport to mimic photosynthesis.

2015 MIT engineers have designed what may be the Band-Aid of the future: a sticky, stretchy, gel-like material that can incorporate temperature sensors, LED lights, and other electronics, as well as tiny, drug-delivering reservoirs and channels. The “smart wound dressing” releases medicine in response to changes in skin temperature and can be designed to light up if, say, medicine is running low. The key to the design is a hydrogel matrix designed by Xuanhe Zhao.

2016 A new advance from MIT, Boston Children’s Hospital, and several other institutions may offer a better treatment for Type 1 diabetes, which leaves patients without the ability to naturally control blood sugar by damaging the pancreas. Replacing patients’ destroyed pancreatic islet cells with healthy cells is a treatment with one major drawback—the patients’ immune systems attack the transplanted cells—requiring patients to take immunosuppressant drugs for the rest of their lives. The researchers, including Daniel Anderson, have designed a material that can be used to encapsulate human islet cells before transplanting them without provoking an immune response.

2016 Scientists have observed ripples in the fabric of spacetime called gravitational waves, arriving at the Earth from a cataclysmic event in the distant universe. This confirms a major prediction of Albert Einstein’s 1915 general theory of relativity. Physicists have concluded that the detected gravitational waves are produced during the final fraction of a second of the merger of two black holes to produce a single, more massive spinning black hole. The first gravitational waves were detected on Sept. 14, 2015 at 5:51 a.m. Eastern Daylight Time (09:51 UTC) by both of the twin Laser Interferometer Gravitational-Wave Observatory (LIGO) detectors, located in Louisiana and Washington, U.S. Scientists detected gravitational waves for a second time on Dec. 26, 2015. The LIGO Observatories were conceived, built, and are operated by Caltech and MIT. The discovery was made by the LIGO Scientific Collaboration and the Virgo Collaboration using data from the two LIGO detectors. Rainer Weiss shares the 2017 Nobel Prize in Physics for his contributions to this work.

2016 Scientists at MIT, including Susan Solomon and research scientist Diane Ivy, and elsewhere have identified signs that the Antarctic ozone hole has shrunk by more than 4 million square kilometers—about half the area of the contiguous United States—since 2000, when ozone depletion was at its peak. The team also showed for the first time that this recovery has slowed somewhat at times, due to the effects of volcanic eruptions from year to year. 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).
2016 On Friday, Sept. 30, 2016, at 9:25 p.m. EDT, scientists and engineers at MIT’s Plasma Science and Fusion Center made a leap forward in the pursuit of clean energy. The team 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, have created 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 was 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 A team of scientists from MIT and Harvard have adapted a CRISPR protein that targets RNA (rather than DNA), for use as a rapid, inexpensive, highly sensitive diagnostic tool with the potential to transform research and global public health. Feng Zhang, Jim Collins, Deb Hung, Aviv Regev, and Pardis Sabeti describe how this RNA-targeting CRISPR enzyme was harnessed as a highly sensitive detector—able to indicate the presence of as little as a single molecule of a target RNA or DNA. The new tool, SHERLOCK (Specific High-sensitivity Enzymatic Reporter unLOCKing), could one day be used to respond to viral and bacterial outbreaks, monitor antibiotic resistance, and detect cancer.

2017 MIT researchers have developed a new system to help visually impaired users to navigate. The system uses a 3D camera, a processing unit that runs the team’s proprietary algorithms, a belt with separately controllable vibrational motors distributed around it, and an electronically reconfigurable Braille interface to give visually impaired users more information about their environments. The belt motors can vary the types of vibrations, as well as the intervals between them, to send different types of tactile signals to the user. For instance, an increase in frequency and intensity generally indicates that the wearer is approaching an obstacle in the direction indicated by that particular motor.

2017 For the first time, scientists have directly detected gravitational waves—ripples in space-time—in addition to light from the spectacular collision of two neutron stars. This marks the first time that a cosmic event has been viewed in both gravitational waves and light. The discovery was 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.
A team from MIT’s Computer Science and Artificial Intelligence Laboratory (CSAIL), including PhD candidate Robert Katzschmann and CSAIL director Daniela Rus, unveiled “SoFi,” a soft robotic fish that can independently swim alongside real fish in the ocean. Using its undulating tail and a unique ability to control its own buoyancy, SoFi can swim in a straight line, turn, or dive up or down. During test dives in Fiji, SoFi swam at depths of more than 50 feet for up to 40 minutes at once, nimbly handling currents and taking high-resolution photos and videos.

MIT researchers, including Fadel Adib, working with scientists from Brigham and Women’s Hospital, have developed 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. In tests in animals, the researchers showed that the waves can power devices located 10 centimeters deep in tissue, from a distance of 1 meter. The prototype is about the size of a grain of rice. Such devices could be used to deliver drugs, monitor conditions inside the body, or treat disease by stimulating the brain with electricity or light.

Scientists at MIT and elsewhere have analyzed data from K2, the follow-up mission to NASA’s Kepler Space Telescope, and have discovered nearly 80 new planetary candidates, including a particular standout: a likely planet that orbits the star HD 73344, which would be the brightest planet host ever discovered by the K2 mission. Assistant professor Ian Crossfield co-led the study with graduate student Liang Yu. The new analysis is also noteworthy for the speed with which it was performed. The researchers were able to use tools developed at MIT to rapidly search through graphs of light intensity called “lightcurves” from each of the 50,000 stars that K2 monitored in its two recent observing campaigns. They quickly identified the planetary candidates and released the information to the astronomy community just weeks after the K2 mission made the spacecraft’s raw data available. A typical analysis of this kind takes between several months and a year.

A team at MIT, including Kripa Varanasi and Karen Gleason, has come up with a coating that adds water-repellency to natural fabrics and outperforms conventional materials in water-repellency tests. The coated materials have been subjected to repeated washings with no degradation of the coatings, and also have passed severe abrasion tests, with no damage to the coatings after 10,000 repetitions. The process could offer a nontoxic alternative to environmentally harmful chemicals and also works on nonfabric materials such as paper.
Faculty and Staff

As of October 31, 2017, MIT employs 12,607 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, 2017–2018

<table>
<thead>
<tr>
<th>Employee Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>1,047</td>
</tr>
<tr>
<td>Other academic and instructional staff</td>
<td>1,180</td>
</tr>
<tr>
<td>Research staff and research scientists (includes postdoctoral positions)</td>
<td>3,204</td>
</tr>
<tr>
<td>Administrative staff</td>
<td>3,290</td>
</tr>
<tr>
<td>Support staff</td>
<td>1,647</td>
</tr>
<tr>
<td>Service staff</td>
<td>824</td>
</tr>
<tr>
<td>Clinical and Medical staff</td>
<td>136</td>
</tr>
<tr>
<td>Affiliated faculty, scientists, and scholars</td>
<td>1,279</td>
</tr>
<tr>
<td><strong>Total campus faculty and staff</strong></td>
<td>12,607</td>
</tr>
</tbody>
</table>

Faculty

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

Faculty Profile, 2017–2018

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professors</td>
<td>662</td>
<td>63</td>
</tr>
<tr>
<td>Associate professors</td>
<td>219</td>
<td>21</td>
</tr>
<tr>
<td>Assistant professors</td>
<td>166</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,047</td>
<td>100</td>
</tr>
<tr>
<td>Male</td>
<td>808</td>
<td>77</td>
</tr>
<tr>
<td>Female</td>
<td>239</td>
<td>23</td>
</tr>
</tbody>
</table>

See page 52 for a chart of faculty and students from 1865–2018.

Seventy-five percent of faculty are tenured.

Faculty by School, 2017–2018

<table>
<thead>
<tr>
<th>School</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture and Planning</td>
<td>85</td>
<td>8</td>
</tr>
<tr>
<td>Engineering</td>
<td>378</td>
<td>36</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>183</td>
<td>17</td>
</tr>
<tr>
<td>Management</td>
<td>112</td>
<td>11</td>
</tr>
<tr>
<td>Science</td>
<td>278</td>
<td>27</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,047</td>
<td>100</td>
</tr>
</tbody>
</table>

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

Each year, MIT employs about 1,350 graduate students as teaching assistants and 3,400 graduate students as research assistants.

MIT Lincoln Laboratory employs about 4,050 people, primarily at Hanscom Air Force Base in Lexington, Massachusetts. See page 92 for additional Lincoln Laboratory staffing information.
Twenty percent of faculty are members of a U.S. minority group; seven percent of faculty identify with an underrepresented minority group.

**Faculty by U.S. Minority Group, 2017–2018**

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Female Count</th>
<th>Male Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian</td>
<td>30</td>
<td>106</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>African American</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>American Indian or Alaskan Native</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Native Hawaiian or Other Pacific Islander</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Ethnicity is self-identified, and faculty members may identify with more than one group.

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

**Country of Origin of Internationally Born Faculty, 2017–2018**

- China 10%
- India 8%
- United Kingdom 8%
- Canada 6%
- Germany 6%
- Greece 4%
- Italy 4%
- France 3%
- Russia 4%
- Spain 3%
- South Korea 3%
- Israel 3%
- All others 38%

**Elapsed Years at MIT of Faculty, 2017–2018**

(Excludes time as student)
Researchers
MIT campus research staff and scientists total 3,204. These researchers work with MIT faculty and students on projects funded by government, nonprofits and foundations, and industry.

<table>
<thead>
<tr>
<th>Employee Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Researchers</td>
<td>55</td>
</tr>
<tr>
<td>Principal Researchers</td>
<td>115</td>
</tr>
<tr>
<td>Research Scientists and Technicians</td>
<td>1,120</td>
</tr>
<tr>
<td>Visiting Scientists</td>
<td>409</td>
</tr>
<tr>
<td>Postdoctoral Associates</td>
<td>1,041</td>
</tr>
<tr>
<td>Postdoctoral Fellows</td>
<td>464</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,204</strong></td>
</tr>
</tbody>
</table>

Approximately 3,000 graduate students were research assistants in fall 2017.
Postdoctoral Scholars
The MIT campus hosts 1,505 postdoctoral associates and fellows—418 females and 1,087 males. These individuals work with faculty in academic departments, laboratories, and centers.

U.S. Citizen and Permanent Resident Postdoctoral Scholars by Ethnicity, 2017–2018

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic or Latino</td>
<td>33</td>
</tr>
<tr>
<td>African American</td>
<td>4</td>
</tr>
<tr>
<td>American Indian or Alaskan Native</td>
<td>0</td>
</tr>
<tr>
<td>Total underrepresented minorities (URM)</td>
<td>37</td>
</tr>
<tr>
<td>White</td>
<td>285</td>
</tr>
<tr>
<td>Asian</td>
<td>82</td>
</tr>
<tr>
<td>Two or more races</td>
<td>11</td>
</tr>
<tr>
<td>Unknown</td>
<td>85</td>
</tr>
<tr>
<td>Total</td>
<td>500</td>
</tr>
</tbody>
</table>

Ethnicity of Postdoctoral Scholars, 2017–2018

- International: 67%
- White: 19%
- Asian: 5%
- URM: 2%
- Two or more races: <1%
- Unknown: 6%

Years at MIT of Postdoctoral Scholars, 2017–2018

International Postdoctoral Scholars Top Countries of Citizenship, 2017–2018

<table>
<thead>
<tr>
<th>Country of Citizenship</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>245</td>
</tr>
<tr>
<td>India</td>
<td>86</td>
</tr>
<tr>
<td>South Korea</td>
<td>69</td>
</tr>
<tr>
<td>Germany</td>
<td>63</td>
</tr>
<tr>
<td>Canada</td>
<td>52</td>
</tr>
<tr>
<td>France</td>
<td>47</td>
</tr>
<tr>
<td>Iran</td>
<td>42</td>
</tr>
<tr>
<td>Italy</td>
<td>38</td>
</tr>
<tr>
<td>Israel</td>
<td>36</td>
</tr>
</tbody>
</table>

Country of Citizenship of International Postdoctoral Scholars, 2017–2018

Postdoctoral scholars come from over seventy foreign countries.
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

<table>
<thead>
<tr>
<th>Recipients</th>
<th>Award Name and Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>153</td>
<td>American Academy of Arts and Sciences Member</td>
</tr>
<tr>
<td>93</td>
<td>American Association for the Advancement of Science Fellow</td>
</tr>
<tr>
<td>12</td>
<td>American Philosophical Society Member</td>
</tr>
<tr>
<td>89</td>
<td>American Physical Society Fellow</td>
</tr>
<tr>
<td>22</td>
<td>American Society of Mechanical Engineers Fellow</td>
</tr>
<tr>
<td>35</td>
<td>Association for Computing Machinery Fellow</td>
</tr>
<tr>
<td>4</td>
<td>John Bates Clark Medal, American Economic Association</td>
</tr>
<tr>
<td>4</td>
<td>Dirac Medal, Abdus Salam International Centre for Theoretical Physics</td>
</tr>
<tr>
<td>9</td>
<td>Fulbright Scholar, Council for International Exchange of Scholars (CIES)</td>
</tr>
<tr>
<td>9</td>
<td>Gairdner Award, Gairdner Foundation</td>
</tr>
<tr>
<td>60</td>
<td>Guggenheim Fellow, John Simon Guggenheim Memorial Foundation</td>
</tr>
<tr>
<td>16</td>
<td>HHMI Investigator, Howard Hughes Medical Institute (HHMI)</td>
</tr>
<tr>
<td>58</td>
<td>Institute of Electrical and Electronics Engineers, Inc. Fellow</td>
</tr>
<tr>
<td>1</td>
<td>Japan Prize, Science and Technology Foundation of Japan</td>
</tr>
<tr>
<td>3</td>
<td>Kavli Prize, Norwegian Academy of Science and Letters</td>
</tr>
<tr>
<td>1</td>
<td>Kyoto Prize, Inamori Foundation of Japan</td>
</tr>
<tr>
<td>26</td>
<td>MacArthur Fellow, John D. and Catherine T. MacArthur Foundation</td>
</tr>
<tr>
<td>2</td>
<td>Millennium Technology Prize, Millennium Prize Foundation</td>
</tr>
<tr>
<td>71</td>
<td>National Academy of Engineering Member, National Academies</td>
</tr>
<tr>
<td>27</td>
<td>National Academy of Medicine Member, National Academies</td>
</tr>
<tr>
<td>84</td>
<td>National Academy of Sciences Member, National Academies</td>
</tr>
<tr>
<td>7</td>
<td>National Medal of Science, National Science &amp; Technology Medals Foundation</td>
</tr>
<tr>
<td>1</td>
<td>National Medal of Technology and Innovation, National Science &amp; Technology Medals Foundation</td>
</tr>
<tr>
<td>2</td>
<td>Rolf Nevanlinna Prize, International Mathematical Union (IMU)</td>
</tr>
<tr>
<td>34</td>
<td>Presidential Early Career Awards for Scientists and Engineers (PECASE)</td>
</tr>
<tr>
<td>3</td>
<td>Pulitzer Prize, Pulitzer Board</td>
</tr>
<tr>
<td>2</td>
<td>Queen Elizabeth Prize for Engineering, The Queen Elizabeth Prize for Engineering Foundation</td>
</tr>
<tr>
<td>4</td>
<td>Royal Academy of Engineering Fellow, Royal Academy of Engineering</td>
</tr>
<tr>
<td>6</td>
<td>A. M. Turing Award, Association for Computing Machinery</td>
</tr>
<tr>
<td>2</td>
<td>John von Neumann Medal, Institute of Electrical and Electronics Engineers, Inc.</td>
</tr>
<tr>
<td>4</td>
<td>Alan T. Waterman Award, National Science Foundation</td>
</tr>
<tr>
<td>3</td>
<td>Wolf Prize, Wolf Foundation</td>
</tr>
</tbody>
</table>
Award Highlights

Joan Jonas

2018 Kyoto Prize

Joan Jonas, professor emerita in the MIT Program in Art, Culture and Technology, is one of three individuals honored with the 2018 Kyoto Prize.

The Kyoto Prize is Japan’s highest private award for global achievement, created by Japanese philanthropist Kazuo Inamori and awarded by the Inamori Foundation. Awarded annually in three categories—Advanced Technology, Basic Sciences, and Arts and Philosophy—the prize honors individuals who have contributed significantly to the scientific, cultural, and spiritual betterment of humankind. Jonas is a recipient in the Arts and Philosophy category for her lifetime of accomplishment and global influence as an artist.

“Jonas created a new artistic form by integrating performance art and video art, and has evolved her original medium at the forefront of contemporary art continuously,” the prize announcement states. “Creating labyrinth-like works that lead audiences to diverse interpretations, she hands down the legacy of 1960s avant-garde art by developing it into a postmodern framework, profoundly impacting artists of later generations.”


Edward “Ed” Boyden

2018 Canada Gairdner International Award

Ed Boyden, the Y. Eva Tan Professor in Neurotechnology, has been named a recipient of the 2018 Canada Gairdner International Award—Canada’s most prestigious scientific prize—for his role in the discovery of light-gated ion channels and optogenetics, a technology to control brain activity with light.

Boyden’s work has given neuroscientists the ability to precisely activate or silence brain cells to see how they contribute to—or possibly alleviate—brain disease. By optogenetically controlling brain cells, it has become possible to understand how specific patterns of brain activity might be used to quiet seizures, cancel out Parkinsonian tremors, and make other improvements to brain health.


Rainer Weiss

2017 Nobel Prize in physics, shared

Rainer Weiss ’55, PhD ’62, professor emeritus of physics at MIT, has won the Nobel Prize in physics for 2017. Weiss won half of the prize, with the other half of the award shared by Kip S. Thorne, professor emeritus of theoretical physics at Caltech, and Barry C. Barish, professor emeritus of physics at Caltech.

The Nobel Foundation, in its announcement this morning, cited the physicists “for decisive contributions to the LIGO detector and the observation of gravitational waves.”

Section 2
Major MIT Initiatives

National Policy Initiatives  40
Research Initiatives  46
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. A more formal “policy initiative” model first emerged in 2005 when incoming MIT President Susan Hockfield announced that MIT would create a major cross-disciplinary, cross-school initiative around energy. Over the intervening decade, policy initiatives have been created to tackle several other 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. Major policy initiatives to date are described below. Some have had relatively short-term, specifically defined goals, while others, such as the original energy initiative, address broader long-term goals.

Energy

The MIT Energy Initiative (MITEI) was formally launched in the fall of 2006, following the recommendations of the 2006 Report of the Energy Research Council regarding new approaches to multidisciplinary research, education across school and department boundaries, energy use on campus, and outreach to the policy world through technically grounded analysis.

MITEI is widely recognized as a leader in energy policy. It is a campus-wide energy program at a U.S. academic institution, 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.

A major consortium research study in collaboration with industry and government members, The Utility of the Future: Preparing for a Changing Energy Sector, was released in November 2016. Ongoing studies include The Mobility of the Future, which examines how modes of transportation are evolving, and The Future of Nuclear Energy in a Carbon Constrained World.

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. (See energy.mit.edu/lcec.)

Convergence

“Convergence” is a term for the integration of engineering, physical sciences, computation, and life sciences with profound benefits for medicine and health, energy, and the environment. Convergence implies a broad thinking of how all scientific research can be conducted, to capitalize on a range of knowledge bases, from microbiology to computer science to engineering design and more. It is a new organizational model for innovation, taking the tools and approaches of one field of study and applying them to another, paving the way for advances in all fields involved. At MIT, the policy focus has been on Convergences for biomedical advances.

In 2011, then-President Susan Hockfield appointed Institute Professors Phillip Sharp and Robert Langer to lead a faculty committee which developed a widely cited whitepaper entitled Third Revolution: Convergence of The Life Sciences, Physical Sciences and Engineering. Simultaneously, MIT created the Koch Institute for Integrative Cancer Research and
organized it around the convergence research model, with biologists, engineers and physical scientists working in close collaboration.

The National Academy of Sciences has also provided leadership in the convergence effort through its Board on Life Sciences which published *Convergence—Facilitating Transdisciplinary Integration of Life Sciences, Physical Science, Engineering and Beyond* (National Academies Press, 2014), co-chaired by MIT President Emerita Hockfield.

The National Science Foundation highlighted Convergence as one of its ten “Big Ideas” in summer 2016. The Big Ideas are proposed as visioning and organizing principles for future NSF investments.

MIT released a new policy report on June 24, 2016 titled, *Convergence: The Future of Health* at the National Academies in Washington, DC. The report was co-chaired by Philip Sharp, Susan Hockfield, and Tyler Jacks, Director, The Koch Institute, MIT. The report included 24 scientific advisors from 16 institutions, universities, and government agencies. An additional ~40 workshop attendees contributed to the discussions and content of the report, from dozens of academic, industrial, philanthropic, and federal institutions. The report outlined the need for convergence investments in several illustrative areas: brain disorders; infection and immunity; cancer; and other unmet health needs. It also highlighted advances in convergence technologies: imaging in the body; nanotechnology for drug delivery; regenerative engineering and medicine; and big data & health information technology. The report concluded with policy recommendations to advance convergence research and health outcomes within the university, federal government, and industrial sectors.

Philip Sharp and Susan Hockfield published a letter in the February 10, 2017 issue of *Science*, which was co-signed by over 100 scientists and leaders. The letter urged the new administration to embrace the potential of Convergence to develop new therapies, advance science, and foster health innovations. Additional information on the convergence research model, including a copy of the 2016 report and videos of its release, are available online at http://www.convergencerevolution.net/.

**Digital Health**

As part of the Convergence Initiative, MIT is building an effort to use digital technologies to transform healthcare. The key question is: *How can the digital revolution and the evolution of health systems converge to optimally prevent, detect, understand, and treat disease in order to improve health outcomes and lower cost?*

The opportunities in digital health are far reaching. The challenge is to develop approaches to optimally acquire, curate, and interpret vast amounts of data in a way that can be acted upon by a health system operated by humans. Continuous monitoring of patients with chronic disease will detect disease progression and predict dangerous episodes like heart attacks or seizures sooner, leading to prevention, faster treatment, better recovery and lower costs. Early detection will prevent or ameliorate the onset of acute disease, and facilitate early intervention. Real-time updates to standardized, interoperable electronic health records will ensure that medical histories are available to healthcare practitioners at a moment’s notice in an emergent situation, while protecting patient privacy. This could be a key tool to combat the opioid epidemic, by reducing prescription abuse and helping first responders identify overdose victims. Personalized medicine will offer widespread benefits as we develop the tools to collect, analyze, interpret and act on vast amounts of genomic, molecular, and environmental data specific to an individual.

MIT is uniquely positioned to confront this national and global grand challenge. The Institute has a long history of providing systems-level engineering and management solutions to complex societal problems, based on superb engineering and science. Many students are excited by opportunities to innovate the future of health. Departments from across the university offer expertise in big data analytics, computer science, modeling, device design and manufacturing, life sciences and engineering (including systems biology and genetics), systems engineering, and economics. A critical mass of faculty members is passionate about health and healthcare and understand its unique challenges. MIT has formed strategic partnerships with leading organizations in the industry, hospitals and healthcare deliverers, to medical device and pharmaceutical
companies. And we are located in a region served by world-class hospitals and home to leading companies at the intersection of life sciences and information technology, including Kendall Square, a major hub of the biotech industry.

Over the past year, the Provost has engaged in several collaborative activities with local hospitals and academic institutions and the Commonwealth of Massachusetts with a focus on Digital Health. He has also charged a faculty group to consider what contributions MIT could make in digital health that would integrate MIT’s expertise across campus to transform health care and lower costs.

Advanced Manufacturing
MIT leaders have played a major role in the design of national efforts to confront structural problems in the U.S. manufacturing sector, starting in 2011 with the MIT Production in the Innovation Economy (PIE) study project. Building on PIE research, national policy work continued with MIT taking a leadership role in the President’s Advanced Manufacturing Partnership (AMP). Two major reports (AMP1.0, 2012, and AMP2.0, 2014) were issued, and led to federal support for a network of regional institutes to promote manufacturing innovation, which became the Obama Administration’s largest new technology initiative and focus. These competitively selected partnerships between federal research agencies and state governments, academia, and private companies seek to integrate new technologies and processes into the U.S. manufacturing industry and ensure that workers have the knowledge and skills needed to implement these innovations domestically. On campus, this focus on advanced manufacturing has led to new research and educational activities while stimulating regional outreach to and partnerships with manufacturers and other educational institutions. It has also helped define the campus-wide innovation initiative.

Campus leaders in manufacturing, including President L. Rafael Reif, Provost Martin A. Schmidt, and Professor Krystyn J. Van Vliet, who were the technical co-leads of AMP, continue to engage with key federal officials and business leaders to help pave a robust path for the utilization of advanced technologies by U.S. manufacturers. Further details follow below.

Advanced Manufacturing Partnership
MIT Presidents Susan Hockfield and Rafael Reif were named by President Obama as successive co-chairs of the steering committee for his industry-university Advanced Manufacturing Partnership (AMP) in its two phases, from 2012 through 2014. MIT Provost Martin Schmidt and Professor Krystyn Van Vliet served as successive technical co-leads for AMP1.0 and AMP2.0.

The AMP1.0 report in 2012 proposed the establishment of a new network of advanced manufacturing institutes, modeled on the German Fraunhofer institutes. The AMP2.0 report, released in October 2014, refined the recommendations for what is now known as ManufacturingUSA. It also proposed strategies for collaborative R&D efforts across leading federal agencies, best practices for apprenticeship and training programs, and policies to support financing of production scale-up for advanced manufacturing processes and technologies. President Reif and Provost Schmidt led the AMP2.0 Steering Committee, along with Dow CEO Andrew Liveris, and the President’s National Economic Council Director, Science Advisor, and Commerce Secretary, in 2013–2014. Professor Van Vliet co-chaired the AMP2.0 technology development workgroup, which prepared model technology strategies on digital manufacturing, advanced materials for manufacturing, and sensors/measurement/process control areas. Van Vliet, now serving as Associate Provost, continues to help set the path for the ManufacturingUSA as a member of the Leadership Council for the MForesight advisory group (see http://www.mforesight.org).

Manufacturing Innovation Institutes
Fourteen Manufacturing Innovation Institutes (MIIs) have been stood up, with lead sponsorship from the Departments of Commerce, Energy, and Defense. Combined federal, state, and industry funding for these institutes is expected to exceed a half billion dollars annually.

MIT participates in many of the 14 MIIs, and has leadership roles in two. MIT faculty members Michael Watts and Lionel Kimerling lead the technology development and workforce education teams, respectively, for the AIM Photonics Institute. AIM Photonics, a regional consortium including New York and Massachusetts firms and universities, was
established by the Department of Defense in July 2015 to develop integrated photonic devices. In April 2016, Secretary of Defense Ash Carter visited the MIT campus to announce the creation of the Advanced Functional Fabrics of America (AFFOA). AFFOA’s national headquarters in Cambridge, Massachusetts opened on June 19, 2017 with an event featuring Under Secretary of Defense for Acquisition, Technology, and Logistics James MacStravic, Governor Charlie Baker, members of the Massachusetts Delegation, industry leaders, and MIT President Rafael Reif. MIT Professor Yoel Fink serves as CEO of the institute, which is managed by an independent nonprofit organization founded by MIT. Regional and national partners are participating in the institute, which integrates revolutionary fibers into textiles to make new capabilities available to U.S. clothing and soft goods manufacturers.

The “Future Postponed”–addressing the Innovation Deficit
Federal support is the primary mainstay of U.S. basic research. As federal R&D funding has stagnated, the strategy to maintain the U.S. edge in science and technology must include new ways of explaining the central societal need for science to policy makers. The MIT report The Future Postponed: Why Declining Investment in Basic Research Threatens a U.S. Innovation Deficit, released in April 2015, is one such effort. The science community has often told the story of how past investments in research paid off in now-ubiquitous technologies like the Global Positioning System, Magnetic Resonance Imaging, and the Google search engine. But it has not adequately communicated how research cutbacks today will affect the science of tomorrow. The Future Postponed explains the critical importance of federal investment in science research to grow the economy, stay competitive internationally, and solve global challenges in health, energy, security, food supply, and other areas through the development of better therapies, cures, tools, and technologies.

The MIT Committee to Evaluate the Innovation Deficit, named in October 2014 and comprising 30 MIT faculty and researchers from across all schools at MIT, selected, wrote, and vetted case studies of 15 vital areas of science and engineering from infectious disease, to batteries, Alzheimer’s, cybersecurity, catalysis, economics and plant science. The report is not a list of priorities in science research, but rather a short set of illustrative examples from a much longer list of critical fields worthy of investment. It’s a vision of the future of innovation in America and a call for sustained support for research.

The report gained national press attention in such forums as the Wall Street Journal, the New York Times, Reuters, the Los Angeles Times, and others. A group from the faculty committee, led by Professor Marc Kastner, former MIT Dean of Science and currently President of the Science Philanthropy Alliance, held a forum hosted by AAAS and briefed Congressional staff, White House staff, and other national stakeholders during a Washington DC visit on April 27, 2015.

A second volume of the report, The Future Postponed 2.0, was released on February 22, 2017. The report was led by Marc Kastner, and vetted by an advisory committee of nine noted experts from outside MIT. Working with researchers across the country, thirteen additional case studies were published beyond the first volume. The newest case studies were written by experts at 15 institutions around the country, and covered diverse topics such as protein design, circadian rhythms, forest ecology, dark matter, clean energy technology, arctic oceanography, and more. All individual case studies and volume two of the Future Postponed report can be found online at http://www.futurepostponed.org/.

On the same day as the report release, an op-ed was published in The Hill, co-authored by Maria Zuber, Vice President for Research at MIT, and Rush Holt, CEO of AAAS. The op-ed titled, Neglecting Research Today Threatens US Innovation Tomorrow, discussed the Future Postponed 2.0 report and the importance of investing in basic research.
Innovation
In October 2013, President Reif announced an “innovation initiative” at MIT, which was followed by a report on the proposed project in December 2014, http://innovation.mit.edu/sites/default/files/images/MIT_Innovation_Initiative_PreliminaryReport_12-03-14.pdf. The initiative has primarily focused on MIT itself. As summarized on its website (http://innovation.mit.edu/about) the report emphasizes:

- Capability-building Programs: Growing existing education opportunities while creating a select few new programs of interest to MIT students and faculty
- Convening Infrastructure: Expanding maker and collaborative spaces across campus and creating digital tools that connect them into a unified campus
- Communities: Linking the MIT community more deeply with corporations, governments, and innovation hubs in Cambridge and around the world
- Lab for Innovation Science and Policy: an organized effort to develop the ‘science of innovation’ and evidence-base to inform both internal and external program design

In May 2015, President Rafael Reif announced a new innovation programmatic focus in a Washington Post op-ed (http://newsoffice.mit.edu/2015/reif-op-ed-washington-post-0524). President Reif emphasized the need for regional and national policy elements to fill a gap he identified in the national innovation system. Following his words with action, President Reif announced the creation of a new kind of accelerator on October 26, 2016. Called The Engine, the new Cambridge-based accelerator supports startup companies working on “tough technologies” with potential for societal impact. It provides funding, space, tools, resources, and expertise to companies pursuing capital- and time-intensive technologies with “great potential for positive impact for humanity” as described by President Reif. By April 2017, The Engine had raised over $150 million for its first fund. A formal opening event highlighting some of The Engine’s first investments was held on September 19, 2017.

Online Education
Educational innovation has been a central component of the Institute’s mission throughout its history. Many curricular and organizational innovations developed at MIT have had national impact, as have educational technologies developed and pioneered on campus. In his September 2012 inaugural address, Rafael Reif announced that continued educational innovation would be a major focus of his presidency. In 2013, he established an Institute-wide Task Force on the Future of MIT Education to envision how new capabilities and instructional models can spark innovation in higher education on campus and beyond. MIT is now a national leader in the growing effort to utilize online technology to enhance learning while providing new educational opportunities both on campus and beyond. MIT’s Office of Digital Learning (ODL) and edX, an online learning destination co-founded by MIT and Harvard University in 2012, spearhead these activities.

edX currently offers open online courses from over 130 partner institutions to students from every country in the world, serving almost 13 million unique learners to date. The founding partners alone offered 290 courses in edX’s first four years. edX continues to offer free, open enrollment for most courses, while expanding its verified certificate program and new micromasters program, which offer enhanced options for earning course credit at low cost. ODL manages the Institute’s course contributions to edX, known as MITx, and provides leadership for on-campus innovations in teaching and learning. It also manages MIT’s OpenCourseWare initiative (OCW), which has made instructional materials from MIT courses freely available since 2001. OCW has now delivered material from over 2,400 MIT courses to 200 million learners and educators worldwide.

In August 2014, Professor Sanjay Sarma and Professor Karen Wilcox, who had co-chaired the Task Force on the Future of MIT Education, assumed the leadership of a study of the national policy aspects and implications of online education, with support from the Carnegie Foundation. This Online Education Policy Initiative (OEPI) explored teaching pedagogy and efficacy, institutional business models, and global educational engagement strategies. Important input was also obtained through a May 2015 workshop, sponsored
by the National Science Foundation, which brought the learning science and online learning technology communities together to discuss emerging ideas about online pedagogy. OEPI released its final report, *Online Education: A Catalyst for Higher Education Reform*, on April 1st, 2016 at the National Academy of Sciences (see https://oepi.mit.edu/final-report).

edX and the Office of Digital Learning continue to explore the frontiers of education through research into pedagogy, student motivation and behavior, assessment methods, and the science of learning itself, through studies of online learning experiences and outcomes, and through continued development of learning platforms. See https://www.edx.org/about/research-pedagogy and https://openlearning.mit.edu/value-digital-learning/research.

### 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.

### Research

IPRI produces research across five main areas: cybersecurity, privacy, networks, critical infrastructure, and the Internet experience. IPRI research has already impacted the national debate on encryption policy and the security of new electronic surveillance proposals. Developed with colleagues from around the world, IPRI’s Keys Under Doormats paper has been widely cited at several legislative hearings and IPRI members have testified to Congress and been featured in the world press.

### Education

In addition to research, the initiative focuses on training a new generation of technology policy leaders who can move effectively between technology and policy roles. As an example, the initiative has developed a joint course with Georgetown Law School on privacy technology and legislation that combines MIT and Georgetown students in teams of lawyers and engineers to develop draft legislation related to current technology issues. IPRI also partnered with a leading Chinese university to teach Chinese engineering, law and business students a comparative perspective of the Foundations of Internet Policy course in Shanghai, China. Other courses taught by IPRI researchers focus on privacy legislation and technology, cybersecurity policy, information policy, and app development.

### Engagement

The third pillar of the initiative is engaging with policy makers throughout the world and helping inform policymaking from a solid technological foundation. IPRI has hosted a range of high-level policy makers at MIT including Vice President Ansip of the European Commission, Secretary Penny Pritzker of the U.S. Department of Commerce, Director Robert Hannigan of GCHQ in the UK, and the European Data Protection Supervisor Giovanni Buttarelli. IPRI engagement also extends to the business community in areas such as the protection of critical infrastructure from cyberattacks (oil, gas, financial, electricity and communication networks). IPRI held five expert workshops with industry, governments and academia in each of the sectors to understand the needs and challenges, and develop a research agenda to address the most pressing issues and published a report of its findings.
Research Initiatives

Cybersecurity Initiatives
In 2015, MIT launched three campus-wide cybersecurity 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 launched in 2015 with 5 founding industrial partners. The goal of CyberSecurity@CSAIL is to identify and develop technologies to 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. CyberSecurity@CSAIL aims 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 multidisciplinary 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.

MIT Sloan’s Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity (IC)³
It is not a question as to whether you will have a cyber attack, only when and how. (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, lead by Sloan, along with industry partners (such as: ExxonMobil, Schneider Electric, State Street Bank), 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.

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 launches a new, multidisciplinary minor in Environment and Sustainability open to undergraduates from all majors. ESI works closely with faculty who teach required undergraduate classes (GIRs) 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. ESI’s research seed grant program has supported 15 projects spanning these domains with field sites across the globe.

ESI’s core forum for convening, ESI’s People and the Planet series of invited lectures brings fresh and sometimes provocative points of view into contact with the MIT and Cambridge communities.

ESI is guided by a Faculty Advisory Committee and a Student Advisory Council, and is building an External Advisory Board with broad representation.

http://environmentalsolutions.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. J-WAFS, as an interdepartmental lab reporting to the Vice President for Research, spearheads the efforts of MIT’s faculty, labs, and centers to work towards solutions for water and food security that are environmentally benign and energy-efficient, including the development of transformative water and food technologies. 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. J-WAFS also supports graduate student-driven food and water research and business communities on campus, through fellowships, conference sponsorship, and other mentoring and assistance.

http://jwafs.mit.edu/

MIT Energy Initiative
The MIT Energy Initiative (MITEI) plays an important catalytic role in accelerating responses to the many challenges facing our global energy system through energy research, education, and outreach efforts.

MITEI brings together researchers from across the Institute and facilitates collaborations with government and industry to analyze challenges, develop solutions, and bring new technologies to the marketplace. Member companies and organizations have supported more than 900 projects to date. Nearly 30 percent of the MIT faculty is engaged with MITEI’s programs. The Initiative delivers comprehensive analyses for policy makers and regulators, such as the “Future of” study series, including The Future of Solar Energy (2015), and a study currently underway, The Future of Nuclear Energy in a Carbon-Constrained World, with the Nuclear Science and Engineering Department. Other studies include systems-level research such as the 2016 Utility of the Future study and report, and a new study under development: Mobility of the Future.

As a vital component of MIT’s Plan for Action on Climate Change, MITEI’s eight Low-Carbon Energy Centers present opportunities for faculty, students, industry, and government to advance research and development in key technology areas for addressing climate change, from solar energy to electric power systems, fusion, and other areas. (See http://energy.mit.edu/lcec.)

The MITEI Seed Fund Program supports innovative early-stage research projects that address energy and related environmental issues. Including 2017 grants, the program has supported a total of 161 energy-focused research projects representing $21.4 million in funding over the past nine years. The program encourages researchers from throughout MIT’s five schools to collaborate in exploring new energy-related ideas, and attracts a mix of established energy faculty as well as many who have just begun approaching energy in their research or are new to MIT.
MITEI leads Institute energy education efforts and has engaged thousands of undergraduate, graduate, and postdoctoral students through sponsored research opportunities and other programs. Energy education programs include the Energy Studies Minor, Undergraduate Research Opportunities Program (UROP) in energy, short modules during the Independent Activities Period, Discover Energy: Learn, Think, Apply (DELTA) Freshman Pre-orientation Program, graduate Society of Energy Fellows, and other initiatives. Faculty associated with MITEI help shape energy education at both the undergraduate and graduate levels, by teaching, advising, and developing new curricula.

In addition to informing public policy through research reports, MITEI fosters dialogue within the academic research community and provides the public with context on current energy issues. Convening events throughout the year, MITEI hosts thought leaders from across the energy value chain. MITEI staff, faculty affiliates, and graduate students share their research and perspectives at domestic and international events. Staff members also participate in Institute-wide efforts focused on addressing climate change. MITEI highlights the research and achievements of faculty and students through articles, media outreach, social media, and other digital and print platforms to reach diverse audiences.

http://energy.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. In the words of MIT President L. Rafael Reif, “[B]ecause nanoscience and nanotechnology are omnipresent in innovation today, a state-of-the-art nano facility is the highest priority for MIT, the School of Science, and the School of Engineering.”

Tools to build the Nano Age will be available within MIT.nano, the new nanoscience and technology center at the heart of the MIT campus. Opening in the summer of 2018, MIT.nano is a comprehensive, 200,000-sq ft shared facility for nano-scale advancements. It is designed to give our researchers and innovators, as well as our partners, access to a broad and versatile toolsets that can do more—from imaging to synthesis, fabrication and prototyping—entirely within the facility’s protective envelope.

The opening of MIT.nano will also mark the beginning of a new era of nano-education at MIT, with hands-on learning spaces and advanced teaching tools integrated throughout the facility. The top floor of MIT.nano houses the new undergraduate chemistry labs 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. There, inventors can translate nano-scale advancements into hand-held systems, transitioning academic pursuits into prototypes for a better World.

Quantifying and analyzing technology translations from MIT.nano will give insights into the steps comprising the innovation process, which we expect will enable us to transform the mere art of innovation into a systematic science. Knowledge and insights that we gain we are committed to share broadly in order to accelerate the advancements of the Nano Age, through both act and deed.
Clinical and Transformational Research in Health and Life Sciences
A series of related initiatives from the Institute of Medical Engineering and Science (IMES) have propelled MIT into the forefront of transformational research in health and life sciences. These initiatives are specifically designed to shift the fulcrum which in the past has been positioned to early-on propel emerging concepts from the academic laboratories at MIT to clinical domains of hospitals. Such a paradigm provides early feedback as to the function and efficacy of a putative medical device, diagnostic or drug but often times ideas get “lost in the translation”. With the notion that technology development requires iterative interactions and refinement best performed where technology is developed, they chose to move the fulcrum to balance the flow from MIT to hospitals and to shift from a translational or translocational paradigm which simply moves projects from one place to another to one which allows for ideas to be transformed while be moved.

The expectation and goal is to use these initiatives to formally change how technology is developed and evaluated and to bring MIT from the periphery of this space to the center, to make MIT the place that collaborators, local, regional, national and internationally come to for idea transformation rather than seek ideas for clinical testing.

American Heart Association One Brave Idea and BWH-MIT Initiative
The “One Brave Idea” (OBI) was a competition sponsored by the American Heart Association (AHA), Verily, and AstraZeneca, for a single award of $75M to address coronary heart disease (CHD), the most prevalent cause of morbidity and mortality in the developed world. The winning project, submitted jointly by Brigham and Women’s Hospital (BWH) and MIT, and headed by Drs. Calum MacRae (Chief of Cardiology, BWH) and Elazer Edelman (Director MIT Biomedical Engineering Center and Clinical Research Center) focuses on developing novel tools to increase the information content in coronary heart disease assessment to allow much earlier and more definitive characterization of the disease, thus improving immediately preventative strategies, but also efficiently laying the groundwork for the discovery of new disease pathways and interventions. The basic premise is to provide better matching of the 1069 level of discrimination on a genetic level with the now 104 scale of disease phenotypes.

Exploiting the capabilities of MIT and BWH, OBI proposes to discover, through innovative pheno-typing of early preclinical stages in those with definitive CHD genotypes or definitive premature CHD, upstream biologic traits, or endophenotypes, that are broadly applicable and would allow, in tiered combination, high sensitivity screening, then high specificity confirmation across the entire population at an early age.

OBI has set ambitious goals to accelerate discovery and intervention through the iterative forging and re-forging of partnerships necessary to achieve. Working with the AHA, AstraZeneca, and Google leadership, MIT and BWH can engage entire areas of activity that to date have not exploited in the study of chronic common disease. The projects started will not be the end result of the award, but rather learning examples of what can be achieved together, a means by which to bring together the greater communities of clinicians, scientists, investigators, engineers and policy makers, and a venue from which to grow an ever impactful array of like programs and a repository for greater and greater support of this nature.
**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 with such resources. The CRC has worked closely with internal MIT resources like 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. The latter involved MIT assuming a role in the National Institute of Health (NIH) network of clinical translational science through National Center for Advancing Translational Sciences program. Indeed, MIT was a key partner in creating a national agreement on IRBs. In 2016, MIT through the leadership of the CRC Director Elazer Edeman joined the Tufts Clinical and Translational Science Institute (CTSI) to renew Tufts’ application for funding of the NIH as one of three national hubs supporting all of the 64 programs with the Clinical and Translational Science Awards (CTSA) program. The Tufts CTSI is comprised of a robust partnership of more than 40 organizations, with a unique identity within the CTSA Consortium and nationally recognized strengths in emergency medicine, large effectiveness trials, clinical trials methods innovations, and translational science education. From bench to bedside, to clinical practice, to care delivery and public health, to public policy and beyond, Tufts CTSI is committed to fostering collaboration and innovation across the translational spectrum.

The MIT CRC joins the Tufts CTSI with a specific focus on medical device innovation and prototyping. Translating a research idea into a medical device or diagnostic tool is a challenging process that requires multiple design improvements during the early stages of prototype development, before human testing in clinical research. As user needs and clinical effects grow clearer during the design and prototyping process, this can prompt iterative changes in design and materials. The CRC seeks to create a research environment that bridges critical translation from preclinical development to initial human studies. They aim to facilitate research teams at this early stage to efficiently turn device concepts into testable prototypes, and effectively incorporate clinical insights into the full span of preliminary research and development (R&D). Successfully traversing this translational process requires specialized facilities and tools, as well as close collaboration between large and diverse groups of scientists, engineers, biomedical researchers, and clinical care providers.

These initiatives will allow MIT to not only address issues MIT must confront to continue active research in health and life sciences research including HIPAA adherence and human subjects safety but to also assume its rightful position as an international leader in technology development and evaluation, to set the tone for public policy debates and to remain as critical thought leader and advisor of federal agencies like the FDA and political leaders.
Section 3
Students

- Undergraduate Students
- Graduate Students
- Degrees
- Alumni
- Undergraduate Financial Aid
- Graduate Financial Aid
Students

The Institute’s fall 2017 student body of 11,466 is highly diverse. Students come from all 50 states, the District of Columbia, four territories and dependencies, and 129 foreign countries. The Institute’s 3,413 international students make up eleven percent of the undergraduate population and forty-two percent of the graduate population. See pages 118–119 for more information about international students.

**Student Profile, 2017–2018**

<table>
<thead>
<tr>
<th>Student Level</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>4,547</td>
<td>40</td>
</tr>
<tr>
<td>Graduate</td>
<td>6,919</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>11,466</td>
<td>100</td>
</tr>
</tbody>
</table>

In fall 2017, 43 percent of MIT’s first-year students (who reported their class standing) were first in their high school class; 93 percent ranked in the top five percent.

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Undergraduate Count</th>
<th>Graduate Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian American</td>
<td>1,381</td>
<td>889</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>645</td>
<td>378</td>
</tr>
<tr>
<td>African American</td>
<td>397</td>
<td>135</td>
</tr>
<tr>
<td>American Indian or Alaskan Native</td>
<td>58</td>
<td>31</td>
</tr>
<tr>
<td>Native Hawaiian or Pacific Islander</td>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>

Students may identify with more than one race or choose not to identify with a group. Sixty-nine undergraduate and 458 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 3,864—54 percent of undergraduate and 21 percent of graduate students.
Undergraduate Students

Students first enrolled at MIT in 1865. Twenty-seven students enrolled as undergraduate students that first year. In fall 2017, there were 4,547 undergraduate students.

Undergraduate Students by Citizenship, 2017–2018

<table>
<thead>
<tr>
<th>Citizenship</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. citizen</td>
<td>3,850</td>
<td>85</td>
</tr>
<tr>
<td>U.S. permanent resident</td>
<td>176</td>
<td>4</td>
</tr>
<tr>
<td>International</td>
<td>521</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,547</td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Undergraduate Students by School, 2017–2018

<table>
<thead>
<tr>
<th>School</th>
<th>Count</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture and Planning</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>2,455</td>
<td></td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>Science</td>
<td>737</td>
<td></td>
</tr>
<tr>
<td>Undesignated*</td>
<td>1,165</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,547</td>
<td></td>
</tr>
</tbody>
</table>

*Undesignated comprises freshman who do not enroll in a major and undesignated sophomores.
Graduate Students

Graduate students have outnumbered undergraduate students at MIT since 1980. In fall 2017, they comprised 60 percent of the student population with 6,919 students—2,977 master’s students (includes 139 non-matriculating) and 3,942 doctoral students.

Graduate Students by Citizenship, 2017–2018

<table>
<thead>
<tr>
<th>Citizenship</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. citizen</td>
<td>3,779</td>
<td>55</td>
</tr>
<tr>
<td>U.S. permanent resident</td>
<td>248</td>
<td>4</td>
</tr>
<tr>
<td>International</td>
<td>2,892</td>
<td>42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6,919</td>
<td>100</td>
</tr>
</tbody>
</table>

*Excludes non-matriculating students

Graduate Students by Gender, 2017–2018

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2,660</td>
</tr>
<tr>
<td>Female</td>
<td>1,282 1,109</td>
</tr>
</tbody>
</table>

Graduate Students by School, 2017–2018

<table>
<thead>
<tr>
<th>School</th>
<th>Master’s Count*</th>
<th>Doctoral Count</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture and Planning</td>
<td>455</td>
<td>203</td>
<td>658</td>
</tr>
<tr>
<td>Engineering</td>
<td>1,021</td>
<td>2,105</td>
<td>3,126</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>27</td>
<td>303</td>
<td>330</td>
</tr>
<tr>
<td>Management</td>
<td>1,325</td>
<td>176</td>
<td>1,501</td>
</tr>
<tr>
<td>Science</td>
<td>10</td>
<td>1,155</td>
<td>1,165</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,838</td>
<td>3,942</td>
<td>6,780</td>
</tr>
</tbody>
</table>

*Excludes non-matriculating students
Students

Degrees

In 2017–2018, MIT awarded 3,490 degrees.

### Degrees Awarded by Type, 2017–2018

<table>
<thead>
<tr>
<th>Degree Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor of Science degrees</td>
<td>1,45</td>
</tr>
<tr>
<td>Master of Science degrees</td>
<td>632</td>
</tr>
<tr>
<td>Master of Architecture, Master in City Planning,</td>
<td>1,156</td>
</tr>
<tr>
<td>Master of Engineering, Master of Business</td>
<td></td>
</tr>
<tr>
<td>Administration, Master of Finance, Master of</td>
<td></td>
</tr>
<tr>
<td>Applied Science, and Master of Business Analytics</td>
<td></td>
</tr>
<tr>
<td>Engineer's degrees</td>
<td>12</td>
</tr>
<tr>
<td>Doctoral degrees</td>
<td>645</td>
</tr>
</tbody>
</table>

### Degrees Awarded by School, 2017–2018

<table>
<thead>
<tr>
<th>School</th>
<th>Bachelor's Count</th>
<th>Master's and Engineer's Count</th>
<th>Doctorate Count</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture and Planning</td>
<td>8</td>
<td>208</td>
<td>32</td>
<td>248</td>
</tr>
<tr>
<td>Engineering</td>
<td>772</td>
<td>776</td>
<td>355</td>
<td>1,903</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>18</td>
<td>20</td>
<td>52</td>
<td>90</td>
</tr>
<tr>
<td>Management</td>
<td>22</td>
<td>780</td>
<td>29</td>
<td>831</td>
</tr>
<tr>
<td>Science</td>
<td>225</td>
<td>16</td>
<td>177</td>
<td>418</td>
</tr>
<tr>
<td>Total</td>
<td><strong>1,045</strong></td>
<td><strong>1,800</strong></td>
<td><strong>645</strong></td>
<td><strong>3,490</strong></td>
</tr>
</tbody>
</table>

### Degrees Awarded by Gender, 2017–2018

- Bachelor's
  - Female: 197
  - Male: 448
- Master's and Engineer's
  - Female: 665
  - Male: 1,135
- Doctorate
  - Female: 490
  - Male: 555
Alumni

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 career, and their MIT undergraduate experience. The survey closed at the end of May with a 36% response rate.

Seventy-four percent of alumni respondents said they have enrolled in a graduate or professional degree program since graduating from MIT. Of those who have enrolled in a graduate or professional degree program, 46% did so immediately upon graduation. Seventy-five percent of respondents said they are employed either full-time or part-time. Among those respondents who are employed, 60% work in the for-profit sector, 17% work in the nonprofit sector, 15% work in government or other public institution or agency, including military, and 7% 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% of respondents are employed, with just 2% 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%; in a U.S. four-year college or university, 13%; or to be self-employed, 9%. 3.8% were employed by the U.S. federal government; 0.4% by U.S. state government; and 0.7% in U.S. local government. A spirit of entrepreneurship flourishes, as 28% of all surveyed graduate alumni have started a company. Among doctoral alumni, 41% have at least one patent or invention. A survey of graduate alumni will be administered during 2018.

MIT’s 136,079 living alumni are connected to the Institute through graduating-class events, departmental organizations, and over 43 clubs in the United States and 42 abroad. Beyond classes and regional clubs, the MIT Alumni Association supports a range of shared interest groups that foster connectedness among MIT alumni. Nearly 16,000 volunteers offer their time, financial support, and service as student mentors, project advisors, and on boards and committees; as well as on the MIT Corporation, the Institute’s Board of Trustees. MIT graduates hold leadership positions in industries and organizations around the world. Over 22,000 alumni reside in Massachusetts, and about 15 percent of MIT’s alumni live outside of the United States.
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-five percentage points since 2000. In Financial Aid Year 2018, the net cost of undergraduate tuition and fees was 46% 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 2017–2018, the annual price of an MIT education totaled $67,980 per student—$49,892 for tuition and fees, $14,720 for room and board, an estimated $2,818 for books, supplies, and personal expenses, and a per-student average of $550 for travel. With 4,489 undergraduates enrolled, the collective price for undergraduates was $305.2 million. Of this amount, families paid $155.8 million, or 51 percent, and financial aid covered the remaining 49 percent, or $149.4 million. Since MIT subsidizes the cost of educating undergraduates through its tuition pricing 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 are used interchangeably, although grants are gift aid based on need and scholarships are gift aid based on merit. Since 2005-2006 the share of undergraduate aid in the form of grants/scholarships rose from 80.9 to 89.5 percent while the share in the form of student loans fell from 11.1 to 3.4 percent and term-time work decreased from 8.0 to 7.1 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 other higher education institutions.

Types of Financial Aid for MIT Undergraduates
2017–2018

Amounts of Financial Aid for MIT Undergraduates, 2017–2018

<table>
<thead>
<tr>
<th>Aid Type</th>
<th>Amount (in U.S. Dollars)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants and Scholarships</td>
<td>133,645,406</td>
<td>89.5</td>
</tr>
<tr>
<td>Student Loans</td>
<td>5,088,444</td>
<td>3.4</td>
</tr>
<tr>
<td>Term-time employment</td>
<td>10,672,966</td>
<td>7.1</td>
</tr>
<tr>
<td>Total</td>
<td>149,406,816</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Sources of Undergraduate Financial Aid
In 2017–2018, MIT provided 86.7 percent of undergraduate financial aid. State and private resources provided 5.6 percent, and the remaining 7.7 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 $45,524 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. Approximately 18 percent of MIT undergraduates receive a Pell Grant. 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. 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.

The following table summarizes the sources and types of financial aid MIT undergraduates received in 2017–2018.

### Sources of Financial Aid for MIT Undergraduates, 2017–2018

<table>
<thead>
<tr>
<th>Aid Source</th>
<th>Amount (in U.S. Dollars)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT Financial Aid</td>
<td>129,543,705</td>
<td>86.7</td>
</tr>
<tr>
<td>Federal Financial Aid</td>
<td>11,510,335</td>
<td>7.7</td>
</tr>
<tr>
<td>State Financial Aid</td>
<td>188,280</td>
<td>0.1</td>
</tr>
<tr>
<td>Private Financial Aid</td>
<td>8,164,497</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>149,406,816</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

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

### Undergraduate Financial Aid, 2017–2018

<table>
<thead>
<tr>
<th>Source</th>
<th>Scholarships/Grants</th>
<th>Loans</th>
<th>Employment</th>
<th>Total*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount ($)</td>
<td>Students</td>
<td>Amount ($)</td>
<td>Students</td>
</tr>
<tr>
<td>MIT</td>
<td>119,683,420</td>
<td>2,629</td>
<td>171,276</td>
<td>56</td>
</tr>
<tr>
<td>Federal</td>
<td>7,315,806</td>
<td>840</td>
<td>3,210,571</td>
<td>474</td>
</tr>
<tr>
<td>State</td>
<td>188,280</td>
<td>92</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Private</td>
<td>6,457,900</td>
<td>988</td>
<td>1,706,597</td>
<td>81</td>
</tr>
<tr>
<td><strong>Total</strong>*</td>
<td><strong>133,645,406</strong></td>
<td><strong>2,948</strong></td>
<td><strong>5,088,444</strong></td>
<td><strong>555</strong></td>
</tr>
</tbody>
</table>
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 singular 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 ($49,580 for the 2017–2018 academic year). Another portion ($3,000) 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 $37,128 for a doctoral student). MIT houses approximately 33 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.
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 annually 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 AY2018, students that were supported, at least in part, by fellowships were as follows:

<table>
<thead>
<tr>
<th>Sponsor</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Defense</td>
<td>64</td>
</tr>
<tr>
<td>Department of Energy</td>
<td>4</td>
</tr>
<tr>
<td>National Institutes of Health</td>
<td>100</td>
</tr>
<tr>
<td>NASA</td>
<td>23</td>
</tr>
<tr>
<td>National Science Foundation</td>
<td>293</td>
</tr>
<tr>
<td>Other Federal Agencies</td>
<td>2</td>
</tr>
<tr>
<td>Other U.S. sources</td>
<td>62</td>
</tr>
<tr>
<td>Non-U.S. sources</td>
<td>86</td>
</tr>
<tr>
<td>MIT Internal</td>
<td>2,048</td>
</tr>
</tbody>
</table>

Note, students may have received a fellowship from more than one sponsor.

Teaching Assistantships

MIT employs about 1,350 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 3,400 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 $1.7 million in 2017–2018, with 1.9 percent of graduate and professional students (130 students) earning $13,149 on average.

In AY2018, graduate students borrowed loans that totaled $44.9 million, an increase of approximately $4.8 million from the prior year, with 9.2 percent of graduate and professional students (637 students) borrowing an average of $70,531.
Section 4
Campus Research

Research Support  64
Campus Research Sponsors  67
  Department of Defense (DoD)  70
  Department of Energy (DoE)  72
  National Institutes of Health (NIH)  74
  NASA  76
  National Science Foundation (NSF)  78
  Other Federal Agencies  80
  Nonprofit Organizations  82
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 FY2018)

<table>
<thead>
<tr>
<th>Location</th>
<th>Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambridge Campus</td>
<td>$731.5 million</td>
</tr>
<tr>
<td>Lincoln Laboratory*</td>
<td>$973.4 million</td>
</tr>
<tr>
<td>SMART*</td>
<td>$42.2 million</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,747.1 million</strong></td>
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</tbody>
</table>

*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, 2018, there were 3,092 active awards and 497 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 1940–2018

†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 2018 equaling 100.
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. The Office of Sponsored Programs 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 Office of Sponsored Programs website.
MIT subsidizes virtually every research grant that it receives, even when the grant 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 grants and include summer salary support for faculty (when they get no university salary), salaries for research staff and postdocs working on the project, stipends for graduate students assigned to the grant, laboratory supplies, certain research equipment including computers, and travel and publication costs.

**Indirect costs (IDC)**, also known as the F&A (facilities and administrative) rate, represent genuine costs of performing research that are not easily attributable to individual grants. Think of these charges as applying to 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. Note that only resources utilized for federally funded research are counted. The federal government partially reimburses universities for these expenses.

Since most faculty are paid in full by the Institute during the academic year, their participation in research during this time is supported by MIT.

MIT’s indirect cost rate for FY2017 was 54.7% and for FY2018 it is 59.0%. This rate is set through Uniform Guidance 2 CFR 200, whereby universities calculate their actual indirect costs based on previous years and apportion them to various activities—research, instruction, or other. MIT’s rates are negotiated with, and audited each year by the federal government, and rates are applied only to those direct costs that are subject to F&A reimbursement.

The easiest way to think about indirect costs, illustrated in Figure 1, is to understand how the average federal research dollar is spent at MIT. For a 54.7% indirect cost rate (FY17), 71 cents of every MIT research dollar goes to direct costs and 29 cents goes to indirect, or F&A costs. Figure 1 shows breakdowns within these categories and illustrates that a 54.7% indirect cost rate does not mean that 54.7 cents of every research dollar goes to indirect costs. It is 29 cents, because the rate is a fraction applied to the allowable direct costs and then added to the total direct costs. In 1991, the government implemented a cap of 26% on the total negotiated F&A rate for administrative costs. MIT has historically been under this cap, with a current rate of 21%.

Whenever a sponsor pays less than full F&A, it generates under-recovery. Some institutions do not accept grants unless they carry full indirect costs, some write off the differential, and MIT, almost uniquely, identifies internal funds to cover the difference.
It is important, though, when comparing indirect cost rates among research sponsors to be sure there is an “apples-to-apples” comparison. Many foundations, for example, categorize some expenses as direct costs that the federal government labels as indirect. As a result, foundations are often paying a higher percentage of research costs than is apparent just by looking at their rates. Also, foundations generally negotiate a separate rate for each grant rather than having a standard rate for an institution. This would be an impossible burden for the federal government, which provides far more grants.

### 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 85. Expenditures funded by industrial sponsors are shown on page 101 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 (in thousands of U.S. Dollars)*

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</tr>
</thead>
<tbody>
<tr>
<td>Federal</td>
<td>381,459</td>
<td>430,154</td>
<td>469,521</td>
<td>472,583</td>
<td>465,947</td>
<td>454,939</td>
<td>459,979</td>
<td>477,169</td>
<td>461,626</td>
<td>454,497</td>
</tr>
<tr>
<td>Non-federal</td>
<td>158,596</td>
<td>184,216</td>
<td>191,305</td>
<td>208,497</td>
<td>208,402</td>
<td>223,473</td>
<td>236,912</td>
<td>250,985</td>
<td>257,880</td>
<td>277,012</td>
</tr>
<tr>
<td>Total</td>
<td>540,055</td>
<td>614,371</td>
<td>660,825</td>
<td>681,079</td>
<td>674,348</td>
<td>678,412</td>
<td>696,891</td>
<td>728,154</td>
<td>719,506</td>
<td>731,509</td>
</tr>
<tr>
<td>Constant dollars†</td>
<td>624,258</td>
<td>703,354</td>
<td>741,645</td>
<td>742,618</td>
<td>723,241</td>
<td>716,409</td>
<td>730,605</td>
<td>758,258</td>
<td>735,720</td>
<td>731,509</td>
</tr>
</tbody>
</table>

*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 2018 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.
Recent Research Highlights

LIGO and Virgo make first detection of gravitational waves produced by colliding neutron stars
For the first time, scientists have directly detected gravitational waves—ripples in space-time—in addition to light from the spectacular collision of two neutron stars. This marks the first time that a cosmic event has been viewed in both gravitational waves and light. The discovery was 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.

Neutron stars are the smallest, densest stars known to exist and are formed when massive stars explode in supernovas. As these neutron stars spiraled together, they emitted gravitational waves that were detectable for about 100 seconds; when they collided, a flash of light in the form of gamma rays was emitted and seen on Earth about two seconds after the gravitational waves. In the days and weeks following the smashup, other forms of light, or electromagnetic radiation—including X-ray, ultraviolet, optical, infrared, and radio waves—were detected.

The NSF-funded LIGO observatories were conceived, constructed, and operated by Caltech and MIT. Virgo is funded by the Istituto Nazionale di Fisica Nucleare (INFN) in Italy and the Centre National de la Recherche Scientifique (CNRS) in France, and operated by the European Gravitational Observatory.

Scientists unveil CRISPR-based diagnostic platform
A team of scientists from MIT and Harvard has adapted a CRISPR protein that targets RNA (rather than DNA), for use as a rapid, inexpensive, highly sensitive diagnostic tool with the potential to transform research and global public health.

In a study published in Science, Broad Institute members Feng Zhang, Jim Collins, Deb Hung, Aviv Regev, and Pardis Sabeti describe how this RNA-targeting CRISPR enzyme was harnessed as a highly sensitive detector—able to indicate the presence of as little as a single molecule of a target RNA or DNA. Co-first authors Omar Abudayyeh and Jonathan Gootenberg, graduate students at MIT and Harvard, respectively, dubbed the new tool SHERLOCK (Specific High-sensitivity Enzymatic Reporter unLOCKing); this technology could one day be used to respond to viral and bacterial outbreaks, monitor antibiotic resistance, and detect cancer.

Because the tool can be designed for use as a paper-based test that does not require refrigeration, the researchers say it is well-suited for fast deployment and widespread use inside and outside of traditional settings—such as at a field hospital or a rural clinic.

Wearable system helps visually impaired users navigate
Researchers from MIT’s Computer Science and Artificial Intelligence Laboratory (CSAIL) have developed a new system that uses a 3D camera, a processing unit that runs the team’s proprietary algorithms, a belt with separately controllable vibrational motors distributed around it, and an electronically reconfigurable Braille interface to give visually impaired users more information about their environments.

The key to the system is an algorithm for identifying surfaces and their orientations from the 3D-camera data. That data is processed to send signals to the belt motors which can vary the frequency, intensity, and duration of their vibrations, to send different types of tactile signals to the user to indicate that the wearer is approaching an obstacle or target in the direction indicated by that particular motor.

MIT researchers create new form of matter
MIT physicists, led by Wolfgang Ketterle, have created 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 was 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. Studies into this apparently contradictory phase of matter could yield deeper insights into superfluids and superconductors, which are important for improvements in technologies such as superconducting magnets and sensors, as well as efficient energy transport.
### Campus Research Expenditures by Primary Sponsor*

<table>
<thead>
<tr>
<th>Primary Sponsor</th>
<th>FY2018 (In U.S. Dollars)</th>
<th>Percent of Campus Total‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Defense</td>
<td>123,512,935</td>
<td>17</td>
</tr>
<tr>
<td>Department of Energy</td>
<td>72,827,587</td>
<td>10</td>
</tr>
<tr>
<td>National Institutes of Health†</td>
<td>130,668,192</td>
<td>18</td>
</tr>
<tr>
<td>NASA</td>
<td>33,023,532</td>
<td>5</td>
</tr>
<tr>
<td>National Science Foundation</td>
<td>81,563,231</td>
<td>11</td>
</tr>
<tr>
<td>All other federal</td>
<td>12,901,728</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Federal</strong></td>
<td><strong>454,497,205</strong></td>
<td><strong>62</strong></td>
</tr>
<tr>
<td>Industry</td>
<td>144,126,295</td>
<td>20</td>
</tr>
<tr>
<td>Foundations and other nonprofit</td>
<td>94,322,337</td>
<td>13</td>
</tr>
<tr>
<td>State, local, and foreign governments</td>
<td>24,471,339</td>
<td>3</td>
</tr>
<tr>
<td>MIT internal</td>
<td>14,091,658</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Non-Federal</strong></td>
<td><strong>277,011,630</strong></td>
<td><strong>38</strong></td>
</tr>
<tr>
<td><strong>Campus Total</strong></td>
<td><strong>731,508,835</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*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.
‡Total may not sum due to rounding.

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# Campus Research

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MIT Briefing Book
Department of Defense (DoD)

Selected projects funded by the DoD

Cell-sized robots can sense their environment

Researchers at MIT have created what may be the smallest robots yet that can sense their environment, store data, and even carry out computational tasks. These devices, which are about the size of a human egg cell, consist of tiny electronic circuits made of two-dimensional materials, piggybacking on minuscule particles called colloids.

Colloids are insoluble particles or molecules anywhere from a billionth to a millionth of a meter across—so small they can stay suspended indefinitely in a liquid or even in air. By coupling these tiny objects to complex circuitry, the researchers hope to lay the groundwork for devices that could be dispatched to carry out diagnostic journeys through anything from the human digestive system to oil and gas pipelines, or perhaps to waft through air to measure compounds inside a chemical processor or refinery.

The MIT robots are self-powered, requiring no external power source or even internal batteries. A simple photodiode generates the trickle of electricity required to power their computation and memory circuits. That’s enough to let them sense information about their environment, store those data in their memory, and then later have the data read out after accomplishing their mission.

Professor Michael Strano is senior author of the study, which was published in the journal *Nature Nanotechnology*. Postdoc Volodymyr Koman is the paper’s lead author. The research team included Pingwei Liu, Daichi Kozawa, Albert Liu, Anton Cottrill, Youngwoo Son, and Jose Lebron.


MIT engineers recruit microbes to help fight cholera

Cholera outbreaks are usually caused by contaminated drinking water, and infections can turn fatal if not treated. The most common treatment is rehydration, which must be done intravenously if the patient is extremely dehydrated. However, intravenous treatment is not always available to patients who need it, and the disease kills ~95,000 people per year.

The MIT team’s new probiotic mix could be consumed regularly as a preventative measure in regions where cholera is common, or used to treat people soon after infection occurs, says Professor James Collins, senior author of the study. The lead authors of the paper, which appears in *Science Translational Medicine*, are former Boston University graduate student Ning Mao, MIT postdoc Andres Cubillos-Ruiz, and former MIT postdoc D. Ewen Cameron.


“Body on a chip” could improve drug evaluation

MIT engineers have developed new technology that could be used to evaluate new drugs and detect possible side effects before the drugs are tested in humans. Using a microfluidic platform that connects engineered tissues from up to 10 organs, the researchers can accurately replicate human organ interactions for weeks at a time, allowing them to measure the effects of drugs on different parts of the body.

Such a system could reveal, for example, whether a drug that is intended to treat one organ will have adverse effects on another. These chips could also be used to evaluate antibody drugs and other immunotherapies, which are difficult to test thoroughly in animals because they are designed to interact with the human immune system.

Professors Linda Griffith and David Trumper, and research scientist Murat Cirit, are senior authors of the paper, which appears in the journal *Scientific Reports*. The paper’s lead authors are former MIT postdocs Collin Edington and Wen Li Kelly Chen.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2018
(Shown in descending order of expenditures)

- Research Laboratory of Electronics
- Computer Science and Artificial Intelligence Laboratory
- Biological Engineering
- Mechanical Engineering
- Aeronautics and Astronautics
- Institute for Soldier Nanotechnologies
- Koch Institute for Integrative Cancer Research
- Microsystems Technology Laboratories
- Chemical Engineering Laboratory for Information and Decision Systems

In fall 2017, the Department of Defense funded the primary appointments of graduate students with 317 research assistantships and 55 fellowships.

Thirty-four current faculty and staff have received the Office of Naval Research Young Investigator Program Award.
Keeping the balance: How flexible nuclear operation can help add more wind and solar to the grid

In the Southwestern U.S., sunlight can shine down for up to 14 hours a day. This makes the location ideal for implementing solar energy—and the perfect test-bed for MIT Energy Initiative researcher Jesse Jenkins and his colleagues at Argonne National Laboratory to model the benefits of pairing renewable resources with more flexible operation of nuclear power plants. They report their findings in *Applied Energy*.

In power grids, supply and demand hang in a delicate balance on a second-to-second timeframe. Flexible backup energy sources must stay online at all times to maintain this equilibrium by meeting small variations in demand throughout the day or stepping in quickly if a power plant should suddenly go offline. Currently, certain coal, oil, natural gas, and hydro plants take on the important role of providing these standby capacity services.

“We primarily rely on gas and coal plants to meet all those flexibility needs today, while we operate our nuclear plants fixed, or ‘must-run,’ 24/7,” says Jenkins. “The question here is: What would the benefits be if we stopped operating them so inflexibly, if we started using more of their technical capabilities to ‘ramp’ output up and down on different time scales from seconds to hours to seasons?” The answer, he says, is less reliance on the gas and coal plants—and more renewable energy integration.

Because power systems today have very little energy storage capability, there are a growing number of places where excess renewable energy might be produced on a sunny or windy day and must simply be wasted. Rather than disabling a solar panel or wind turbine, Jenkins points out, it makes more sense to operate the nuclear plant at a lower output and to absorb as much free wind or sun as possible.

The proton’s weak charge is very precisely predicted in the Standard Model. Comparison with the similarly precise Qweak result provides insight into predictions of hitherto unobserved heavy particles, such as those that may be produced by the Large Hadron Collider at CERN in Europe or future high-energy particle accelerators.

The proton’s weak charge is very precisely predicted in the Standard Model. Comparison with the similarly precise Qweak result provides insight into predictions of hitherto unobserved heavy particles, such as those that may be produced by the Large Hadron Collider at CERN in Europe or future high-energy particle accelerators.

The Qweak Collaboration consists of about 100 scientists and more than 20 institutions. MIT efforts were directed by professor Stanley Kowalski. Other MIT contributors included postdocs W. Deconinck, Jean-Francoise Rajotte, and Rupesh Silwal.
Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2018
(Shown in descending order of expenditures)

<table>
<thead>
<tr>
<th>Department/Center</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<tbody>
<tr>
<td>Plasma Science and Fusion Center</td>
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<tr>
<td>Laboratory for Nuclear Science</td>
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<td>Nuclear Science and Engineering</td>
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<tr>
<td>Mechanical Engineering</td>
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<tr>
<td>Materials Research Laboratory</td>
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<td>Research Laboratory of Electronics</td>
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<tr>
<td>Chemical Engineering</td>
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<tr>
<td>Civil and Environmental Engineering</td>
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<tr>
<td>Chemistry</td>
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<tr>
<td>Nuclear Reactor Laboratory</td>
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</table>

In fall 2017, the Department of Energy funded the primary appointments of graduate students with 170 research assistantships and 17 fellowships.

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

*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2018 equaling 100.
National Institutes of Health (NIH)

Selected projects funded by NIH

Restricting a key cellular nutrient could slow tumor growth

Remove tumor cells from a living organism and place them in a dish, and they will multiply even faster than before. The mystery of why this is has long stumped cancer researchers. A group of MIT researchers suggests that the growth limitations in live organisms may stem from a different source: the cell’s environment. More specifically, they found that the amino acid aspartate serves as a key nutrient needed for the “proliferation” or rapid duplication of cancer cells when oxygen is not freely available.

The biologists took cancer cells from various tissue types and engineered them to convert another, more abundant substrate into aspartate. This had no effect on the cells sitting in a dish, but the same cells implanted into mice engendered tumors grew faster than ever before. The researchers had increased the cells’ aspartate supply, and in doing so successfully sped up proliferation in a living entity.

“There hasn’t been a lot of thought into what slows tumor growth in terms of the cellular environment, including the sort of food cancer cells need,” says associate professor Matthew Vander Heiden, senior author of the study which appeared in Nature Cell Biology. “For instance, if you’re trying to get to a given destination and I want to slow you down, my best bet is to set up a roadblock at a place on your route where you’d experience a slow-down anyways, like a long traffic light. That’s essentially what we’re interested in here—understanding what nutrients the cell is already lacking that put the brakes on proliferation, and then further limiting those nutrients to inhibit growth even more.”


Wireless system can power devices inside the body

MIT researchers, working with scientists from Brigham and Women’s Hospital, have developed a new way to power and communicate with devices implanted deep within the human body. Such devices could be used to deliver drugs, monitor conditions inside the body, or treat disease by stimulating the brain with electricity or light.

The implants have no batteries and are powered by radio frequency waves, which can safely pass through human tissues. In tests in animals, the researchers showed that the waves can power devices located 10 centimeters deep in tissue, from a distance of 1 meter. In this study, the researchers tested a prototype about the size of a grain of rice, but they anticipate that it could be made even smaller.

Assistant professor Fadel Adib is senior author of the paper presented at the Association for Computing Machinery Special Interest Group on Data Communication (SIGCOMM) conference. Other authors of the paper are Giovanni Traverso, an assistant professor at Brigham and Women’s Hospital (BWH), Harvard Medical School, a research affiliate at MIT’s Koch Institute for Integrative Cancer Research, postdoc Yunfei Ma, graduate student Zhihong Luo, and Koch Institute and BWH affiliate postdoc Christoph Steiger.


Fluorescent dye could enable sharper imaging

Fluorescence imaging is widely used for visualizing biological tissues such as the back of the eye, where signs of macular degeneration can be detected. It is also commonly used to image blood vessels during reconstructive surgery, allowing surgeons to make sure the vessels are properly connected. For these procedures, as well as others, researchers use a portion of the light spectrum known as the near-infrared (NIR). A dye that fluoresces at this wavelength is administered to the body or tissue and then imaged using a specialized camera. Researchers have shown that light with wavelengths known as short-wave infrared (SWIR), offers much clearer images than NIR, but there are no FDA-approved fluorescence dyes with peak emission in the SWIR range.

A team at MIT and Massachusetts General Hospital has taken a major step toward making SWIR imaging widely available. They have shown that an FDA-approved, commercially available dye now used for NIR imaging also works very well for SWIR imaging.

Professor Moungi Bawendi and former research scientist Oliver Bruns are the senior authors of the study, which appears in the Proceedings of the National Academy of Sciences. Lead authors are graduate students Jessica Carr and Daniel Franke.

https://bit.ly/2x7X1MI
Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2018
(Shown in descending order of expenditures)

In fall 2017, the National Institutes of Health funded the primary appointments of graduate students with 193 research assistantships and 30 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.

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

National Institutes of Health Campus Research Expenditures (in U.S. Dollars)*
Fiscal Years 2014–2018

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus research</td>
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<td>116,469,457</td>
<td>113,562,813</td>
<td>111,834,707</td>
<td>130,668,192</td>
</tr>
<tr>
<td>Constant dollars†</td>
<td>121,519,837</td>
<td>122,103,968</td>
<td>118,257,916</td>
<td>114,354,840</td>
<td>130,668,192</td>
</tr>
</tbody>
</table>

*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.
**NASA**

*Selected projects funded by NASA*

**Sprawling galaxy cluster found hiding in plain sight**

MIT scientists have uncovered a sprawling new galaxy cluster hiding in plain sight. The cluster is made up of hundreds of individual galaxies and surrounds an extremely active supermassive black hole, or quasar. The central quasar is intensely bright—so bright that for decades astronomers observing it in the night sky have assumed that the quasar was quite alone in its corner of the universe, shining out as a solitary light source from the center of a single galaxy. But as the MIT team reports in the *Astrophysical Journal*, the quasar’s light is so bright that it has obscured hundreds of galaxies clustered around it.

In their new analysis, the researchers estimate that there are hundreds of individual galaxies in the cluster, which, all told, is about as massive as 690 trillion suns. Our Milky Way galaxy, for comparison, weighs in at around 400 billion solar masses.

The team believes the discovery of this hidden cluster shows there may be other similar galaxy clusters hiding behind extremely bright objects that astronomers have miscatalogued as single light sources. The researchers are looking for more hidden galaxy clusters, which could be important clues to estimating how much matter there is in the universe and how fast the universe is expanding.

The paper’s co-authors include assistant professor Michael McDonald, lead author and graduate student Taweewat Somboonpanyakul, Henry Lin of Princeton University, Brian Stalder of the Large Synoptic Survey Telescope, and Antony Stark of the Harvard-Smithsonian Center for Astrophysics.


**Nearly 80 exoplanet candidates identified in record time**

Scientists at MIT and elsewhere have analyzed data from K2, the follow-up mission to NASA’s Kepler Space Telescope, and have discovered a trove of possible exoplanets amid some 50,000 stars. In a paper in *The Astronomical Journal*, the scientists report the discovery of nearly 80 new planetary candidates, including a particular standout: a likely planet that orbits the star HD 73344, which would be the brightest planet host ever discovered by the K2 mission. Assistant professor Ian Crossfield co-led the study with graduate student Liang Yu.

The new analysis is also noteworthy for the speed with which it was performed. The researchers were able to use existing tools developed at MIT to rapidly search through graphs of light intensity called “lightcurves” from each of the 50,000 stars that K2 monitored in its two recent observing campaigns. They quickly identified the planetary candidates and released the information to the astronomy community just weeks after the K2 mission made the spacecraft’s raw data available. A typical analysis of this kind takes between several months and a year.


**Dense stellar clusters may foster black hole megamergers**

When LIGO’s twin detectors first picked up faint wobbles in their respective, identical mirrors, the signal didn’t just provide first direct detection of gravitational waves—it also confirmed the existence of stellar binary black holes, which gave rise to the signal in the first place.

Stellar binary black holes are formed when two black holes, created out of the remnants of massive stars, begin to orbit each other. Eventually, the black holes merge in a spectacular collision that, according to Einstein’s theory of general relativity, should release a huge amount of energy in the form of gravitational waves.

Now, an international team led by MIT astrophysicist Carl Rodriguez suggests that black holes may partner up and merge multiple times, producing black holes more massive than those that form from single stars. These “second-generation mergers” should come from globular clusters—small regions of space, usually at the edges of a galaxy, that are packed with hundreds of thousands to millions of stars.

He and his colleagues report their results in a paper appearing in *Physical Review Letters*.

In fall 2017, NASA funded the primary appointments of graduate students with 37 research assistantships and 23 fellowships.

**Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2018**
(Shown in descending order of expenditures)

- Kavli Institute for Astrophysics and Space Research
- Aeronautics and Astronautics
- Earth, Atmospheric and Planetary Sciences
- Haystack Observatory
- Center for Global Change Science
- Civil and Environmental Engineering
- Computer Science and Artificial Intelligence Laboratory
- Research Laboratory of Electronics
- Mechanical Engineering
- Plasma Science and Fusion Center
National Science Foundation (NSF)

Selected projects funded by NSF

Wireless communication breaks through water-air barrier

MIT researchers have taken a step toward solving a longstanding challenge with wireless communication: direct data transmission between underwater and airborne devices. Today, underwater sensors cannot share data with those on land, as both use different wireless signals that only work in their respective mediums. Radio signals that travel through air die very rapidly in water. Acoustic signals, or sonar, sent by underwater devices mostly reflect off the surface without ever breaking through. This causes inefficiencies and other issues for a variety of applications, such as ocean exploration and submarine-to-plane communication.

In a paper presented at the SIGCOMM conference, MIT Media Lab researchers, led by assistant professor Fadel Adib, have designed a system that tackles this problem. An underwater transmitter directs a sonar signal to the water’s surface, causing tiny vibrations that correspond to the 1s and 0s transmitted. Above the surface, a highly sensitive radar system bounces microwave signals off these minute disturbances and replicates the pattern sent by the sonar. Adib co-authored the paper with his graduate student Francesco Tonolini.

“Trying to cross the air-water boundary with wireless signals has been an obstacle. Our idea is to transform the obstacle itself into a medium through which to communicate,” says Adib.

SoFi has a simple and lightweight setup—a single camera, a motor, and the same lithium polymer battery that’s found in consumer smartphones.

The paper was published in Science Robotics. CSAIL PhD candidate Robert Katzschmann worked on the project and wrote the paper with CSAIL director Daniela Rus, graduate student Joseph DelPreto and former postdoc Robert MacCurdy.

Soft robotic fish swims alongside real ones in coral reefs

A team from MIT’s Computer Science and Artificial Intelligence Laboratory (CSAIL) unveiled “SoFi,” a soft robotic fish that can independently swim alongside real fish in the ocean. During test dives in Fiji, SoFi swam at depths of more than 50 feet for up to 40 minutes at once, nimbly handling currents and taking high-resolution photos and videos using a fisheye lens.

Using its undulating tail and a unique ability to control its own buoyancy, SoFi can swim in a straight line, turn, or dive up or down. The team also used a waterproofed Super Nintendo controller and developed a custom acoustic communications system that enabled them to change SoFi’s speed and have it make specific moves and turns.

Scientists at MIT, Harvard University, and elsewhere have now demonstrated that photons can indeed be made to interact—an accomplishment that could open a path toward using photons in quantum computing.

In a paper published in the journal Science, the team, led by Professor Vladan Vuletic, and Professor Mikhail Lukin from Harvard University, reports that it has observed groups of three photons interacting and, in effect, sticking together to form a completely new kind of photonic matter.

In controlled experiments, the researchers found that when they shone a very weak laser beam through a dense cloud of ultracold rubidium atoms, rather than exiting the cloud as single, randomly spaced photons, the photons bound together in pairs or triplets, suggesting some kind of interaction—in this case, attraction—taking place among them.

Vuletic’s co-authors include Qi-Yung Liang, Sergio Cantu, and Travis Nicholson from MIT, Lukin and Aditya Venkatramani of Harvard, Michael Gullans and Alexey Gorshkov of the University of Maryland, Jeff Thompson from Princeton University, and Cheng Ching of the University of Chicago.
Leading Departments, Laboratories, and Centers
Receiving Support in Fiscal Year 2018
(Shown in descending order of expenditures)

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

In fall 2017, the National Science Foundation (NSF) funded the primary appointments of graduate students with 277 research assistantships. In the 2017–2018 academic year, NSF supported, at least in part, 293 students through fellowships.

The National Science Foundation has awarded Faculty Early Career Development (CAREER) Awards to 169 current faculty and staff members.

National Science Foundation Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2014–2018

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Expenditures (in Millions)</th>
<th>Constant Dollars (in Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>79,255,278</td>
<td>83,128,333</td>
</tr>
<tr>
<td>2015</td>
<td>78,978,705</td>
<td>81,564,260</td>
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<td>2016</td>
<td>78,952,919</td>
<td>80,948,344</td>
</tr>
<tr>
<td>2017</td>
<td>82,160,804</td>
<td>83,672,128</td>
</tr>
<tr>
<td>2018</td>
<td>80,410,343</td>
<td>80,410,343</td>
</tr>
</tbody>
</table>

*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2018 equaling 100.
Other Federal Agencies

Selected projects funded by other federal agencies

New theory describes intricacies of a splashing droplet

As a single raindrop falls to the ground, it can splash back up in a crown-like sheet, spraying smaller droplets from its rim before sinking back to the surface—all in the blink of an eye.

Researchers at MIT have found a way to track the thickness of a droplet’s rim as it splashes up from a variety of surfaces. This incredibly specific measurement, they say, is key to predicting the number, size, and speed of smaller droplets that can be ejected from the rim, into the air.

Assistant professor Lydia Bourouiba says the group’s results can be used to model the physics of sprays, such as pesticides that splash back up from crop leaves, or raindrops that may pick up and spread diseases as they bounce off contaminated surfaces.

“Our fundamental investigation aims to understand spray physics, and identify the key ingredients that control sprays, whether one wants to minimize secondary droplets that are undesirable, or improve sprays to homogenously coat a surface,” Bourouiba says. “To do all that, one needs to know how the fluid breaks up.”

Bourouiba and her students have published their results in the journal Physical Review Letters. Her co-authors are graduate students Yongji Wang, Raj Dandekar, Nicole Bustos, and Stephane Poulain.


Study: Low-emissions vehicles are less expensive overall

You might think cars with low carbon emissions are expensive. Think again. A study published by MIT researchers shows that when operating and maintenance costs are included in a vehicle’s price, autos emitting less carbon are among the market’s least expensive options, on a per-mile basis.

The study also evaluates the U.S. automotive fleet—as represented by 125 model types—against emissions-reduction targets the U.S. has set for the years from 2030 to 2050. Overall, the research finds, the average carbon intensity of vehicles that consumers bought in 2014 is more than 50 percent higher than the level it must meet to help reach the 2030 target. However, the lowest-emissions autos have surpassed the 2030 target.

The paper was published in the journal Environmental Science and Technology. Jessika Trancik is the study’s senior author. The authors of the study are doctoral students Marco Miotti and Elia Kim, and postdoc Geoffrey Supran PhD ’16.

The research group also released the results in the form of an app, CarbonCounter, that consumers can use to evaluate any or all of the 125 vehicle types. People can use the app to look up their current car, or a car they are considering buying or leasing, and see how it performs in terms of costs and carbon emissions.

On a national basis, the study reinforces the need to continue modernizing the country’s vehicle fleet and decarbonizing it in the next few decades.

http://bit.ly/2cZv6ak
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 Transportation, the Federal Aviation Administration, and the Intelligence Advanced Research Projects Activity (IARPA).

**Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2018**

(Shown in descending order of expenditures)

- Mechanical Engineering
- Aeronautics and Astronautics
- Center for Transportation and Logistics
- Computer Science and Artificial Intelligence Laboratory
- Civil and Environmental Engineering
- Urban Studies & Planning
- Center for Global Change Science
- Architecture
- Media Laboratory
- Nuclear Science and Engineering

In fall 2017, other federal agencies funded the primary appointments of graduate students with 31 research assistantship.
Nonprofit Organizations

Selected projects funded by nonprofit organizations

Brain circuit helps us learn by watching others

It’s often said that experience is the best teacher, but the experiences of other people may be even better. If you saw a friend get chased by a neighborhood dog, for instance, you would learn to stay away from the dog without having to undergo that experience yourself.

This kind of learning, known as observational learning, offers a major evolutionary advantage, says associate professor Kay Tye. “So much of what we learn day-to-day is through observation,” she says. “Especially for something that is going to potentially hurt or kill you, you could imagine that the cost of learning it firsthand is very high. The ability to learn it through observation is extremely adaptive, and gives a major advantage for survival.”

Tye and her colleagues at MIT have now identified the brain circuit that is required for this kind of learning. This circuit, which is distinct from the brain network used to learn from firsthand experiences, relies on input from a part of the brain responsible for interpreting social cues.

Former MD/PhD student Stephen Allsop, along with Romy Wichmann, Fergil Mills, and Anthony Burgos-Robles co-led this study, which appears in Cell. https://bit.ly/2wLtUlm

Brewing up Earth’s earliest life

Around 4 billion years ago, Earth was an inhospitable place, devoid of oxygen, bursting with volcanic eruptions, and bombarded by asteroids, with no signs of life in even the simplest forms. But somewhere amid this chaotic period, the chemistry of the Earth turned in life’s favor, giving rise, however improbably, to the planet’s very first organisms.

What prompted this critical turning point? This is just one of the questions researchers have puzzled over in trying to piece together the origins of life on Earth.

Planetary scientists from MIT and the Harvard-Smithsonian Center for Astrophysics have found that a class of molecules called sulfidic anions may have been abundant in Earth’s lakes and rivers when the first organisms appeared on Earth. They calculate that, around 3.9 billion years ago, erupting volcanoes emitted huge quantities of sulfur dioxide into the atmosphere, which eventually settled and dissolved in water as sulfidic anions.

Preliminary work by postdoc Sukrit Ranjan and his collaborators suggest that sulfidic anions would have sped up the chemical reactions required to convert very simple prebiotic molecules into RNA, a genetic building block of life.

Ranjan and his colleagues published their results in the journal Astrobiology. https://bit.ly/2EUi5bf

Physicists discover new quantum electronic material

A motif of Japanese basketweaving known as the kagome pattern has preoccupied physicists for decades. Kagome baskets are typically made from strips of bamboo woven into a highly symmetrical pattern of interlaced, corner-sharing triangles.

In a paper published in Nature, physicists from MIT, Harvard University, and Lawrence Berkeley National Laboratory report that they have for the first time produced a kagome metal—an electrically conducting crystal, made from layers of iron and tin atoms, with each atomic layer arranged in the repeating pattern of a kagome lattice.

When they flowed a current across the kagome layers within the crystal, the researchers observed that the triangular arrangement of atoms induced strange, quantum-like behaviors in the passing current. Instead of flowing straight through the lattice, electrons instead veered, or bent back within the lattice. This behavior is a three-dimensional cousin of the Quantum Hall effect, in which electrons flowing through a two-dimensional material will exhibit a “chiral, topological state,” in which they bend into tight, circular paths and flow along edges without losing energy.

The team was led by assistant professors Joseph Checkelsky and Riccardo Comin, graduate students Linda Ye and Min Gu Kang in collaboration with associate professor Liang Fu, and postdoc Junwei Liu. https://bit.ly/2pqDfc3
Nonprofit Organizations Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2014–2018

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus research</td>
<td>72,117,488</td>
<td>78,666,639</td>
<td>84,015,000</td>
<td>86,752,718</td>
<td>94,322,337</td>
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<tr>
<td>Constant dollars*</td>
<td>76,156,756</td>
<td>82,472,340</td>
<td>87,488,489</td>
<td>88,707,643</td>
<td>94,322,337</td>
</tr>
</tbody>
</table>

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 2018
(Shown in descending order of expenditures)

Koch Institute for Integrative Cancer Research
Economics
Computer Science and Artificial Intelligence Laboratory
Civil and Environmental Engineering
McGovern Institute for Brain Research
Earth, Atmospheric and Planetary Sciences
Media Laboratory
Research Laboratory of Electronics
Mechanical Engineering
Materials Research Laboratory
Section 5
Lincoln Laboratory

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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.

Since its establishment in 1951, MIT Lincoln Laboratory’s mission has been to apply technology to problems of national security. The Laboratory’s technology development is focused on its primary mission areas—space control; air and missile defense technology; communication systems; cyber security and information sciences; intelligence, surveillance, and reconnaissance systems and technology; advanced technologies; tactical systems; and homeland protection. In addition, Lincoln Laboratory undertakes government-sponsored, nondefense projects in areas such as air traffic control and weather surveillance.

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

MIT Lincoln Laboratory also emphasizes meeting the government’s FFRDC goals of maintaining long-term competency, retaining high-quality staff, providing independent perspective on critical issues, sustaining strategic sponsor relationships, and developing technology for both long-term interests and short-term, high-priority needs. The Laboratory supported approximately 680 sponsored programs for national security.

A few of the highlights are included below.

• The Laboratory demonstrated a coordinated autonomous formation of more than 100 miniature UAVs after they were dispensed from three F/A-18 Super Hornets.

• The Multi-look Airborne Collector for Human Encampment and Terrain Extraction (MACHETE) 3D ladar completed numerous real-world, operational sorties. It collects data on activities under heavy foliage, exploiting new noise-filtering and data-aggregation algorithms to produce imagery with dramatically improved resolution.

• A beam-combined fiber laser system demonstrated record brightness. The coherently combined beam was generated from 10s of optical fiber amplifiers and had near-ideal beam quality and high beam-combining efficiency.

• Advanced technologies were prototyped for a new airborne signals intelligence system that is currently being transferred to an industrial partner for production and fielding.

• The Laboratory completed the integration and test of a prototype compact airborne laser communications terminal that supports robust spatial tracking and near-theoretical communications performance against a low-average-power burst-mode signal.

• Automated video analysis software developed for site security significantly accelerates the process of extracting information from video streams.

• The Laboratory developed advanced graph analytics algorithms to rapidly detect cyber threat actors within communication networks.

• The Laboratory fabricated, integrated, and tested the detector arrays and optical subsystem for the science payload that will be carried on the Transiting Exoplanet Survey Satellite on a mission to discover exoplanets. The payload was jointly developed by the MIT Kavli Institute for Astrophysics and Space Research and the Laboratory under funding from NASA.
Breakdown of Laboratory Program Funding

Total Funding FY2017* = $1,015.3 million

Sponsor

- Air Force: 26%
- Special: 18%
- Non-DoD: 13%
- Other DoD: 14%
- DARPA: 3%
- MDA: 7%
- Army: 4%
- Navy: 7%
- OSD Non-Line: 4%
- ASD Line: 4%
- Special: 18%

Mission Area

- Communication Systems: 20%
- Advanced Technology Portfolio: 11%
- Tactical Systems: 11%
- Advanced Research Portfolio: 4%
- Homeland Protection: 6%
- Aviation Research—FAA: 4%
- Ballistic Missile Defense: 7%
- Air Defense: 7%
- Cyber Security: 7%
- ISR Systems and Technology: 6%
- Space Control: 17%
- Aviation Research—FAA: 4%

Total Funding
Fiscal Years 2013–2017*

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Authorized Funding in Millions</th>
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</thead>
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<tr>
<td>2013</td>
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<tr>
<td>2014</td>
<td>719.3</td>
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<tr>
<td>2015</td>
<td>851.3</td>
</tr>
<tr>
<td>2016</td>
<td>842.8</td>
</tr>
<tr>
<td>2017</td>
<td>881.0</td>
</tr>
<tr>
<td>2018</td>
<td>886.9</td>
</tr>
</tbody>
</table>

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

DARPA: Defense Advanced Research Projects Agency
MDA: Missile Defense Agency
ASD: Assistant Secretary of Defense
OSD: Office of the Secretary of Defense
DoD: Department of Defense
**Major Programs/Prototypes**

**Space Surveillance Telescope**
Lincoln Laboratory’s Near-Earth Asteroid Research (LINEAR) program supports NASA in fulfilling Congressional mandates to find and catalog by 2020 90% of near-Earth objects that have a diameter of 140 m or greater. In 15 years of operations, two 1 m ground-based electro-optical telescopes at White Sands Missile Range in New Mexico discovered 231,082 objects. Since January 2014, the LINEAR program has reported more than nine million observations of asteroids and comets. The surge in observations is due to the Space Surveillance Telescope (SST)—a highly capable telescope whose innovative curved focal plane enables deep, wide-area searches of the night sky. It detects small objects in geosynchronous orbits and achieves highly sensitive, rapid, wide-area sky surveys. The submission of 7.2 million observations in 2015 made the SST the most productive asteroid search instrument ever in terms of number of observations by a search program in a single calendar year. Since 2014, the SST has found 4,548 new objects, including four potentially hazardous objects and three new comets.

**Localizing Ground-Penetrating Radar**
Lincoln Laboratory has demonstrated the use of a novel subsurface map-based registration that offers the potential for low sensitivity to the limitations (snow, heavy rain, fog, or dirt) that cause optical sensors to fail to localize autonomous ground vehicles (AGVs) and perform accurate lane keeping. This technique, Localizing Ground-Penetrating Radar (LGPR), uses a new class of GPR technology to profile the environment below the road. The LGPR captures features such as soil layering and deeply buried rocks that are inherently static. From the underground features, the LGPR develops a map of the road’s subsurface that is used as a reference for estimating an AGV’s location on the road. In addition, VHF radio waves can penetrate through rain, fog, soil, dust, and snow. Because the LGPR deduces location on the basis of underground features, it can operate under conditions that incapacitate optical or infrared localization sensors, providing position estimates even if the AGV encounters severe weather, obscured or unpaved roads, disrupted or altered roads, or GPS-denied areas.
Major Technology Transfers

Cyber Security and Information Sciences
The Lincoln Adaptable Real-Time Information Assurance Testbed (LARIAT) was transitioned to a commercial startup company. Lincoln Laboratory’s Secure High-Assurance Micro Crypto and Key-management (SHAMROCK) processor was transferred to a commercial partner in support of a USAF effort to develop foundations for agile and resilient embedded systems.

Intelligence, Surveillance, and Reconnaissance Systems and Technology
Open architecture technologies based on prototypes developed over the past several years for the USAF Distributed Common Ground System were transitioned to AFRL’s Information Directorate.

Air, Missile, and Maritime Defense Technology
To support the MDA’s initiative to improve homeland defense capabilities, the Laboratory is developing prototype flight articles that can be used to test the Ballistic Missile Defense System. The Laboratory successfully built and flight-tested prototype hardware; these designs are being transferred to industry for production and deployment on future flight tests. Several efforts for the U.S. Navy are focused on electronic countermeasures to defend ships against advanced antiship missile threats. A prototype for an advanced offboard countermeasure for ship-based defense has been completed, and technology from that prototype has been transitioned to the Navy.

Communication Systems
The fifth-generation advanced training waveform specifications, models, and the prototype implementation were transferred to defense industry participants in the USAF’s Live, Virtual, and Constructive Advanced Technology Demonstration program. Lincoln Laboratory has transferred modem and optical terminal technology that will support the development of terminals for NASA’s Laser Communications Relay Demonstration. The Laboratory worked with multiple industry vendors to validate subsystems that NASA will use for the terminals.
Lincoln Laboratory Mission Areas

Air and Missile Defense Technology
Lincoln Laboratory develops and assesses integrated systems for defense against ballistic missiles, cruise missiles, and air and maritime platforms in tactical, regional, and homeland defense applications. Activities in this mission area include the investigation of system architectures, development of advanced sensor and decision support technologies, development of pathfinder prototype systems, extensive field measurements and data analysis, and the verification and assessment of deployed system capabilities. A strong emphasis is on developing innovative solutions, maturing technologies, rapidly prototyping systems, and transitioning new capabilities for operational systems to the government and government contractors.

Communication Systems
Lincoln Laboratory is working to enhance and protect the capabilities of the nation’s global defense networks. Emphasis is placed on synthesizing communication system architectures, developing component technologies, building and demonstrating end-to-end system prototypes, and then transferring this technology to industry for deployment in operational systems. Current efforts focus on radio-frequency (RF) military satellite communications, free-space laser communications, tactical network radios, quantum systems, and spectrum operations.

Cyber Security and Information Sciences
Lincoln Laboratory conducts research, development, evaluation, and deployment of cyber-resilient components and systems designed to ensure that national security missions can be accomplished successfully despite cyber attacks. Work in cyber security includes research; cyber analysis; architecture engineering; development and assessment of prototypes that demonstrate the practicality and value of new cyber protection, detection, and reaction techniques; and, where appropriate, deployment of prototype technology into operations. The Laboratory plays a major role in the design, development, and operation of large-scale cyber ranges and cyber exercises. In addition, the Laboratory develops advanced hardware, software, and algorithms for processing large, high-dimensional datasets from a wide range of sources, including speech, imagery, text, and network traffic. To facilitate this development, researchers employ high-performance computing architectures, machine learning for advanced analytics, and relevant metrics and realistic datasets.

Intelligence, Surveillance, and Reconnaissance Systems and Technology
To expand intelligence, surveillance, and reconnaissance (ISR) capabilities, Lincoln Laboratory conducts research and development in advanced sensing, signal and image processing, automatic target classification, decision support, and high-performance computing. By leveraging these disciplines, the Laboratory produces novel ISR system concepts for surface and airborne applications. Sensor technology for ISR includes passive and active electro-optical systems, surface surveillance radar, and RF geolocation. Increasingly, the work extends from sensors and sensor platforms to include the processing, exploitation, and dissemination technologies that transform sensor data into the information and situational awareness needed by operational users. Prototype ISR systems developed from successful concepts are then demonstrated and transitioned to industry and the user community.

Tactical Systems
Lincoln Laboratory assists the DoD in improving the development of various tactical air and counterterrorism systems through a range of activities that includes systems analysis to assess technology impact on operationally relevant scenarios, detailed and realistic instrumented tests, and rapid prototype development of U.S. and representative threat systems. A tight coupling between the Laboratory’s efforts and DoD sponsors and warfighters ensures that these analyses and prototype systems are relevant and beneficial to the warfighter.
Space Control
Lincoln Laboratory develops technology that enables the nation to meet the challenges of an increasingly congested and contested space domain. The Laboratory develops and utilizes systems to detect, track, identify, characterize, and assess the growing population of resident space objects, and investigates technologies to improve monitoring of the space environment. Given the emerging potential for conventional conflict to extend to space, the Laboratory is examining space mission resilience to determine critical services and is assessing the impact of potential threats. The Laboratory is proposing alternative disaggregated architectures and prototyping advanced sensors and systems.

Advanced Technology
The Advanced Technology mission supports national security by identifying new phenomenology that can be exploited in novel system applications and by then developing revolutionary advances in subsystem and component technologies that enable key, new system capabilities. These goals are accomplished by a community of dedicated employees with deep technical expertise, collectively knowledgeable across a wide range of relevant disciplines and working in unique, world-class facilities. This highly multidisciplinary work leverages solid-state electronic and electro-optical technologies, innovative chemistry, materials science, advanced RF technology, and quantum information science.

Homeland Protection
The Homeland Protection mission supports the nation’s security by innovating 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 either man-made or natural disasters. The broad sponsorship for the mission area spans the DoD, the Department of Homeland Security, and federal, state, and local entities. Recent efforts include humanitarian assistance and disaster response architectures and technologies, new microfluidic technologies for DNA assembly and transformation and for gene synthesis, improvement of the detection and classification for air vehicle threats, and technologies for border and maritime security.

Aviation Research
Since 1971, Lincoln Laboratory has supported the FAA in the development of new technology for air traffic control. This work initially focused on aircraft surveillance and weather sensing, collision avoidance, and air-ground data link communication. The program has evolved to include safety applications, decision support services, and air traffic management automation tools. The current program is supporting the FAA’s Next Generation Air Transportation System (NextGen). Key activities include development of the next-generation airborne collision avoidance system; refinement and technology transfer of NextGen weather architectures, including cloud processing and net-centric data distribution; and development of standards and technology supporting unmanned aerial systems’ integration into civil airspace.

Advanced Research Portfolio
Internal research and development at Lincoln Laboratory is supported through congressionally appropriated funding, known as the Line, administered by the office of the Assistant Secretary of Defense for Research and Engineering. 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.

The projects supported by the Line are organized according to technology categories that have been selected to address gaps in existing and envisioned mission areas. Nine technology categories were selected to include both core and emerging technology initiatives. There are currently five core-technology areas in the Advanced Research Portfolio: advanced devices; optical systems and technology; information, computation and exploitation; RF systems and technology; and cyber security. In addition, there are four emerging-technology initiatives: novel and engineered materials, quantum system sciences, biomedical sciences, and autonomous systems.
Lincoln Laboratory Technical Staff

Lincoln Laboratory employs 1,823 technical staff, 544 technical support personnel, 1,168 support personnel, and 516 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.

Lincoln Laboratory recruits at more than 60 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.

Composition of Professional Technical Staff

Academic Disciplines of Staff

- Electrical Engineering: 33%
- Computer Science, Computer Engineering, Computer Information Systems: 16%
- Physics: 16%
- Biology, Chemistry, Meteorology, Materials Science: 11%
- Mechanical Engineering: 8%
- Mathematics: 6%
- Mechanical Engineering: 8%
- Aerospace/Astronautics: 5%
- Other: 5%

Academic Degrees Held by Staff

- Doctorate: 42%
- Bachelor’s: 20%
- Master’s: 16%
- No Degree: 2%
Lincoln Laboratory’s Economic Impact

During fiscal year 2017, the Laboratory issued subcontracts with a value of approximately $522 million. The Laboratory awarded subcontracts to businesses in all 50 states. Massachusetts businesses were awarded $203 million in contracts, and states as distant as Colorado and Arizona also realized significant benefits to their economies.

Contracted Services (FY2017)*

*Estimates from $522.2M, total FY2017 spend.
• Includes orders to MIT ($32.2M)
• 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 2016. Lincoln Laboratory expanded the number of noncredit courses organized and led by its technical staff members to eight activities. 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 2016, eight undergraduates were hired as UROP interns and four 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 an engine for innovative research and a mechanism for expanding project-based learning opportunities for students. By leveraging the expertise of MIT faculty, researchers, and Lincoln Laboratory staff, 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 tools and 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 local K–12 schoolchildren. In 2016, nine groups were involved in different science, technology, engineering, and mathematics (STEM) programs held at the center, including a build-a-radar workshop directed by instructors from the Lincoln Laboratory; weekly practices for the Lincoln Laboratory teams that participate in the national CyberPatriot computer-network security challenges; and an ongoing mentorship program with the Community Charter School of Cambridge.
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 Facility houses several Lincoln Laboratory–operated aircraft used for rapid prototyping of airborne sensors and communications.

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.

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.

Other Sites
Other sites include the Pacific Missile Range Facility in Kauai, Hawaii and the Experimental Test Site in Socorro, New Mexico.
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 of our most successful programs are listed below.

**LLRISE**
Nine technical staff members taught various portions of the sixth 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 computer-aided design, 3D printing, circuit board assembly, electromagnetics, pulse compression, signal processing, antennas, and MATLAB, electronics.

**LLCipher**
Lincoln Laboratory’s one-week workshop, LLCipher provides an introduction for high-school students to modern cryptography—a math-based, theoretical approach to securing data. Lessons in abstract algebra, number theory, and complexity theory provided students with the foundational knowledge needed to understand theoretical cryptography.

**CyberPatriot**
Lincoln Laboratory sponsored three teams in CyberPatriot, a national competition for high-school students learning defensive computer security. The students were mentored by Laboratory staff. After learning how to identify malware, “clean” a computer system, and establish a secure network, the teams competed in the statewide competition. One team advanced to the Northeast regional competition.

Lincoln Laboratory Outreach in 2016
Section 6
MIT and Industry

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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.


- Over 700 companies provided R&D/gift support to MIT; 40 companies funded $1 million+, 219 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.

Formal collaboration between MIT and industry is often coordinated between three offices:

- **Corporate Relations (CR)** — early in the engagement cycle, explores mutual interests and opportunities between researchers/principal investigators (PIs) and corporations worldwide

- **Office of Sponsored Programs (OSP)** — negotiates and establishes the terms and structure of the collaboration.

- **Technology Licensing Office (TLO)** — manages any intellectual property (IP) that may result from the collaboration.

Below is a table that summarizes activities involved in the engagement lifecycle of sponsored research at MIT, separated by office responsibility.

### ENGAGEMENT LIFECYCLE

<table>
<thead>
<tr>
<th><strong>CR</strong></th>
<th><strong>OSP</strong></th>
<th><strong>TLO</strong></th>
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<tbody>
<tr>
<td><strong>EXPLORATION</strong></td>
<td><strong>NEGOTIATION</strong></td>
<td><strong>IP MANAGEMENT/COMMERCIALIZATION</strong></td>
</tr>
<tr>
<td>MIT Industrial Liaison Program</td>
<td>Project Management</td>
<td>Benefits of Collaboration</td>
</tr>
<tr>
<td>MIT Startup Exchange</td>
<td>Proposals</td>
<td>IP Protection</td>
</tr>
<tr>
<td>Developing relationships with PIs</td>
<td>Negotiation</td>
<td>IP Licensing</td>
</tr>
<tr>
<td>Finding Convergence/Overlap of Scientific Interests</td>
<td>Award Set-up</td>
<td>New Ventures/Startups</td>
</tr>
<tr>
<td>Engagement Management</td>
<td>Subaward Issuance &amp; management</td>
<td></td>
</tr>
<tr>
<td>Philanthropic Opportunities</td>
<td>Award Management &amp; Closeout</td>
<td></td>
</tr>
<tr>
<td>Provost</td>
<td>Cost Analyses &amp; Audit</td>
<td></td>
</tr>
<tr>
<td>Departments, Labs, Centers</td>
<td>Conflict of Interest Management</td>
<td></td>
</tr>
<tr>
<td>Educational Opportunities</td>
<td></td>
<td></td>
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<tr>
<td>Recruiting</td>
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</tbody>
</table>
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 230 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-world 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.

ExxonMobil
 In 2014, ExxonMobil became a founding member of the MIT Energy Initiative (MITEI), and currently collaborates on a wide range of projects, including research to improve and expand renewable energy sources and find more efficient ways to produce and use conventional hydrocarbon resources.

Novartis
 The Novartis-MIT Center for Continuous Manufacturing combines the industrial expertise of Novartis with MIT’s leadership in scientific and technological innovation. The center works to develop new technologies that could replace the conventional batch-based system in the pharmaceuticals industry with continuous manufacturing processes from start to finish.

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.

Tata
 The Tata Center brings together technical, pedagogical, and organizational expertise from across MIT to provide holistic support to more than 40 projects in the developing world, focused on agriculture, energy, environment, health, urbanization, and water.
Selected Projects funded by Industry

**Offshore Nuclear Power Plants**
Driven by a desire to decarbonize the economy, Jacopo Buongiorno, director for MIT’s Center of Advanced Nuclear Energy Systems, is taking a fresh look at nuclear power with the Offshore Nuclear Power Plant. The floating design eliminates earthquakes as accident initiators, and a cylindrical hull design and robust mooring system eliminates excessive motion during severe storms. The offshore concept also provides passive cooling to the reactor indefinitely and can use ocean water as an infinite heat sink, providing emergency cooling to the reactor. http://bit.ly/2wufiX5

**Taming the Wild West of the Internet of Things**
Building on the success of the MIT’s Auto ID Center which helped standardize RFID technology, Sanjay Sarma is now taking on the Internet of Things, a network of objects embedded in intelligence that interacts with the environment. While the Internet of Things offers the promise of efficiently marshalling the planet’s resources, it carries the risk of interference from malicious third parties. Sarma’s research is focused on developing and promoting an agreed-upon architecture with easy-to-understand methods. Sarma maintains that in a system of orderliness, safeguards and security can be built in, and that remnants of disorderliness will stand out and be detected. http://ilp.mit.edu/newsstory.jsp?id=21289

**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. http://bit.ly/2xbMO3O

**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. http://bit.ly/2jFdTqv

**Enabling Safe, Sustainable, and Equitable Mobility**
MIT Spinoff Optimus Ride leverages the latest advances in complex sensor fusion, computer vision, and machine learning to develop autonomous vehicle systems focused on transporting people and goods safely and efficiently. Its founding team—coming from the Media Lab, CSAI, Aeronautics, and Sloan—hope to usher in a transportation revolution, drawing on their 30 years of interdisciplinary university research in self-driving technologies, electric vehicles, and Mobility-on-Demand Systems. The Optimus Ride team is taking on an array of challenges from developing scalable business models to urban architecture, with a goal of providing efficient solutions, adaptable at a relatively low cost to any urban environment. http://bit.ly/2w5OgAO
Campus Research Sponsored by Industry

Industry Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2014–2018

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus research</td>
<td>112,379,455</td>
<td>119,238,077</td>
<td>128,308,988</td>
<td>132,914,760</td>
<td>144,126,295</td>
</tr>
<tr>
<td>Constant dollars*</td>
<td>118,673,777</td>
<td>125,006,527</td>
<td>133,613,753</td>
<td>135,909,921</td>
<td>144,126,295</td>
</tr>
</tbody>
</table>

*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2018 equaling 100.

Technology Licensing Office Statistics for FY2017

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of invention disclosures:</td>
<td>794</td>
</tr>
<tr>
<td>Number of U.S. new utility patent applications filed:</td>
<td>399</td>
</tr>
<tr>
<td>Number of U.S. patents issued:</td>
<td>279</td>
</tr>
<tr>
<td>Number of licenses granted (not including trademarks and end-use software):</td>
<td>101</td>
</tr>
<tr>
<td>Number of options granted (not including options as part of research agreements):</td>
<td>36</td>
</tr>
<tr>
<td>Number of software end-use licenses granted:</td>
<td>38</td>
</tr>
<tr>
<td>Number of companies started (number of new license or option agreement to MIT technologies that serve as the foundation for a start-up company):</td>
<td>25</td>
</tr>
</tbody>
</table>
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 proprietary database of over 1,500 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 & 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

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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. Digital learning programs are expanding the Institute’s global reach. At home, MIT hosts many international students and scholars, and offers cultural and historical education and language training for MIT students preparing to go overseas. The following are some of MIT’s many international activities.

A Global Strategy for MIT

A Global Strategy for MIT was published by the Associate Provost for International Activities in May 2017. This plan addresses three important questions for MIT over the coming decade:

- How can our international activities best contribute to advancing the frontiers of knowledge in science, technology, and other areas of scholarship?

- How can they help bring forefront knowledge to bear on solving the world’s most challenging problems?

- How can they contribute to educating future leaders who will work creatively, cooperatively, effectively, and wisely for the betterment of humankind?

The 2017 Global Strategy for MIT stated as one of its eight core principles, “MIT is an American institution. When members of the MIT community operate internationally they must be in compliance with relevant U.S. laws and regulations, and when MIT considers major new international engagements it must be cognizant of the national interest.”

Individual faculty members initiate and implement most of MIT’s international activities. The role of the MIT administration is to encourage and support these activities and to safeguard faculty members’ freedom to pursue them. In addition, MIT sometimes seeks to act internationally on a larger scale.

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 calls for MIT to:


2. Commit to providing an MIT-quality international educational experience to every undergraduate who desires one.

3. Streamline our approach to international institution- and capacity-building.

4. Explore the feasibility of a new MIT Global Leaders graduate program.

5. Review the cap on international undergraduate admissions.

6. Strengthen the governance of MIT’s international activities.

7. Improve operational support.

The plan also considers whether MIT can pursue its global goals and aspirations successfully in the present international environment. 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 proposes several mitigating measures to help protect MIT against new risks in the international arena.

See http://web.mit.edu/globalstrategy/ for full report.
Capacity Building

Asian School of Business, Malaysia
In 2016, a collaboration of MIT Sloan with the Bank Negara Malaysia established the Asia School of Business (ASB). The ASB will take a practice-oriented approach to management, which is one of the hallmarks of MIT Sloan and reflects the central bank’s desire for education for practical application. The vision of ASB is to be a global knowledge and learning center infused with regional expertise, insights and perspectives of Asian and emerging market economies.

Dubai Institute for Design and Innovation, United Arab Emirates
The MIT School of Architecture and Planning (SA+P) is collaborating 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—will help 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.

Set to open in Fall 2018 as a private, nonprofit education institution that will be accredited by the Dubai Ministry of Higher Education, DIDI will offer the region’s first-ever Bachelor of Design degree with concentrations in Product Design, Strategic Design Management, Media, Visual Art, and Fashion Design.

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 centre outside of Cambridge, Massachusetts, and its largest international research endeavor. See page 115 for information on Singapore-MIT Undergraduate Research Fellowships.

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, focused on a small number of pressing global issues and designed to stimulate the development of a robust innovation ecosystem in Russia. The first phase of this joint effort between MIT, Skoltech, and the Skolkovo Foundation (the MIT Skoltech Initiative) comprised a wide span of agreed activities leading to the launch and early growth of Skoltech. This phase of the collaboration ended in February 2016 and the second phase of the MIT-Skoltech relationship, known as the MIT Skoltech Program, began immediately thereafter.

In this second phase, the MIT Skoltech Program is oriented around a narrower set of collaborative activities to promote the continued development of Skoltech and the Skolkovo ecosystem. The Program features a focused set of core research and advisory activities, including an MIT faculty advisory committee, a joint annual conference and multiple collaborative research projects, such as the Next Generation Program and Seed research funds, as well as two Centers for Research, Education, and Innovation (CREIs) that continued from the first phase. There is also the flexibility to initiate additional collaborative projects that faculty from MIT and Skoltech will work on together, building on existing strengths and mutual interest.

http://skoltech.mit.edu/
Tata Center for Technology and Design, India
The MIT Tata Center for Technology and Design, founded in 2012, provides comprehensive support to MIT faculty members who apply their skills and knowledge to the pressing challenges in India and the rest of the developing world. Some 40 faculty members from all five Schools have participated, along with over 100 Tata Fellows enrolled in Master’s and PhD programs across the Institute. Their projects address large-scale opportunities for social impact using science, technology, and policy. Tata Center researchers travel to India at least twice a year to gather data, conduct field trials, and engage with communities to understand their needs and discover opportunities. Researchers work closely with on-the-ground collaborators in the corporate, nonprofit, and government spheres.

The Tata Center’s project portfolio has continued to grow with several promising projects transitioning to the implementation stage through products and government programs. One project, led by Professor Kripa Varanasi, uses electrical fields to recapture up to 80% of water vapor plumes that would normally escape from cooling towers of power plants. Varanasi’s team is now doing an industrial pilot test and plans to launch a spinoff soon so that they can expand into not only the power industry, but also commercial HVAC, large data centers, hospitals, and large industrial facilities. Another project led by Professor Alan Hatton is tackling child malnutrition in India, which affects an estimate of 8 million children in India alone, and 20 million children per year worldwide—with a fatality rate as high as 30%. Hatton and Tata Fellow Tonghan Gu are using local ingredients to adapt a ready-to-use therapeutic food (RUTF) to cater to the palette of Indian children, who do not like the taste of the conventional RUTF made with peanut butter. In addition, Tata Center alumni Katie Taylor and Victor Lesniewski have established Khethworks, a startup company that hopes to make low-cost solar pumping systems available to millions of Indian smallholder farmers. They plan to ship their first commercial products next spring, after an extensive period of field-testing.

http://tatacenter.mit.edu/

Faculty and Research Collaboration
Accelerating Innovation in Brazil
The MIT Industrial Performance Center (IPC) is engaged in a five-year research project focused on building greater innovation capacity in Brazil. At the center of the research is a new network of Institutes of Innovation created by SENAI, Brazil’s National Service for Industrial Training. Building upon the German Fraunhofer model, SENAI (the research sponsor) is creating a network of 25 Innovation Institutes (ISIs), each of which specializes in a particular technology or group of technologies associated with one or several industries in which Brazil has existing capabilities. IPC research examines the ISIs and the role of SENAI within the broader Brazilian innovation ecosystem while also addressing a range of issues of importance to building stronger innovation capacity in the country. Topics include assessments of how Brazilian industries fit into global value chains, institutional innovations in Brazil, the role of universities, and the role of the state. The project will run through the Spring of 2019.

CSAIL-Qatar Computing Research Institute, Qatar
The CSAIL-Qatar Computing Research Institute (QCRI) research collaboration is a medium for knowledge joint-creation, transfer, and exchange of expertise between MIT-CSAIL and QCRI scientists. Scientists from both organizations are undertaking a variety of core computer science research projects—Arabic speech and language processing, content-adaptive video re-targeting, database management, understanding health habits from social media pictures, understanding and developing for cultural identities across platforms, a vertically-integrated approach to resource-efficient shared computing, urban data analytics to improve mobility for growing cities in the context of mega events and accurate map making with mobile sensor data—with the goal of developing innovative solutions that can have a broad and meaningful impact. The agreement also offers CSAIL researchers and students exposure to the unique challenges in the Gulf region. Scientists at QCRI are benefiting from the expertise of MIT’s faculty and researchers through joint research projects that will enable QCRI to realize its vision to become a premier center of computing research regionally and internationally.
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, under the leadership of 7 faculty members.

MIT leads another effort that is based at CERN, although the detector is located on the International Space Station. The Alpha Magnetic Spectrometer (AMS) experiment is under the direction of 2 MIT faculty members. The 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. This includes undergraduate and graduate students, postdoctoral associates, senior/principal/research scientists and engineers, and staff scientists and administrators. Each year, a number of MIT undergraduates participate in research at CERN through the MISTI and IROP programs.

Hong Kong Innovation Node, Hong Kong
The creation of MIT’s Hong Kong Innovation Node was announced in November 2015. The focus of the Node is 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—working together with alumni, affiliates and friends in the Hong Kong community to help strengthen the region’s innovation ecosystem. By bringing MIT to Hong Kong and Hong Kong to MIT, the Innovation Node is deepening MIT’s links to Hong Kong, Shenzhen and China’s Pearl River Delta.

The Hong Kong Innovation Node 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. Twice a year the Node’s flagship program, MEMSI (MIT Entrepreneurship and Maker Skills Integrator) brings 15 MIT students together with 15 local Hong Kong university students for 2 intense and immersive weeks in Hong Kong. MEMSI combines lectures drawn from Martin Trust Center’s Disciplined Entrepreneurship Program with hands-on maker skills and visits to manufacturing facilities in China. The Node has created an engaging physical space for collaboration, connection and making in Kowloon Tong. The new space is enabling MIT students, faculty, and alumni to connect with local universities, entrepreneurs, and companies.
MIT and the Instituto Tecnológico de Monterrey, Mexico

Launched in 2015, this partnership between MIT and the Instituto Tecnológico de Monterrey is designed to foster exchanges and collaborations among researchers at both institutions, with an initial focus on nanotechnology and nanoscience. The program was funded by a gift from the family of Eugenio Garza Sada, founder of Tec de Monterrey, on the occasion of the 100th anniversary of his graduation from MIT Sloan School. The program is housed at MIT’s Microsystems Technology Laboratories (MTL).

A key element of the Tec de Monterrey and MIT Nanotechnology Program is the creation of opportunities for students, postdocs and professors from Monterrey Tec to carry out extended research stays at MIT in areas of nanoscience and nanotechnology. In its second year, one faculty member, two postdoctoral researchers, three graduate students and one undergraduate student spent time at MIT working with MIT faculty in areas of biotechnology, microfluidics and nanofabrication. For the third cohort, one faculty member, six postdocs, and one graduate student have been selected to participate in a wide range of research activities in visits that will span between 4 and 10 months.

The program also includes participation of MIT faculty, postdocs and students in MTL’s nanoLab course that provides a hands-on introduction to nanotechnology. To date, 70 Tec members have attended this course. In addition, the program fosters technical visits by MIT faculty to the Tec. In June 2016, an MIT Day at the Tec brought 11 MIT graduate students, postdocs and faculty for a day long workshop on Sensors and Actuators.

Yearly meetings of an Advisory Committee composed of two Tec faculty members and two MIT faculty members take place to review progress in the program, chart future activities and report to the MIT Provost.

MIT Portugal Program, Portugal

The MIT Portugal Program (MPP) is a strategic partnership between Portuguese universities and research centers, MIT, and the Portuguese government. Launched in 2006 and renewed in 2013, MPP’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) and by industrial partners. The first program phase focused on the internationalization of Portuguese universities in the areas of Bioengineering, Engineering Design and Advanced Manufacturing, Sustainable Energy, and Transportation. MPP’s programs have enabled Portuguese universities to overcome patterns of isolation by encouraging inter-university cooperation through joint partnerships with MIT, facilitating a build-up of critical mass in priority areas. MPP has also contributed to the strengthening of innovation and entrepreneurship at Portuguese universities, through entrepreneurial education. MPP’s second phase focuses on extending the gains of Phase 1, including the promotion of an education and research ecosystem connected to trans-disciplinary innovation and entrepreneurship, and close collaborations between universities and industry. As of June 2017, almost 500 of the 1,100 MPP students have graduated in Portugal. MPP has supported 250 MIT visits of its students and scholars, and has involved 270 faculty in Portugal as well as 80 faculty and 30 staff at MIT. MPP is widely recognized as a model for international alliances involving universities, industry, and governmental agencies, that focus on knowledge creation, innovation, and entrepreneurship to increase the international competitiveness of the sponsoring country.

http://www.mitportugal.org/
Global Engagement

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 that are critical to the School’s high-level goals: Knowledge Creation; Regional Awareness; Admissions; Action Learning; and Strengthen the Alumni Network. The office encourages and supports research, teaching, and knowledge-sharing opportunities for MIT Sloan and MIT faculty. The office has focused its efforts in three main themes that are relevant to the region and where MIT can assist in solving some of Latin America’s greatest challenges: 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.

For more information about the office: http://mitsloan.mit.edu/office-of-international-programs/mit-sloan-latin-america-office/

Multi-Scale Materials Science for Energy and Environment, France
The joint CNRS-MIT unit, UMI <MSE>2 (Multi-Scale Materials Science for Energy and Environment) was opened in Summer 2012. The CNRS-MIT UMI is hosted at MIT by MITEI. Under the leadership of Roland Pellenq (CNRS Director of Research (DR1) and MIT-CEE Senior Research Scientist) and Franz-Josef Ulm (CEE-MIT Professor), the UMI has emerged as an active research center fully integrated into the research and educational fabric of MIT. As of today, the UMI has 4 senior CNRS researchers and about 10 postdocs and students working with MIT faculty from various departments on projects related to the fundamental physics of materials for energy and the environment including cement sciences, shale gas, nuclear waste and urban physics. In the 2012–2016 period, UMI was supported through the Laboratory of Excellence ICoME2 grant as part of the French National Research Strategy. UMI senior researchers have co-Pi status at MIT and can apply for U.S. funds jointly with MIT faculty through MIT. Conversely, MIT faculty can apply with UMI researchers for grants from ANR and Europe as co-Pis through CNRS. In September 2016, the UMI contract was renewed with Aix-Marseille University (AMU) as a UMI co-sponsor. The CNRS-AMU CINaM laboratory (Centre Interdisciplinaire des Nanosciences de Marseille) is now the official mirror unit of the UMI in France. The interactions between the UMI and CINaM are being strengthened through research programs such the MITEI/FASTER-Shale program sponsored by TOTAL.

Thanks to this first-of-a-kind institutional agreement, the UMI has become an integral part of the intellectual research and educational environment of MIT and beyond. On the MIT campus, the UMI plays a critical role in MIT’s ability to respond to the research challenges in the field of materials science and engineering for complex systems. On the educational side, the affiliation of UMI researchers as “Visiting Professors” allows the integration into the educational landscape of MIT. With AMU, UMI also organizes, the Marseille Winter School (MWS) on the science and engineering of multi-scale porous materials. MWS is now part of the MIT-IAP program.

UMI also leads a focused international research network of universities and research centers in the U.S. and Europe, dedicated to “Multiscale Materials Under the Nanoscope” (incl. Georgetown, NIST, Princeton, UC-Berkeley, UC-Irvine, UC-LA, Cambridge U., Newcastle, San Sebastian, Bilbao and 12 CNRS labs). UMI has become an important point of contact for large French industrial corporations (Total...); as well as a close partner for the MIT-France program.

http://umi.mit.edu/
Other International Initiatives

China Leaders for Global Operations, China
The China Leaders for Global Operations (CLGO) program was started in 2005 as a collaboration of MIT and the Shanghai Jiao Tong University (SJTU). The program was launched at the request of LGO industry partners to strengthen LGO global content for faculty and students, help partner companies’ operations in China, and promote global manufacturing. CLGO offers China’s only dual-degree, graduate-level academic program. The CLGO program is jointly offered by SJTU’s two engineering schools, the SJTU Antai College of Economics and Management, and a dedicated group of CLGO industry partners. Graduates of the CLGO program receive the MBA degree from Antai, an SM degree from one of two SJTU engineering schools, and a certificate from the MIT LGO program. MIT supports the China LGO program by hosting SJTU faculty (36 to date) at MIT for extensive mentoring in courses that they in turn lead for the CLGO program, and by providing the all-English language CLGO curriculum. In addition, a review committee of MIT faculty makes periodic visits to meet CLGO stakeholders and assess the program’s quality. MIT LGO and China LGO students collaborate each year through visits to Shanghai and Cambridge, including joint plant tours of partner company sites.

Global Supply Chain and Logistics Excellence (SCALE) Network, multiple countries
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 (Zaragoza, Spain and Luxembourg City, Luxembourg), South America (Bogota, Colombia), and Asia (Kuala Lumpur, Malaysia and Ningbo, China). Each SCALE 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; many of which include a three week student and faculty exchange at MIT. The SCALE Network also features partnerships with over a hundred global corporations, such as Procter & Gamble, UPS, BASF, and Wal-Mart, that sponsor research, participate in events, and recruit students. Research projects recently undertaken by the SCALE network include projects on decision making under uncertainty, supply chain resilience, humanitarian logistics, sustainable supply chains, and global transportation reliability.

MIT-Africa Initiative
Present MIT engagements with Africa span half the countries on the continent and center on research, education and innovation. Multiple faculty members and a growing number of students are involved in these engagements. The MIT-Africa Initiative (http://misti.mit.edu/mit-africa-initiative) was set up in 2013 by Prof. Hazel Sive. The Initiative serves to communicate and coordinate engagement in Africa among the MIT community and is a point of entry for new partnerships.

The Initiative has been housed at the MIT International Science and Technology Initiative (MISTI) together with several other Africa-focused programs, including student internships through the MIT-South Africa and MIT-Africa Internship programs, and MIT-Global Startup Labs. These Internship Programs are the fastest growing at MIT, and in 2016–17 a total of 93 students traveled to Africa. The pedagogy programs Empowering the Teachers and MIT-Educator are also based at MISTI.

The MIT-Africa Fund and the MIT-South Africa Fund were established through the Office of Giving to welcome African alumni and friends. Alumni events have been organized in Nigeria and South Africa.

The Africa Advisory Committee (AAC) was set up as a strategic planning group for MIT-AFRICA, comprising faculty, staff and students. The AAC was pleased to advise Associate Provost Richard Lester and prepare a strategic plan for MIT engagement in Africa. The priorities in MIT’s Campaign for a Better World resonate with enormous opportunities for collaboration with partners throughout Africa on issues of vital importance. The time has never been better to expand MIT engagement with Africa.
MIT-Haiti Initiative
The MIT-Haiti Initiative, led by Prof. Michel DeGraff (Linguistics, P.I.), Dr. Vijay Kumar (J-WEL; co-P.I.) and Prof. Haynes Miller (Mathematics), is a collaboration between MIT and Haitian faculty to help provide training and resources for secondary and tertiary education that are founded on contemporary educational theory, active-learning methods and the use of Kreyòl in the classroom. As part of the Initiative, digital tools created at MIT and elsewhere are translated into Kreyòl and provide proof of concept that Kreyòl is indeed a necessary ingredient for active learning in Haiti. More generally, the Initiative is forging a model of the use of local languages such as Kreyòl as the primary language of instruction at all educational levels.

Making high-quality STEM materials openly accessible to Haitian faculty in Kreyòl will eventually allow greater and more democratic access to educational resources in the one language that the vast majority of Haitians are by far the most comfortable in. As a long-term side effect, wider access to Kreyòl materials can be expected to endow Haiti’s national language with both scientific and cultural capital. The promotion of Kreyòl is a key component for nation building in a country where the use of the French language has long created a deep divide in a population where only a small minority of fluent French speakers (no more than 5%) have had access to quality education and political and economic power. Only through the systematic use of Kreyòl as language of instruction will the majority population become full participants in the economic and social development of the country.

The MIT-Haiti Initiative is already having a profound impact on the way educators and policy makers in Haiti think about teaching STEM in their native Kreyòl. This Initiative can also serve as an important model for similar initiatives around the globe where indigenous or other local languages continue to face systemic marginalization, with disastrous impact for the wellbeing and the socio-economic development of these communities. The model that is set up by the use of Kreyòl in the MIT-Haiti Initiative is all the more important when we consider that some 200 million children are still being educated in what is, in effect, a foreign language that they barely speak, if at all.

For more details about the Initiative and its rationale, including research articles, please see: http://haiti.mit.edu and http://mit.edu/degraff

MIT Ibn Khaldun Fellowship for Saudi Arabian Women, Saudi Arabia
This competitive fellowship program is open to Saudi Arabian women scientists and engineers who hold a doctoral degree. Fellows are supported to spend one year doing research at MIT in collaboration with an MIT faculty member. The Fellowship was launched by MIT in 2009, in collaboration with Saudi universities. This successful and highly competitive program has flourished thanks to a substantial expansion in 2013 supported by Saudi Aramco. The MIT Ibn Khaldun Fellowship for Saudi Arabian Women is uniquely positioned to facilitate the development of Saudi Arabian women scientists and engineers as leaders in their respective fields of research as well as the Kingdom’s top educational managers and teachers. Fellows have returned to Saudi Arabia equipped for advanced technical research, and they have achieved positions of leadership in both their institutions and their local governments.

MIT Norman B. Leventhal Center for Advanced Urbanism, multiple countries
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 Colombia, China, UAE and the U.S., the LCAU is also exploring the global condition of affordable housing as part of its fourth biennial theme. Five graduate-level workshops have already been offered, with site visits occurring to: Cartagena, Colombia, Kigali, Rwanda, Gujarat, India, Sao Paulo, Brazil, and Hangzhou, China. Two more workshops will be offered during IAP 2018, with potential sites in Guyana and Bangladesh.
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. With support from the Residential Education team, and using the resources, platform, and pedagogical innovations of MITx, faculty also develop digital learning courses and modules for use in on-campus education. MITx also now offers the MicroMasters online credential, which represents a new path to an MIT master’s degree.

Since the first MITx course was offered in August 2012, there have been more than 5.7 million enrollments in MITx courses, with nearly 2.7 million participants (some people register for a course but then fail to follow through with any studies or use of course materials). Individual registrants come from more than 200 different countries.

Cumulative Worldwide Impact of MITx since Inception

- Cumulative total enrollment: 5.7 million*
- Cumulative total participation: 3.3 million
- Certificates of Completion: 160 thousand
- ID-verified Certificates: 51 thousand

*2.7 million unique enrollments

On average OCW attracts about 2.3 million visits per month, and to date more than 200 million people from almost every country on earth have accessed these resources. Since 2003, more than 200 million individuals have accessed MIT academic content through these programs, sometimes with remarkable results. Please see http://ocw.mit.edu/about/ocw-stories/ for inspiring examples.

International Study Opportunities

There is a broad range of global activities for students to choose from. These run the gamut from traditional study-abroad programs to innovative short term projects, but most are infused with the Institute’s philosophy of *mens et manus*. In spring 2016, 50 percent of students graduating with a bachelor’s degree, and 39 percent of students graduating with a master’s degree, reported having at least one educational experience abroad.

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

Departmental Exchanges

The Department of Aeronautics and Astronautics offers study at the University of Pretoria in South Africa. The Department of Architecture has two exchange programs, one with Delft University of Technology in the Netherlands and the other with the University of Hong Kong. The Department of Materials Science and Engineering has exchange programs with Oxford University, Imperial College London, and the University of Tokyo. The Department of Mechanical Engineering has exchange programs with ETH Zurich in Switzerland and the University of Tokyo. The Department of Nuclear Science and Engineering has exchange programs with Imperial College London and the University of Tokyo. The Department of Political Science has an exchange program with Sciences Po in France.
Other Study Abroad Options
MIT students may also apply for admission directly to foreign institutions that offer study abroad programs. Examples of direct enroll programs include l’École Polytechnique in France, the London School of Economics, in the UK, University of Sydney in Australia, and Tsinghua University in China.

International Research Opportunities
International Research Opportunities (IROP) is designed for MIT undergraduates who want to conduct UROP research mentored by MIT faculty in an international setting. These overseas research opportunities 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, IROP experiences 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 (SMURF)
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 to engage in research at the SMART Centre over the summer. The SMURFs work in MIT faculty supervisors’ labs, actively participate in the research projects, and engage with postdoctoral scholars, graduate students, and other researchers. SMART hopes this opportunity encourages them to consider a career in research. Their research experiences are supplemented with numerous social activities. Based on feedback from the students, the SMURFs greatly value their experiences at SMART and the community that forms among them.

Professional Education
Since 2012, MIT Professional Education has delivered its educational offerings to hundreds of industry professionals from diverse sectors such as government, manufacturing, and transportation in 11 countries, including India, Brazil, Taiwan, Hong Kong, South Africa, Italy, Mexico, and the United Arab Emirates.

To date, over 35,000 professionals from 150+ countries, including the U.S., have participated in Professional Education’s programs. The top ten foreign countries represented over 50 percent of the 8,300+ international participants.

For more information on Professional Education, see page 103.
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 Australia, Belgium, Brazil, Chile, China, France, Germany, India, Israel, Italy, Japan, Jordan, Kazakhstan, Korea, Mexico, Morocco, the Netherlands, New Zealand, Portugal, Peru, Russia, Singapore, South Africa, Spain, Switzerland, and the United Kingdom. Over 1,200 students participate in MISTI each year.

Here are a few examples from the more than 9,500 students MISTI has placed since it began by sending a handful of interns to Japan 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.


- Physics major Jason Brylawskijj 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 1,359 proposals. Of these, 536 faculty projects were awarded $11.7 million for projects in 72 countries. No fewer than 544 MIT faculty members and 169 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, Israel, Italy, Japan, Mexico, Spain, Turkey and the United Kingdom. The MISTI GSF General Fund accepts proposals for projects in any country.
**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
- 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

*MISTI year runs from September 1–August 31. 2017 represents the 2016–2017 year.*

**MISTI Annual Internship Placements**

*1994–2017*

**MISTI Global Seed Fund Projects by Country**

*2016–2017*

Total Projects: 84

*Number of Projects*

- Italy
- Israel
- China
- Peru
- United Kingdom
- France
- Chile
- Brazil
- Spain
- Germany
- Japan
- Belgium
- Russia
- Korea
- South Africa
- Norway
- Switzerland
- Kazakhstan
- Pakistan
- Turkey
- Mexico
- Australia

- 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

*MITI year runs from September 1–August 31. 2017 represents the 2016–2017 year.*
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 2017 report, the number of international students enrolled in U.S. colleges during the 2016–2017 academic year reached a record high of 1,078,822 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 2016–2017 academic year, international students contributed $36.9 billion to the U.S. economy and support 450,331 jobs.
Global Engagement

International Undergraduate Students
Top Countries of Citizenship, 2017–2018

<table>
<thead>
<tr>
<th>Country</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>91</td>
</tr>
<tr>
<td>India</td>
<td>29</td>
</tr>
<tr>
<td>Canada</td>
<td>22</td>
</tr>
<tr>
<td>South Korea</td>
<td>21</td>
</tr>
<tr>
<td>Thailand</td>
<td>21</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>18</td>
</tr>
<tr>
<td>Mexico</td>
<td>13</td>
</tr>
<tr>
<td>Singapore</td>
<td>12</td>
</tr>
<tr>
<td>Brazil</td>
<td>11</td>
</tr>
<tr>
<td>Taiwan</td>
<td>11</td>
</tr>
</tbody>
</table>

International Graduate Students
Top Countries of Citizenship, 2017–2018

<table>
<thead>
<tr>
<th>Country</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>724</td>
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<tr>
<td>India</td>
<td>310</td>
</tr>
<tr>
<td>Canada</td>
<td>239</td>
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<tr>
<td>South Korea</td>
<td>183</td>
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<tr>
<td>France</td>
<td>104</td>
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<tr>
<td>Singapore</td>
<td>86</td>
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<tr>
<td>Brazil</td>
<td>63</td>
</tr>
<tr>
<td>Germany</td>
<td>61</td>
</tr>
<tr>
<td>Israel</td>
<td>60</td>
</tr>
<tr>
<td>Spain</td>
<td>60</td>
</tr>
</tbody>
</table>

International Students by Geographic Region of Country of Citizenship
1884–2018

Academic Year

Number of Students

- Asia
- Europe
- Americas and Caribbean
- Africa, Middle East, Oceania
International Alumni

MIT alumni and scholars have made extraordinary contributions in their home countries, the U.S., and the world. The following are some examples:

Kofi Annan, SM Management 1972
Kofi Annan, the seventh Secretary-General of the United Nations and recipient of the Nobel Peace Prize, was born in Kumasi, Ghana, and attended the University of Science and Technology in Kumasi before completing his undergraduate studies at Macalester College in St. Paul, Minnesota. He undertook graduate studies in economics at the Institut universitaire des hautes études internationales in Geneva, and earned his SM in Management as a Sloan Fellow at MIT. Annan worked for the World Health Organization and the Ghana Tourist Development Company, but has spent most of his career at the United Nations.

Ngozi Okonjo-Iweala, MCP 1978, PhD Planning 1981
Former Managing Director of the World Bank, Ngozi Okonjo-Iweala is a globally renowned Nigerian economist. She was the first woman to hold the position of Finance Minister in Nigeria. During her term from 2003 to 2006, she launched an aggressive campaign to fight corruption. She implemented a series of economic and social reforms, including a zero-tolerance policy for corruption; international and local governmental contract bidding; privatizing state-owned refineries; and the Extractive Industry Transparency Initiative, which aims to bring openness to the oil sector. Under her leadership, the country has tripled its reserves from $7 billion to $20 billion; the annual GDP grew at 6 percent; and inflation is down from 23 percent to 9.5 percent. Okonjo-Iweala started her career at the World Bank, where she was the first woman ever to achieve the positions of vice president and corporate secretary.

I. M. Pei, SB Architecture 1940
Ieoh Ming Pei, influential modernist architect and founder of the firm Pei Cobb Freed & Partners, was born in China in 1917. He completed his Bachelor of Architecture degree at MIT in 1940. Pei has designed more than 60 buildings, including the John Fitzgerald Kennedy Library in Boston, Massachusetts, the Grand Louvre in Paris, France, the Miho Museum in Shiga, Japan, the Bank of China Tower in Hong Kong, and the Gateway Towers in Singapore.

Amnon Shashua, PhD Brain & Cognitive Sciences 1993
In 1999, Shashua co-founded Mobileye, an Israeli company developing a system-on-chip and computer vision algorithms for a driving assistance system, providing a full range of active safety features using a single camera. Today, approximately 10 million cars from 23 automobile manufacturers rely on Mobileye technology to make their vehicles safer to drive. In 2014, Mobileye claimed the title for largest Israeli IPO ever, by raising $1 billion at a market cap of $5.3 billion. In 2010, Shashua co-founded OrCam which harnesses the power of artificial vision to assist people who are visually impaired or blind. The OrCam MyEye device is unique in its ability to provide visual aid to hundreds of millions of people, through a discreet wearable platform. Within its wide-ranging scope of capabilities, OrCam’s device can read most texts and learn to recognize thousands of new items and faces.

Tony Tan, SM Physics 1964
Following his master’s from MIT and his Ph.D. from the University of Adelaide in applied mathematics, Tan taught mathematics at the University of Singapore. Tan was elected to the Parliament of Singapore in 1979, and has served in numerous leadership positions in the Singapore government. In December 1991, Tan stepped down from the Cabinet to return to the private sector as the Overseas-Chinese Banking Corporation’s Chairman and Chief Executive Officer. He rejoined the Cabinet in 1995 as Deputy Prime Minister and Minister for Defense. In August 2003, Tan became Deputy Prime Minister and Coordinating Minister for Security and Defense. Tan served as the 7th President of Singapore, holding office from 2011 to 2017.

Songyee Yoon, PhD Brain & Cognitive Sciences ’00
Since 2008, Yoon has served as the Global Chief Strategy Officer of NCsoft. Previously, she served as head of the Communication Intelligence Division at SK Telecom Co. Ltd., leading platform and artificial intelligence strategy. She has taught media and entertainment industry strategy at Seoul universities, and writes for major newspapers, covering technology and humanity. Additionally, she has worked as a consultant at McKinsey and Co., as part of corporate finance and strategy practice, and is running a nonprofit organization, Common Planet, which helps endangered species.
International Scholars

MIT hosts international scholars from around the world who come to the U.S. for teaching, research, collaboration, 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 July 1, 2016 through June 30, 2017 year, the International Scholars Office (ISchO) served 2,379 international scholars affiliated with MIT and their accompanying family members (“international” is defined as non-U.S. citizen, non-U.S. permanent resident).

This reflects a decrease of 2 percent since last year (2,436). According to the most recently published Institute of International Education Open Doors report (2016), MIT ranked 10th nationally with regard to the numbers of international scholars at U.S. institutions. Postdoctoral associates and postdoctoral fellows accounted for 57 percent of MIT’s international scholars.

Foreign national scholars came to MIT from 96 different countries, with the highest numbers coming from China, India, Canada, South Korea, Germany, Japan, France, Italy, Israel, and Spain. Scholars from these top 10 countries constituted nearly 65 percent of MIT’s international scholar population. Seventy-five percent of international scholars at MIT were men and 25 percent were women. In descending order, the areas hosting the greatest number of international scholars were School of Engineering, followed by the interdisciplinary laboratories and centers under the Vice President for Research, School of Science, School of Architecture and Planning, School of Humanities, Arts and Social Sciences, Office of the Provost, and Sloan School of Management.
## Campus Research Sponsored by International Sponsors

### International Sponsor Campus Research Expenditures (in U.S. Dollars)

**Fiscal Years 2014–2018**

<table>
<thead>
<tr>
<th>International Sponsor Type</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations and other nonprofits</td>
<td>35,830,415</td>
<td>36,301,791</td>
<td>33,597,572</td>
<td>31,138,637</td>
<td>32,903,682</td>
</tr>
<tr>
<td>Government</td>
<td>28,803,960</td>
<td>26,712,520</td>
<td>26,673,866</td>
<td>23,458,426</td>
<td>23,001,322</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>106,762,179</strong></td>
<td><strong>110,620,964</strong></td>
<td><strong>108,990,231</strong></td>
<td><strong>99,354,653</strong></td>
<td><strong>98,626,923</strong></td>
</tr>
<tr>
<td>Constant dollars*</td>
<td>112,741,880</td>
<td>115,972,539</td>
<td>113,496,287</td>
<td>101,593,555</td>
<td>98,626,923</td>
</tr>
</tbody>
</table>

*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2018 equaling 100.*
Section 8
Service to Local and World Communities

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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 our programs, we 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.

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

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.

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.

http://studentlife.mit.edu/pkgcenter
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.

Service to the community is not just centralized in one office at MIT—the Institute’s various Departments, Labs and Centers 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 150 affiliated professors at universities around the world, J-PAL draws on results from randomized evaluations to answer critical questions in the fight against poverty. J-PAL builds partnerships with governments, NGOs, donors, and other organizations to share this knowledge, scale up effective programs, and advance evidence-informed decision-making.

J-PAL was launched at MIT in 2003 by professors Abhijit Banerjee, Esther Duflo, and Sendhil Mullainathan as a research institute in the Department of Economics, and now has regional offices at leading research universities in Cape Town, Jakarta, New Delhi, Paris, and Santiago. With more than 300 research, policy, and training staff, J-PAL works across eight broad sectors: Agriculture; Crime, Violence, and Conflict; Education; Environment and Energy; Finance; Health; Labor Markets; and Political Economy and Governance.

Research

J-PAL believes 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 800 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 publishing. J-PAL also creates practical research resources, available to the public, designed to help people develop and carry out high-quality randomized evaluations. Their comprehensive library features evaluation manuals, analysis and survey tools, coding tools, and guidelines on ethics and transparency.

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 and MITx have developed 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 Outreach

The policy group at J-PAL bridges the gaps between researchers and policymakers. Policy staff work with J-PAL affiliated professors to distill research results into lessons that are clear, concise, and relevant to policymakers. With an in-depth understanding of the landscape of high-quality scientific research, they develop and disseminate cross-cutting policy insights and user-friendly frameworks for applying global evidence to local contexts.

Through 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 300 million people.
J-PAL North America
J-PAL North America (NA), one of J-PAL’s six regional offices, is based at MIT. To address the complex causes and consequences of poverty, J-PAL NA’s work spans a range of sectors including health care, housing, criminal justice, education, and labor markets. J-PAL NA works with decision-makers 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 NA runs three major initiatives to support randomized evaluations and evidence-informed policymaking: the State and Local Innovation Initiative, Health Care Delivery Initiative, and General Research Initiative. Amy Finkelstein (MIT) and Lawrence Katz (Harvard University) lead J-PAL NA as its two scientific directors. J-PAL affiliates have carried out over 200 ongoing or completed 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 Botswana, Brazil, China, El Salvador, Ethiopia, Ghana, Guatemala, Greece, Haiti, Honduras, India, Indonesia, Lesotho, Mali, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Philippines, Peru, Sudan, Tanzania, Uganda, Zambia, and others.

Programs & Opportunities

Courses
D-Lab challenges and inspires talented students to use their math, science, engineering, social science, and business skills to tackle global poverty issues. D-Lab’s 20+ MIT courses include design courses as well as courses that cover the principles of creativity, collaborative design, cross-cultural dialogue, supply chain management, and business venture development. Many courses provide an option for fieldwork.

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

Research
MIT D-Lab’s research groups produce accessible knowledge and tools that support technology-enabled solutions to global poverty challenges. The research teams specialize in field research that involves working closely with partners and community members around the developing world. D-Lab specializes in sectors relevant to developing world contexts and the use of the effective, respectful, and collaborative research methodologies for collecting data that inform product and service development. D-Lab’s research groups include Agriculture & Water, Biomass Fuels & Cookstoves, Developing World Mobility, Off-Grid Energy, Mobile Technology, Local Innovation and Development, and Lean Research.

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

Humanitarian Innovation
The world is facing an unprecedented humanitarian crisis with 65 million people displaced by conflict or persecution. Available resources are heavily strained and organizations urgently need creative solutions to providing basic needs to this population.

MIT D-Lab is pioneering a new approach to humanitarian that is teaching refugees and displaced persons the design process and the use of tools, so that they can create the kinds of things they need—cookstoves, fans, water coolers, pumps, for example—to improve their lives and ultimately improve the way humanitarian work is delivered. This initiative is led by D-Lab Founding Director Amy Smith and D-Lab Instructor Martha Thompson.
International Development Innovation Network

Launched at MIT in 2012, the International Development Innovation Network (IDIN) is a program implemented by a global consortium of academic, institutional, and innovation center partners that empowers a diverse, global network of innovators to design, develop, and disseminate technologies to improve the lives of people living in poverty. IDIN manages the International Development Design Summits (co-founded by D-Lab Founding Director Amy Smith) that are held around the world each year. More than 800 inventors and social entrepreneurs from more than 60 countries have participated in the summits over the past 10 years.

http://www.idin.org/

D-Lab Scale-Ups Fellowship

The MIT D-Lab Scale-Ups Fellowship offers one year of support to social entrepreneurs bringing poverty-alleviating products and services to market at scale. Scale-Ups Fellows receive a $20,000 grant, tailored mentorship, skills building, and networking opportunities. MIT alumni and alumni of the International Development Design Summit (IDDS) are eligible to apply. Now in its sixth year, the program has provided fellowships to 33 social entrepreneurs working on four continents in sectors including agriculture, energy, water, health care, housing, livelihoods, mobility, recycling, education, and personal finance.

http://d-lab.mit.edu/scale-ups/about

Comprehensive Initiative for Technology Evaluation

Launched at MIT in 2012, Comprehensive Initiative for Technology Evaluation (CITE) is a pioneering program dedicated to developing methods for product evaluation in global development. CITE researchers evaluate products from three perspectives, including suitability—how well a product performs its purpose, scalability—how well the product’s supply chain effectively reaches consumers, and sustainability—how well the product is used correctly, consistently, and continuously by users over time. To date, CITE has conducted nearly a dozen studies and reports on products ranging from water filters to wheelchairs.

http://cite.mit.edu/

Practical Impact Alliance

The Practical Impact Alliance, launched by D-Lab in 2015, is a network of leaders working across industries and geographies on market-driven social impact initiatives. Members include leading multinational corporations, non-governmental organizations, government agencies, and social ventures. The current members are Ajinomoto, CARE, Danone, Johnson & Johnson, Melton Foundation, 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 celebration showcasing Cambridge as an internationally recognized leader in science, technology, engineering, and math. The festival is presented by the MIT Museum in collaboration with the City of Cambridge, community organizations, schools, universities, and businesses. A multifaceted, multicultural event held every spring, the festival makes science accessible, interactive, and fun, while highlighting the impact of science on all our lives.

http://www.cambridgesciencefestival.org/
Service to Local and World Communities

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 kindergarten through 12th grade students through hands-on science and engineering challenges with the aim of increasing students’ curiosity and desire to pursue these fields in their future. 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. The Edgerton Center instructors mentor faculty and students in local public schools as well. In all aspects of these programs, MIT students are closely involved. All of the programs are provided at no or minimal cost.

Educational Studies Program
Founded by students in 1957, the MIT Educational Studies Program (ESP) shares knowledge and creativity with local high school students in the Boston, Cambridge, and MIT communities. 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.

MIT Integrated Learning Initiative (MITili)
Launched in 2016, MITili’s 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 considers the fundamental processes behind motivation, curiosity, knowledge acquisition, retention, mastery, integration, creativity, transfer, and self-efficacy at the individual level from pre-kindergarten to adulthood. At the system level, MITili researchers consider topics such as school effectiveness, school system design, social factors, education policy, the economics of education, and the impact of socio-economic status.
Teaching Systems Labs
MIT’s Teaching Systems Labs (TSL) helps prepare 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.

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 126–128, and the Global Engagement section beginning on page 105 for additional work.

Abdul Latif Jameel World Education Laboratory
Founded in 2017, the Abdul Latif Jameel World 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 workplace 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.

Selected Service Projects
Combined energy and water system could provide for millions
Many highly populated coastal regions around the globe suffer from severe drought conditions. In an effort to deliver fresh water to these regions, using clean-energy resources, a team of researchers from MIT and the University of Hawaii has created a detailed analysis of a symbiotic system that combines a pumped hydropower energy storage system and reverse osmosis desalination plant that can meet both of these needs in one large-scale engineering project.

The researchers, who have shared their findings in a paper published in *Sustainable Energy Technologies and Assessments*, say this kind of combined system could ultimately lead to cost savings, revenues, and job opportunities.

The basic idea to use a hydropower system to also support a reverse osmosis desalination plant was first proposed two decades ago by Professor Masahiro Murakami of Kochi University of Technology, but was never developed in detail. Recognizing the potential of the concept now, Alexander Slocum and his co-authors developed a detailed engineering, geographic, and economic model to explore the size and costs of the system and enable further analysis to evaluate its feasibility at any given site around the world.

Typically, energy and water systems are considered separately, but combining the two has the potential to increase efficiency and reduce capital costs. Termed an “integrated pumped hydro reverse osmosis system,” this approach uses a reservoir placed in high mountains near a coastal region to store sea water, which is pumped up using excess power from renewable energy sources or nuclear power stations. When energy is needed by the electric grid, water flows downhill to generate hydroelectric power. With a reservoir elevation greater than 500 meters, the pressure is great enough to also supply a reverse osmosis plant.

This work is available as an open access article on *ScienceDirect*, thanks to a grant by the S.D. Bechtel Jr. Foundation through the MIT Energy Initiative.

http://legatum.mit.edu/

Evaluating approaches to agricultural development

Involving local people in figuring out how to improve their farming and fishing methods provides more lasting and widespread benefits than just introducing new technologies or methods, researchers from WorldFish and MIT showed. The findings are described in *Agricultural Systems*, in a paper by Boru Douthwaite of the research funding agency WorldFish, and Elizabeth Hoffecker of the International Development Innovation Network, based at the MIT D-Lab.

Considerable research over the last few decades has shown that bringing about improvements in agricultural systems is a highly complex challenge. Douthwaite says he has often observed a disconnect between the measures agencies use to decide whether a program is working, versus the real effects he saw in some of the communities involved.

For this study, fishing in Zambia was one example the researchers focused on to illustrate these disparities. In Zambia, nearly one-third of the fish caught is lost to spoilage before it reaches the market. Reducing such spoilage could both provide financial benefits for the economically struggling fishing community and help alleviate food shortages for consumers.

The Zambian fisheries were facing two related issues, Hoffecker says: “The narrow challenge was to come up with a way to prevent fish from spoiling.” But in addressing that challenge, it became apparent that “there was a much bigger challenge, which was overfishing.”

The overall process led to four significant outcomes, Douthwaite says—none of which had been planned or anticipated initially and thus might have been missed in an evaluation based just on meeting initial, stated goals. The four outcomes consisted of developing a locally sourced fish-processing method (salting), developing a value chain for the salted fish from harvest to market, creating working groups that could continue to evaluate and improve innovations in the fishery, and improving relationships among the different groups involved, from the fishermen to the government agencies to the traders and buyers. In the end, this led to a growing consensus about the need for measures to prevent overfishing.

Researchers identify opportunities to improve quality, reduce cost of global food assistance delivery

Food assistance delivered to the right people at the right time and in the right place can save lives. In 2016 alone, the U.S. Agency for International Development (USAID) delivered over 1.7 million metric tons of food assistance to over 30 million people in 50 countries around the world. However, USAID estimates that over $10 million of that food never made it to the plates of people in need due to spoilage and infestation.

Proper food assistance packaging can be a major contributing factor toward preventing spoilage and infestation. The right kind of packaging can also reduce the need for costly fumigation and diversify the types of commodities that can be shipped to communities in need, improving recipient satisfaction and nutrition.

MIT researchers have released a report, “New Packaging Types as Innovative International Food Assistance Instruments.” It details the study design and findings of the latest experimental evaluation implemented by the Comprehensive Initiative on Technology Evaluation (CITE), a program supported by the USAID and led by a multidisciplinary team of faculty, staff, and students at MIT.

Food assistance was shipped in eight different types of packaging, then carefully tracked, monitored, and inspected to determine effectiveness of the packaging. In addition, lessons were documented regarding supply chains and processes along the way.

“…This procurement produced generalizable data on the cost, effectiveness, and feasibility of using new packaging types in the food assistance supply chain,” says Mark Brennan, PhD student and CITE researcher leading the project.

At the close of the study, MIT researchers made a number of recommendations for USAID and USDA to consider based on key findings, demonstrating potential for cost savings and quality improvement along the supply chain.

http://bit.ly/2y6aCDE

http://bit.ly/2sWUSnG