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

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Facts and History

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

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

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

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

MIT has forged educational and research collaborations with universities, governments, and companies throughout the world, and draws its faculty and students from every corner of the globe. The result is a vigorous mix of people, ideas, and programs dedicated to enhancing the world’s well-being.
**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 Theatre 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**
- Computer Science and Molecular Biology
- 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
- 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
- Center for Archaeological Materials
- 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 Materials Science and Engineering
- 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
- Haystack Observatory
- Initiative on the Digital Economy
- 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
- Martin Trust Center for MIT Entrepreneurship
- Materials Processing Center
- McGovern Institute for Brain Research
- Media Lab
- 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 Professional Education
- MIT Program in Art, Culture and Technology
- MIT Sea Grant
- Nuclear Reactor Laboratory
- Operations Research Center
- Picower Institute for Learning and Memory
- Plasma Science and Fusion Center
- Research Laboratory of Electronics
- Simons Center for the Social Brain
- Sociotechnical Systems Research Center
- Transportation@MIT
- 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, get 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 provide adaptive learning aids that present educational materials according to students’ varying needs and learning styles.

- **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.

- **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 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.

In 2012 MIT established the Office of Digital Learning (ODL). The mission of ODL is to transform teaching and learning at MIT and around the globe through the innovative use of digital technologies. ODL focuses on the following strategic priorities:

1. **Residential Education.** Collaborate with faculty to instigate, test, and institutionalize pedagogical models that enhance MIT’s unique brand of education through digital and learning technologies and practices.

2. **Open Education.** Enable global access to MIT via MITx MOOCs on edX and course materials and other teaching/learning resources through MIT OpenCourseWare.

3. **Strategic Education Initiatives.** Undertake open education experiments and implementation driven by MIT’s strategic priorities.

4. **Professional Education.** Support and enhance MIT’s capacity to serve businesses, executives and professionals in lifelong learning.

5. **Digital Learning Research.** Encourage and support learning research across MIT, and seek opportunities to exchange data, research, and lessons about digital learning.

6. **Support the Task Force.** Collaborate across MIT to implement recommendations for the Future of MIT Education that pertain to digital learning.

7. **Infrastructure and Support.** Provide infrastructure, tools and related services that support digital teaching and learning at MIT.

8. **Resources and Stewardship.** Attract enthusiastic fiscal and organizational support for ODL initiatives and services from colleagues and funding sources at MIT and beyond.

http://odl.mit.edu/
Academic and Research Affiliations

Collaborative Partnership
edX
A not-for-profit enterprise of its founding partners Harvard University and the Massachusetts Institute of Technology, 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.

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 over a dozen U.S. institutions, including MIT, Cornell University, University of California at Berkeley, and Harvard University.

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. The NUC consists of MIT, Oregon State University, North Carolina State University, The Ohio State University, and University of New Mexico.

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

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

Northeast Radio Observatory Corporation
The Northeast Radio Observatory Corporation (NEROC) 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. NEROC consists of nine educational and research institutions, these are MIT, Boston University, Brandeis University, Dartmouth College, Harvard University, Harvard-Smithsonian Center for Astrophysics, University of Massachusetts, University of New Hampshire, and Wellesley College.

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.

Charles Stark Draper Laboratory
Since 1973, The Charles Stark Draper Laboratory, Inc. has created premiere guidance, navigation and control technologies, the expertise it became known for when it was the MIT Instrumentation Laboratory. Expanding its scope over the decades, Draper uses multidisciplinary approaches in designing, developing and deploying advanced technological solutions for the world’s most challenging and important problems, spanning national security, space, biomedical solutions and energy.
**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. Seventeen 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, Massachusetts College of Art and Design, and the School of the Museum of Fine Arts. At the graduate level, qualified students may enroll in courses at Harvard University, Wellesley College, Boston University, Brandeis University, and Tufts University. A selection of international study opportunities are described on pages 108-110.
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** 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** 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** 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 Hayashi Seed Fund.

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

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 train and 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, 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 offered LLCipher, a one-week workshop providing an introduction to cryptography. Lessons provided high-school students the foundational knowledge to understand a math-based theoretical approach to securing data. Students constructed provably secure encryption and digital signature schemes, and then learned about zero-knowledge proofs and multiparty computation. The workshop’s success warranted an expansion in future years.

2015 MIT created a new credential for online learners: the “MicroMasters,” granted by MITx to students who participate in a given set of online courses and pass a proctored exam. The MITx MicroMasters was piloted in the Supply Chain Management program. Upon attainment of the credential, learners are eligible to apply for an accelerated, one-semester master’s degree program on campus at MIT.
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, provided a new means for studying the structure and function of genes.

1972 Lincoln Laboratory’s Moving Target Detector (MTD) achieved a new performance level for the detection of aircraft in the presence of radar clutter, such as ground, weather, and birds. It employed 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.

1975–1982 Joel Moses develops the first extensive computerized program (MACSYMA) able to manipulate algebraic quantities and perform symbolic integration and differentiation.

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 shared 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 led 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 was later transferred to Westinghouse Corporation, which deployed 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 in operation for over a decade and 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 (1) could be utilized in future land-observing satellites and (2) 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 succeeds 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 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.

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.

2008 Daniel Nocera creates a chemical catalyst that hurls one of the obstacles to widespread use of solar power—the difficulty of storing energy from the sun. The catalyst, which is cheap and easy to make, uses the energy from sunlight to separate the hydrogen and oxygen molecules in water. The hydrogen can then be burned, or used to power an electric fuel cell.

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.

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 being evaluated for 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.
**Facts and History**

**2011** A team, including Karen Gleason, Vladimir Bulović, and graduate student Miles Barr, develops materials that make it possible to produce photo-voltaic 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 Zuber.

**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 developed 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 steelmaking 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 Nimmanmudupong, 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, was 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 Plantes achieve efficiency 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 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 efficiency 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, USA. 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.

2016 Scientists at MIT, including Susan Solomon and research scientist Diane Ivy, and elsewhere have identified signs that the Antarctic ozone layer 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).
Faculty and Staff

As of October 31, 2015, MIT employs 12,109 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, 2015–2016

<table>
<thead>
<tr>
<th>Employee Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>1,036</td>
</tr>
<tr>
<td>Other academic and instructional staff</td>
<td>1,086</td>
</tr>
<tr>
<td>Research staff and research scientists (includes postdoctoral positions)</td>
<td>3,300</td>
</tr>
<tr>
<td>Administrative staff</td>
<td>2,974</td>
</tr>
<tr>
<td>Support staff</td>
<td>1,543</td>
</tr>
<tr>
<td>Service staff</td>
<td>829</td>
</tr>
<tr>
<td>Clinical and Medical staff</td>
<td>144</td>
</tr>
<tr>
<td>Affiliated faculty, scientists, and scholars</td>
<td>1,197</td>
</tr>
<tr>
<td><strong>Total campus faculty and staff</strong></td>
<td><strong>12,109</strong></td>
</tr>
</tbody>
</table>

Faculty

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

Faculty Profile, 2015–2016

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professors</td>
<td>665</td>
<td>64</td>
</tr>
<tr>
<td>Associate professors</td>
<td>194</td>
<td>19</td>
</tr>
<tr>
<td>Assistant professors</td>
<td>177</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,036</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>Male</td>
<td>806</td>
<td>78</td>
</tr>
<tr>
<td>Female</td>
<td>230</td>
<td>22</td>
</tr>
</tbody>
</table>

See page 48 for a chart of faculty and students from 1865–2016.

Seventy-five percent of faculty are tenured.

Faculty may hold dual appointments where they are appointed equally to two departments. Sixteen faculty members have dual appointments.

Faculty by School, 2015–2016

<table>
<thead>
<tr>
<th>School</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture and Planning</td>
<td>84</td>
<td>8</td>
</tr>
<tr>
<td>Engineering</td>
<td>378</td>
<td>37</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>174</td>
<td>17</td>
</tr>
<tr>
<td>Management</td>
<td>117</td>
<td>11</td>
</tr>
<tr>
<td>Science</td>
<td>273</td>
<td>26</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,036</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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

Each year, MIT employs about 1,300 graduate students as teaching assistants and 3,800 graduate students as research assistants.

MIT Lincoln Laboratory employs about 3,700 people, primarily at Hanscom Air Force Base in Lexington, Massachusetts. See page 86 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, 2015–2016

<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>104</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>7</td>
<td>34</td>
</tr>
<tr>
<td>African American</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>American Indian or Alaskan Native</td>
<td>2</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, 2015–2016

- China: 10%
- India: 8%
- United Kingdom: 7%
- Canada: 7%
- Germany: 6%
- Greece: 6%
- Russia: 4%
- Italy: 3%
- France: 3%
- Israel: 3%
- South Korea: 3%
- Spain: 3%
- All others: 38%

### Elapsed Years at MIT of Faculty, 2015–2016

(Excludes time as student)
Researchers

MIT campus research staff and scientists total 3,300. 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>58</td>
</tr>
<tr>
<td>Principal Researchers</td>
<td>116</td>
</tr>
<tr>
<td>Research Scientists and Technicians</td>
<td>1,125</td>
</tr>
<tr>
<td>Visiting Scientists</td>
<td>454</td>
</tr>
<tr>
<td>Postdoctoral Associates</td>
<td>1,090</td>
</tr>
<tr>
<td>Postdoctoral Fellows</td>
<td>457</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,300</strong></td>
</tr>
</tbody>
</table>

Approximately 2,600 graduate students were research assistants in fall 2015.
Postdoctoral Scholars

The MIT campus hosts 1,547 postdoctoral associates and fellows—412 females and 1,135 males. These individuals work with faculty in academic departments, laboratories, and centers.

U.S. Citizen and Permanent Resident

Postdoctoral Scholars by Ethnicity, 2015–2016

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic or Latino</td>
<td>29</td>
</tr>
<tr>
<td>African American</td>
<td>7</td>
</tr>
<tr>
<td>American Indian or Alaskan Native</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total underrepresented minorities (URM)</strong></td>
<td><strong>36</strong></td>
</tr>
<tr>
<td>White</td>
<td>292</td>
</tr>
<tr>
<td>Asian</td>
<td>75</td>
</tr>
<tr>
<td>Two or more races</td>
<td>6</td>
</tr>
<tr>
<td>Unknown</td>
<td>127</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>536</strong></td>
</tr>
</tbody>
</table>

Ethnicity of Postdoctoral Scholars, 2015–2016

- International: 65%
- White: 19%
- Asian: 5%
- Unknown: 8%
- Two or more races: <1%
- URM: 2%
- All Others: 25%

International Postdoctoral Scholars

Top Countries of Citizenship, 2015–2016

<table>
<thead>
<tr>
<th>Country of Citizenship</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>197</td>
</tr>
<tr>
<td>India</td>
<td>89</td>
</tr>
<tr>
<td>South Korea</td>
<td>70</td>
</tr>
<tr>
<td>Germany</td>
<td>67</td>
</tr>
<tr>
<td>Israel</td>
<td>62</td>
</tr>
<tr>
<td>Canada</td>
<td>59</td>
</tr>
<tr>
<td>Italy</td>
<td>45</td>
</tr>
<tr>
<td>France</td>
<td>43</td>
</tr>
<tr>
<td>Iran</td>
<td>37</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>34</td>
</tr>
<tr>
<td><strong>All Others</strong></td>
<td><strong>25%</strong></td>
</tr>
</tbody>
</table>

Years at MIT of Postdoctoral Scholars, 2015–2016

- 0 years: 100
- 1 year: 100
- 2 years: 100
- 3 years: 100
- 4 years: 100
- 5 years: 100
- 6 years: 100
- 7 years: 100

Postdoctoral scholars come from 70 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:

- H. Robert Horvitz: Nobel Prize in Physiology or Medicine (shared)
- Wolfgang Ketterle: Nobel Prize in Physics (shared)
- Robert C. Merton: Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel (shared)
- Richard R. Schrock: Nobel Prize in Chemistry (shared)
- Phillip A. Sharp: Nobel Prize in Physiology or Medicine (shared)
- Susan Solomon: Nobel Peace Prize (co-chair of Working Group One recognized under Intergovernmental Panel on Climate Change (IPCC), shared)
- Samuel C. C. Ting: Nobel Prize in Physics (shared)
- Susumu Tonegawa: Nobel Prize in Physiology or Medicine
- Frank Wilczek: 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>147</td>
<td>American Academy of Arts and Sciences Member</td>
</tr>
<tr>
<td>96</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>84</td>
<td>American Physical Society Fellow</td>
</tr>
<tr>
<td>20</td>
<td>American Society of Mechanical Engineers Fellow</td>
</tr>
<tr>
<td>27</td>
<td>Association for Computing Machinery Fellow</td>
</tr>
<tr>
<td>3</td>
<td>John Bates Clark Medal, American Economic Association</td>
</tr>
<tr>
<td>3</td>
<td>Dirac Medal, Abdus Salam International Centre for Theoretical Physics</td>
</tr>
<tr>
<td>10</td>
<td>Fulbright Scholar, Council for International Exchange of Scholars (CIES)</td>
</tr>
<tr>
<td>8</td>
<td>Gairdner Award, Gairdner Foundation</td>
</tr>
<tr>
<td>61</td>
<td>Guggenheim Fellow, John Simon Guggenheim Memorial Foundation</td>
</tr>
<tr>
<td>17</td>
<td>HHMI Investigator, Howard Hughes Medical Institute (HHMI)</td>
</tr>
<tr>
<td>54</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>24</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>64</td>
<td>National Academy of Engineering Member, National Academies</td>
</tr>
<tr>
<td>31</td>
<td>National Academy of Medicine Member, National Academies</td>
</tr>
<tr>
<td>81</td>
<td>National Academy of Sciences Member, National Academies</td>
</tr>
<tr>
<td>9</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>1</td>
<td>Rolf Nevanlinna Prize, International Mathematical Union (IMU)</td>
</tr>
<tr>
<td>33</td>
<td>Presidential Early Career Awards for Scientists and Engineers (PECASE)</td>
</tr>
<tr>
<td>4</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>5</td>
<td>A. M. Turing Award, Association for Computing Machinery</td>
</tr>
<tr>
<td>1</td>
<td>Von Hippel Award, Materials Research Society</td>
</tr>
<tr>
<td>2</td>
<td>John von Neumann Medal, Institute of Electrical and Electronics Engineers, Inc.</td>
</tr>
<tr>
<td>6</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

Four MIT faculty win Presidential Early Career Awards

2016 Presidential Early Career Awards for Scientists and Engineers (PECASE)

President Barack Obama named four MIT faculty among 105 recipients of the 2016 Presidential Early Career Awards for Scientists and Engineers (PECASE), the highest honor bestowed by the U.S. government on science and engineering professionals in the early stages of their independent research careers.

Those from MIT who were honored were:

- Tonyio Buonassisi, associate professor in the Department of Mechanical Engineering;
- Cullen Buie, associate professor and the Esther and Harold E. Edegton Career Development Chair in the Department of Mechanical Engineering;
- William Tisdale, assistant professor and the Charles and Hilda Roddey Career Development Professor in the Department of Chemical Engineering; and
- Kay M. Tye, assistant professor and the Whitehead Professorship Chair in the Department of Brain and Cognitive Sciences.

Feng Zhang

2016 Canada Gairdner International Award

Feng Zhang, a core institute member of the Broad Institute, an investigator at the McGovern Institute for Brain Research at MIT, and W. M. Keck Career Development Associate Professor in MIT’s Department of Brain and Cognitive Sciences, has been named a recipient of the 2016 Canada Gairdner International Award—Canada’s most prestigious scientific prize—for his role in developing the CRISPR-Cas9 gene-editing system.

In January 2013 Zhang and his team were first to report CRISPR-based genome editing in mammalian cells, in what has become the most-cited paper in the CRISPR field. He is one of five scientists the Gairdner Foundation is honoring for work with CRISPR. Zhang shares the award with Rodolphe Barrangou from North Carolina State University; Emmanuelle Charpentier of the Max Planck Institute; Jennifer Doudna of the University of California at Berkeley and Phillipe Horvath from DuPont Nutrition and Health.

Mircea Dincă

2016 National Science Foundation’s Alan T. Waterman Award

MIT professor of chemistry Mircea Dincă has been selected as the recipient of the National Science Foundation’s 2016 Alan T. Waterman Award. This is the 40th anniversary of this prestigious prize, which is the foundation’s highest honor recognizing an outstanding researcher under the age of 35.

“It’s a pleasure to recognize Dr. Dincă as this year’s recipient of the Alan T. Waterman Award,” said National Science Foundation (NSF) Director France Córdova. “His research in microporous solids is revolutionizing how scientists approach this exciting new technology, opening the door for future discoveries.”
Section 2

Major MIT Initiatives

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- Research Initiatives 44
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 and are ongoing.

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 now recognized as the first and the foremost campus-wide energy program at a U.S. academic institution, with important educational, research, and policy components. MITEI’s educational activities affect MIT students at every level, from incoming freshmen who learn about energy issues in pre-orientation to undergraduates who gain foundational knowledge of energy topics and get hands-on research experience through the multidisciplinary Energy Studies Minor, to graduate fellows researching national and international energy issues. MITEI has helped energy research at MIT grow by developing strategic alliances with companies across a broad range of energy-related businesses, attracting government and philanthropic support, and stimulating faculty members from across the campus to consider how their research expertise is relevant to energy issues. Its policy outreach component has similarly 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, is expected to be released in late 2016. Another multi-year consortium study, The Mobility of the Future study, which examines how modes of transportation are evolving, launched in August 2016.

As it enters its second decade, MITEI is organizing its research efforts around specific technology research areas key to addressing climate change and meeting global energy needs, through eight associated Low-Carbon Energy Centers that 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 merging of distinct technologies, integrating disciplines, into a unified whole that creates a host of new pathways and opportunities. It involves the coming together of different fields of study—particularly engineering, physical sciences, and life sciences—through collaboration among research groups and the
integration of approaches that were originally viewed as distinct and potentially contradictory. Convergence implies a broad rethinking of how all scientific research can be conducted, to capitalize on a range of knowledge bases, from microbiology to computer science to engineering design. 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.

Support for this integrated research approach continues to grow. MIT continues to be a leader in the Convergence revolution on campus and beyond. At MIT, this model is now deeply anchored in many areas of life sciences, including work in quantum information studies of neurons, neuroscience and computing, synthetic biology, and cancer research. Just as engineering and physical sciences are transforming the life sciences, biological models are transforming engineering and physical science, with campus research in biofuels, biomaterials, and viral self-assembly drawing on the Convergence model.

The White House featured “Fostering Convergent Science” in its January 2013 Blueprint For Action, and included advancing the convergence approach among four annual goals. Later that year, President Obama announced the BRAIN (Brain Research through Advancing Innovative Neurotechnologies) initiative, a major public-private partnership utilizing a convergence research approach, with federal participation by NIH, NSF, and DARPA complemented by contributions from companies, health systems, patient advocacy organizations, philanthropists, state governments, research universities, private research institutes, and scientific societies. In 2015, the White House launched the Precision Medicine initiative across three agencies, aimed at applying big data and analytics to enable personalized medicine approaches. In 2016, the White House launched a new Microbiome initiative, also organized on a convergence research model.

The National Academies of Science has also provided leadership in the convergence effort through its Board on Life Sciences. The Board’s September 2013 workshop, “Key Challenges in the Implementation of Convergence,” was co-chaired by MIT President Emerita Hockfield. The workshop findings are summarized in Convergence–Facilitating Transdisciplinary Integration of Life Sciences, Physical Science, Engineering and Beyond (National Academies Press, 2014).

At the American Association for the Advancement of Science’s 2014 Annual Meeting, Professor Phillip Sharp delivered the AAAS President’s Lecture on the topic of Convergence; President Emerita Hockfield led a AAAS workshop on the topic.

The Defense Advanced Research Projects Agency (DARPA) has been expanding its focus on convergence model research, forming a new Biological Technologies Office in 2014 with a research portfolio in areas including bio-fabrication, neuroscience, and infectious disease, and leading DARPA’s participation in the BRAIN initiative.

In the past year, MIT has twice convened large groups experts from around the country to discuss the role of Convergence research in the future of health and healthcare, aiming to develop the framework for a research strategy for biomedical convergence. Cross-sector workshops were held in December 2015 at the American Academy of Arts and Sciences and in March 2016 at the American Association for the Advancement of Science, with contributing experts from academia, industry, government, and philanthropy. A policy report drawing on these convenings is scheduled for release in 2016.

Additional information on the convergence research model, including further details on major developments described above, is available online at http://www.convergencerevolution.net/.
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 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.

Production in the Innovation Economy Study

This MIT study (known as PIE) issued its final report in two volumes from MIT Press (released in September 2013 and January 2014). The report identified a major decline in the ecosystem of support for small and midsized production firms and gaps in financing for production scale-up and in workforce training, drawing lessons from production practices abroad, particularly Germany and China. The report recommended a new innovation effort around what it termed “advanced manufacturing,” to be shared across industry and universities, with new financing, workforce training and collaborative R&D efforts. The PIE report was presented at a major campus forum on September 20-21, 2014, led by MIT President Reif, including Dow Chemical CEO Andrew Liveris, who co-led the Advanced Manufacturing Partnership, and senior federal officials. The National Academy of Sciences hosted key PIE researchers at a November 1 presentation of the PIE report, in its historic Lecture Room in Washington, led by PIE Commission co-chair Suzanne Berger. They summarized the study results to a packed house of federal officials and representatives from industry, universities, and non-governmental organizations. Professor Berger subsequently testified about the PIE findings before the Senate Banking and Senate Commerce Committees, and briefed forums at think tanks and foundations, as well as the President. President Obama’s Administration drew extensively on expertise from the PIE study. The key PIE research findings were discussed on an ongoing basis as the report was developed with industry and government, including directly with President Obama and his senior officials, and had a major effect on developing national manufacturing policies, through the AMP process discussed below. In effect, the MIT initiative flowed almost seamlessly into national manufacturing policy creation at the highest levels.

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 the National Network for Manufacturing Innovation (NNMI). 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. She continues to help set the path for the NNMI as a member of the Leadership Council for the MForesight advisory group (see www.mforesight.org).

**Manufacturing Innovation Institutes**

Fifteen Manufacturing Innovation Institutes (MIIs) will be stood up by the end of 2016, 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 several of the eight institutes operating as of May 2016, 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 consortia including New York and Massachusetts firms and universities, was established by the Department of Defense in July 2015 to develop integrated photon devices. In April 2016, Secretary of Defense Ash Carter visited the MIT campus to announce that DoD’s newest manufacturing institute, would be the Advanced Functional Fabrics of America. AFFOA is establishing headquarters in Cambridge, Massachusetts. Professor Yoel Fink directs the institute, which is managed by an independent nonprofit organization founded by MIT. Regional and national partners are participating in the institute, which will integrate 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. science research. As federal R&D funding has stagnated, new ways of explaining to policy makers the central societal need for science is required. The MIT report *The Future Postponed: Why Declining Investment in Basic Research Threatens a U.S. Innovation Deficit*, released in April 2015, was a new way of explaining science and is designed to be accessible to policymakers. The Future Postponed explains the critical importance of federal investment in science research to grow the economy, develop better therapies and cures, stay competitive, and solve global challenges.

The MIT Committee to Evaluate the Innovation Deficit, named in October 2014 comprised of 30 MIT faculty and researchers from across all schools at MIT, selected and wrote 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.

The science community has tried to tell the stories of how past investments in research have paid off in today’s technologies—like GPS, MRI, and the Google search engine—but has not adequately told how research cutbacks today will affect the science of tomorrow. The “Future Postponed” report explores the remarkable technology opportunities that lie ahead and the science needed to get there, all fully vetted by a faculty review board, but written in short two or three page case studies that are highly accessible to non-scientist readers. 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, held a forum hosted by the AAAS and briefed Congressional staff, White House staff, and other national stakeholders during a Washington DC visit on April 27th.

A second national phase of the report is now wrapping up, with Professor Kastner leading an advisory committee of noted scientists from outside MIT to develop a dozen additional case studies. The 2015 report is available at http://dc.mit.edu/innovation-deficit. Additional case studies are posted online at www.futurepostponed.org, and will be collected in a new report expected in the fall of 2016.
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
- Convener 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. He noted that startups in non-IT fields face major challenges in scaling up to a point where their technologies are demonstrated, tested and de-risked, and placed in range of follow-on financing mechanisms. Calling for new innovation “orchards,” a team at MIT is now exploring relevant models nationwide, and considering new innovation institutions to fill this gap that could be implemented by MIT and regional partners in Massachusetts.

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. Continuing this tradition, MIT’s support for online education entered the national spotlight in 2001 when President Charles Vest announced that the institute would make instructional materials from all its courses freely available through OpenCourseWare (OCW). May 2012 marked a major evolutionary step in MIT’s online and digital learning strategy, with the announcement that MIT and Harvard University had jointly established and endowed edX to make Massively Open Online Courses of the highest quality available to anyone with Internet access.

In his September 2012 inaugural address, Rafael Reif announced that continued educational innovation would be a major focus of his presidency. He soon established the Office of Digital Learning (ODL) to consolidate and strengthen the Institute’s educational technology programs and services. ODL now houses OCW, produces courses for distribution via edX under the MITx nameplate, and provides tools and services to enhance on-campus curricular offerings. OCW has now delivered material from over 2,300 MIT courses to 200 million learners and educators worldwide. There are 8.3 million unique learners on the edX platform. Over 840,000 learners have received certificates of completion for edX courses, including over 100 courses under the MITx nameplate.

In April 2013, Reif established an Institute-wide Task Force on the Future of MIT Education to explore the policy impacts of developing technologies, asking the Task Force members, with input from the entire MIT community, to envision how new capabilities and instructional models can spark innovation in higher education on campus and beyond. 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. Support by the Carnegie Foundation, this Online Education Policy Initiative (OEPI) utilized an internal (MIT) advisory committee, as well as an external advisory committee representing associations
and companies involved in higher education and other universities, to explore teaching pedagogy and efficacy, institutional business models, and global educational engagement strategies. Important input to the OEPI was also obtained through a May 2015 workshop, sponsored by the National Science Foundation, which brought fifty practitioners from 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). OEPI leaders briefed Congressional committees, NSF, the White House, and higher education groups on their findings. The report makes four principal recommendations.

1. To deepen integration of research across all the fields that impact learning, the community should develop an integrated research agenda emphasizing interdisciplinary collaborations.

2. Digital technologies can provide a dynamic scaffolding to facilitate effective learning. They should be promoted to facilitate customized learning, remote collaboration, and continuous assessment, and to support teachers while allowing them to focus on high-value in-person interactions with students.

3. A new class of creative, professional educators, which the report calls “learning engineers,” should be encouraged and supported. Learning engineers would integrate deep disciplinary knowledge with broad understanding of the learning and cognitive sciences, educational technology, and online tools.

4. Institutional and organizational change is needed to implement these reforms. Stakeholders across the higher education community can foster change by creating thinking communities and identifying change agents and role models.

Policymakers and leaders in education are already using the OEPI report to deepen the public discourse surrounding online learning and to encourage productive discussion about the role of technology in the future of higher education in the U.S. and globally.

**Internet Policy Research Initiative**

The goal of the Internet Policy Research Initiative (IPRI) is to work with policy makers and technologists to increase the trustworthiness and effectiveness of interconnected digital systems that support our economy and society. This campus-wide initiative is housed in CSAIL and produces research across four main areas: cybersecurity, privacy, networks, and the “Internet experience.” IPRI research has already helped inform and shape current debates 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 in the U.S. Senate and reported in the world press.

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. Other courses taught by IPRI researchers focus on information policy, app development, cybersecurity and science policy.

The third pillar of the initiative is engaging with policymakers throughout the world and helping inform policymaking from a solid technological foundation. In 2016, IPRI hosted a range of high-level policymakers 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 understand the needs and challenges, and develop a research agenda to address the most pressing issues.
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 multi-disciplinary perspective; and create a test-bed for our industry partners to implement and test our tools as well as have our researchers test tools developed by our partners.

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, cyber safety models, more effective information sharing, better organizational cybersecurity culture, disrupting the cybercrime ecosystem, and metrics and models to better protect organizations.

Environmental Solutions Initiative
The Environmental Solutions Initiative (ESI), launched in 2014, is a major campus-wide effort to coordinate and develop interdisciplinary solutions to urgent challenges in environment and sustainability. ESI aims to harness the MIT community’s ingenuity and passion, and the Institute’s unique culture of collaboration through diverse activities in education, research, and convening.

ESI spans natural and social sciences, engineering, design, management, policy, and the humanities to help drive the kind of progress required in time to make a difference. ESI is guided by a Faculty Advisory Committee and a Student Advisory Council, and is building an External Advisory Board with broad representation.

As emerging leaders, change agents, and innovators, MIT students have a profound interest in, and capacity to shape a more sustainable environment. ESI’s educational mission is to develop this extraordinary capacity within and beyond the classroom, and in so doing equip students to steward a healthy planet in every career path. We are working closely with students and faculty across the Institute to develop an undergraduate minor in Environment and Sustainability—target launch date 2017—and to infuse required undergraduate classes (GIRs) with problem sets and material on climate and environment.

ESI’s research agenda seeks to advance and expand work toward environmental solutions in three key domains: climate science and earth systems, cities and infrastructure, and sustainable economy and society. These research domains are multidisciplinary and promote collaboration across MIT’s five schools. ESI’s nine inaugural seed grant research projects are well underway. A second call for proposals, which will focus on the three domains above, is planned for fall 2016.

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.

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. MITEI supports energy research teams across the Institute by bringing them together with government and industry to analyze challenges and develop solutions. MITEI also leads Institute energy education efforts and delivers comprehensive analyses for policy makers, such as the “Future of” study series, the most recent of which was the 2015 The Future of Solar Energy, and other studies such as The Utility of the Future. MITEI’s accomplishments are enabled through the investment of member companies, government sponsors, and donors. From these funding sources, MITEI has raised more than $600 million to date to support energy research, education, and outreach programs.

MITEI-sponsored researchers are developing cutting-edge solutions and bringing new technologies to the marketplace. MITEI members have sponsored more than 800 projects, many involving collaborations between MIT researchers and member researchers. Nearly 30 percent of the MIT faculty is engaged with MITEI’s programs.

MITEI’s eight Low-Carbon Energy Centers—currently under development—present vital opportunities for faculty, students, industry, and government to advance research and development in key areas for addressing climate change, from solar energy to electric power systems, nuclear fusion, and other areas. (See energy.mit.edu/lcec.)

The MITEI Seed Fund Program supports innovative early-stage research projects that address energy and related environmental issues. Including 2016 grants, the MITEI Seed Fund Program has supported a total of 151 energy-focused research projects representing $19.9 million in funding over the past eight 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 are new to the field or to MIT.

http://web.mit.edu/jwafs/
With support from its members, MITEI has sponsored and engaged thousands of students through programs including the graduate Society of Energy Fellows, Undergraduate Research Opportunities Program (UROP) in energy, Energy Studies Minor, Independent Activities Period, Discover Energy: Learn, Think, Apply (DELTA) Freshman Pre-orientation Program, 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.

MITEI’s outreach program promotes and disseminates energy research findings to the MIT community and members of other academic institutions, as well as to policy makers, industry leaders, interested citizens, and others. Through colloquia, symposia, and seminars, MITEI introduces energy thought leaders from across the energy value chain to these diverse audiences.

http://mitei.mit.edu/
Section 3
Students

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Students

The Institute’s fall 2015 student body of 11,331 is highly diverse. Students come from all 50 states, the District of Columbia, three territories and dependencies, and 120 foreign countries. The Institute’s 3,411 international students make up eleven percent of the undergraduate population and forty-three percent of the graduate population. See pages 112-113 for more information about international students.

<table>
<thead>
<tr>
<th>Student Profile, 2015–2016</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>4,527</td>
<td>40</td>
</tr>
<tr>
<td>Graduate</td>
<td>6,804</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>11,331</td>
<td>100</td>
</tr>
</tbody>
</table>

In fall 2015, 46 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.

Students may identify with more than one race or choose not to identify with a group. Seventy-nine undergraduates and 427 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 3,709—51 percent of undergraduate and 20 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 2015, there were 4,527 undergraduate students.

Undergraduate Students by Citizenship, 2015–2016

<table>
<thead>
<tr>
<th>Citizenship</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. citizen</td>
<td>3,836</td>
<td>84.7</td>
</tr>
<tr>
<td>U.S. permanent resident</td>
<td>206</td>
<td>4.6</td>
</tr>
<tr>
<td>International</td>
<td>485</td>
<td>10.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,527</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Undergraduate Students by School, 2015–2016

<table>
<thead>
<tr>
<th>School</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture and Planning</td>
<td>37</td>
</tr>
<tr>
<td>Engineering</td>
<td>2,455</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>81</td>
</tr>
<tr>
<td>Management</td>
<td>52</td>
</tr>
<tr>
<td>Science</td>
<td>724</td>
</tr>
<tr>
<td>Undesignated*</td>
<td>1,178</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,527</strong></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 2015, they comprised 60 percent of the student population with 6,804 students—2,895 master’s students (includes 173 non-matriculating) and 3,909 doctoral students.

Graduate Students by Citizenship, 2015–2016

<table>
<thead>
<tr>
<th>Citizenship</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. citizen</td>
<td>3,631</td>
<td>53.4</td>
</tr>
<tr>
<td>U.S. permanent resident</td>
<td>247</td>
<td>3.6</td>
</tr>
<tr>
<td>International</td>
<td>2,926</td>
<td>43.0</td>
</tr>
<tr>
<td>Total</td>
<td>6,804</td>
<td>100.0</td>
</tr>
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</table>

Graduate Students by Gender, 2015–2016

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>1,227</td>
</tr>
<tr>
<td>Male</td>
<td>2,682</td>
</tr>
</tbody>
</table>

Graduate Students by School, 2015–2016

<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>413</td>
<td>181</td>
<td>594</td>
</tr>
<tr>
<td>Engineering</td>
<td>1,009</td>
<td>2,114</td>
<td>3,123</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>25</td>
<td>312</td>
<td>337</td>
</tr>
<tr>
<td>Management</td>
<td>1,266</td>
<td>164</td>
<td>1,430</td>
</tr>
<tr>
<td>Science</td>
<td>9</td>
<td>1,138</td>
<td>1,147</td>
</tr>
<tr>
<td>Total</td>
<td>2,722</td>
<td>3,909</td>
<td>6,631</td>
</tr>
</tbody>
</table>
Degrees

In 2015–2016, MIT awarded 3,439 degrees.

Degrees Awarded by Type, 2015–2016

<table>
<thead>
<tr>
<th>Degree Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor of Science degrees</td>
<td>1,111</td>
</tr>
<tr>
<td>Master of Science degrees</td>
<td>721</td>
</tr>
<tr>
<td>Master of Architecture, Master in City Planning, Master of Engineering, Master of Business Administration, and Master of Finance degrees</td>
<td>1,023</td>
</tr>
<tr>
<td>Engineer’s degrees</td>
<td>10</td>
</tr>
<tr>
<td>Doctoral degrees</td>
<td>646</td>
</tr>
</tbody>
</table>

Degrees Awarded by School, 2015–2016

<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>14</td>
<td>185</td>
<td>32</td>
<td>231</td>
</tr>
<tr>
<td>Engineering</td>
<td>786</td>
<td>760</td>
<td>334</td>
<td>1,880</td>
</tr>
<tr>
<td>Humanities, Arts, and Social Sciences</td>
<td>29</td>
<td>20</td>
<td>42</td>
<td>91</td>
</tr>
<tr>
<td>Management</td>
<td>18</td>
<td>773</td>
<td>21</td>
<td>812</td>
</tr>
<tr>
<td>Science</td>
<td>264</td>
<td>16</td>
<td>217</td>
<td>497</td>
</tr>
<tr>
<td>Total</td>
<td>1,111</td>
<td>1,754</td>
<td>646</td>
<td>3,511</td>
</tr>
</tbody>
</table>

Degrees Awarded by Gender, 2015–2016

<table>
<thead>
<tr>
<th>Degree Type</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor's</td>
<td>508</td>
<td>603</td>
</tr>
<tr>
<td>Master's and Engineer's</td>
<td>603</td>
<td>458</td>
</tr>
<tr>
<td>Doctorate</td>
<td>188</td>
<td></td>
</tr>
</tbody>
</table>
Alumni


Seventy-five 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, over half did so immediately upon graduation. This includes students who earned a graduate degree simultaneously with their bachelor’s degree. Eighty-five percent of respondents said they are employed either full-time or part-time. An additional 4 percent are unemployed and seeking employment. The remainder is either on leave or unemployed and not currently seeking employment. Among those respondents who are employed, 64% work in the for-profit sector, 13% work in government or military agencies, 14% work in the nonprofit sector, and 9% are self-employed. Twenty-two percent of respondents reported having started a company. Fourteen percent said they are currently developing a start-up company.

Service is a part of the lives of our alumni. Eighty-seven 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. Thirty-seven percent have been a board member for a nonprofit organization. Seventy-three percent have done volunteer work at least once in the last year.

A Fall 2012 survey of graduate alumni (http://web.mit.edu/ir/surveys/grad_alum.html) 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.

MIT’s 134,344 living alumni are connected to the Institute through graduating-class events, departmental organizations, and over 43 clubs in the United States and 39 abroad. Beyond classes and regional clubs, the MIT Alumni Association supports a range of shared interest groups that foster connectedness among MIT alumni. More than 15,000 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 21,000 alumni reside in Massachusetts, and about 14 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.

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 received, minus MIT undergraduate scholarships.
Who Pays for an MIT Undergraduate Education
In 2015–2016, the annual price of an MIT education totaled $63,750 per student—$46,704 for tuition and fees, $13,730 for room and board, an estimated $2,816 for books, supplies, and personal expenses, and a per-student average of $500 for travel. With 4,474 undergraduates enrolled, the collective price for undergraduates was $285.2 million. Of this amount, families paid $151.9 million, or 53 percent, and financial aid covered the remaining 47 percent, or $133.3 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 86.8 percent while the share in the form of student loans fell from 11.1 to 5.6 percent and term-time work decreased from 8.0 to 7.6 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
2015–2016


<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>115,726,328</td>
<td>87</td>
</tr>
<tr>
<td>Student Loans</td>
<td>7,420,072</td>
<td>5</td>
</tr>
<tr>
<td>Term-time employment</td>
<td>10,130,889</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>133,277,289</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Sources of Undergraduate Financial Aid
In 2015-2016, MIT provided 80.2 percent of undergraduate financial aid. State and private resources provided 10.7 percent, and the remaining 9.1 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 56 percent of MIT undergraduates received an MIT scholarship, averaging $38,871 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 the three campus-based programs: the Federal Supplemental Educational Opportunity Grant, the Federal Perkins Loan Program, 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 2015–2016.

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aid Source</td>
</tr>
<tr>
<td>MIT Financial Aid</td>
</tr>
<tr>
<td>Federal Financial Aid</td>
</tr>
<tr>
<td>State Financial Aid</td>
</tr>
<tr>
<td>Private Financial Aid</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

The following table summarizes the sources and types of financial aid MIT undergraduates received in 2015–2016.


<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>97,099,378</td>
<td>2,498</td>
<td>303,812</td>
<td>95</td>
</tr>
<tr>
<td>Federal</td>
<td>6,527,195</td>
<td>814</td>
<td>4,986,938</td>
<td>704</td>
</tr>
<tr>
<td>State</td>
<td>176,322</td>
<td>N/A</td>
<td>90</td>
<td>N/A</td>
</tr>
<tr>
<td>Private</td>
<td>11,923,433</td>
<td>1,293</td>
<td>2,129,322</td>
<td>96</td>
</tr>
<tr>
<td>Total*</td>
<td>115,726,328</td>
<td>3,118</td>
<td>7,420,072</td>
<td>838</td>
</tr>
</tbody>
</table>

*The total column and row are unduplicated numbers of students.
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 ($46,400 for the 2015–2016 academic year). Another portion ($2,568) 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 $34,488 for a doctoral student). MIT houses approximately 31 percent of the graduate student body on campus, which contributes to keeping average housing costs at a reasonable level for graduate students within the context of the Boston area. The graduate residences also help foster a thriving on-campus graduate community that many graduate students cite as one of the most positive aspects of their time here.

How Graduate Students are Supported

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

Graduate Student Financial Support, 2015–2016

Doctoral Graduate Student Support, 2015–2016
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.

For the Fall semester 2015, the breakdown of funding sources for students that were primarily supported by fellowships were as follows:

<table>
<thead>
<tr>
<th>Sponsor</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Defense</td>
<td>82</td>
</tr>
<tr>
<td>Department of Energy</td>
<td>20</td>
</tr>
<tr>
<td>National Institutes of Health</td>
<td>31</td>
</tr>
<tr>
<td>NASA</td>
<td>22</td>
</tr>
<tr>
<td>National Science Foundation</td>
<td>188</td>
</tr>
<tr>
<td>Other Federal Agencies</td>
<td>6</td>
</tr>
<tr>
<td>Other U.S. sources</td>
<td>38</td>
</tr>
<tr>
<td>Non-U.S. sources</td>
<td>114</td>
</tr>
<tr>
<td>MIT Internal</td>
<td>1,301</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,802</strong></td>
</tr>
</tbody>
</table>

Teaching Assistantships
MIT employs about 1,300 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 3,800 graduate students at MIT hold appointments as research assistants. The principal duty of a research assistant is to contribute to a program of departmental or interdepartmental research. Research assistants receive stipends as well as tuition support for the services that they provide, and are compensated on the basis of time devoted to their research.

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

Self-Support
Graduate and professional students are eligible for need-based financial aid, including student loans, as well as student employment under the Federal Work-Study Program, both of which are administered and reported by MIT Student Financial Services (SFS). Graduate student employment earnings under the Federal Work-Study Program, including on- and off-campus programs, totaled $0.9 million in 2015–2016, with 1.9 percent of graduate and professional students (132 students) earning $6,752 on average.

In AY2016, graduate students borrowed loans that totaled $44.9 million, an increase of approximately $1.5 million from the prior year, with 10.9 percent of graduate and professional students (739 students) borrowing an average of $60,719.
Section 4
Campus Research

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Department of Energy 66
National Institutes of Health 68
NASA 70
National Science Foundation 72
Other Federal Agencies 74
Nonprofit Organizations 76
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 FY2016)

Cambridge Campus $728.1 million
Lincoln Laboratory* $926.6 million
SMART* $32.8 million
Total $1,687.6 million

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

All federal research on campus is awarded competitively based on the scientific and technical merit of the proposals. As of June 30, 2016, there were 2,755 active awards and 411 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 1940–2016

†SMART: Singapore-MIT Alliance for Research and Technology
‡Total Research constant dollars are calculated using the Consumer Price Index for all Urban Consumers weighted with fiscal year 2016 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.
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 79. Expenditures funded by industrial sponsors are shown on page 95 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.

<table>
<thead>
<tr>
<th>Fiscal Years 2007–2016</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Federal</strong></td>
</tr>
<tr>
<td>2007</td>
</tr>
<tr>
<td>2008</td>
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<tr>
<td>2009</td>
</tr>
<tr>
<td>2010</td>
</tr>
<tr>
<td>2011</td>
</tr>
<tr>
<td><strong>Non-federal</strong></td>
</tr>
<tr>
<td>2007</td>
</tr>
<tr>
<td>2008</td>
</tr>
<tr>
<td>2009</td>
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<tr>
<td>2010</td>
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<tr>
<td>2011</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<tr>
<td>2007</td>
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<td>2008</td>
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<tr>
<td>2009</td>
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<tr>
<td>2010</td>
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<tr>
<td>2011</td>
</tr>
<tr>
<td><strong>Constant dollars†</strong></td>
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<tr>
<td>2007</td>
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<tr>
<td>2008</td>
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<tr>
<td>2009</td>
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<tr>
<td>2010</td>
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<tr>
<td>2011</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Fiscal Years 2012–2016</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Federal</strong></td>
</tr>
<tr>
<td>2012</td>
</tr>
<tr>
<td>2013</td>
</tr>
<tr>
<td>2014</td>
</tr>
<tr>
<td>2015</td>
</tr>
<tr>
<td>2016</td>
</tr>
<tr>
<td><strong>Non-federal</strong></td>
</tr>
<tr>
<td>2012</td>
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<tr>
<td>2013</td>
</tr>
<tr>
<td>2014</td>
</tr>
<tr>
<td>2015</td>
</tr>
<tr>
<td>2016</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<tr>
<td>2012</td>
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<tr>
<td>2013</td>
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<tr>
<td>2014</td>
</tr>
<tr>
<td>2015</td>
</tr>
<tr>
<td>2016</td>
</tr>
<tr>
<td><strong>Constant dollars†</strong></td>
</tr>
<tr>
<td>2012</td>
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<tr>
<td>2013</td>
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<tr>
<td>2014</td>
</tr>
<tr>
<td>2015</td>
</tr>
<tr>
<td>2016</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 2016 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.
### Campus Research Expenditures by Primary Sponsor*

<table>
<thead>
<tr>
<th>Primary Sponsor</th>
<th>FY2007</th>
<th>FY2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Defense</td>
<td>91M</td>
<td>132M</td>
</tr>
<tr>
<td>Department of Energy</td>
<td>65M</td>
<td>84M</td>
</tr>
<tr>
<td>National Institutes of Health†</td>
<td>114M</td>
<td>114M</td>
</tr>
<tr>
<td>NASA</td>
<td>28M</td>
<td>50M</td>
</tr>
<tr>
<td>National Science Foundation</td>
<td>63M</td>
<td>82M</td>
</tr>
<tr>
<td>All other federal</td>
<td>13M</td>
<td>16M</td>
</tr>
<tr>
<td>Industry</td>
<td>68M</td>
<td>128M</td>
</tr>
<tr>
<td>Foundations and other nonprofit</td>
<td>25M</td>
<td>84M</td>
</tr>
<tr>
<td>State, local, and foreign governments</td>
<td>13M</td>
<td>28M</td>
</tr>
<tr>
<td>MIT internal</td>
<td>8M</td>
<td>10M</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.

### Campus Research Expenditures by Primary Sponsor*

<table>
<thead>
<tr>
<th>Primary Sponsor</th>
<th>FY2016 (In U.S. Dollars)</th>
<th>Percent of Campus Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Defense</td>
<td>131,624,119</td>
<td>18</td>
</tr>
<tr>
<td>Department of Energy</td>
<td>84,419,109</td>
<td>12</td>
</tr>
<tr>
<td>National Institutes of Health†</td>
<td>113,562,813</td>
<td>16</td>
</tr>
<tr>
<td>NASA</td>
<td>49,663,884</td>
<td>7</td>
</tr>
<tr>
<td>National Science Foundation</td>
<td>82,160,804</td>
<td>11</td>
</tr>
<tr>
<td>All other federal</td>
<td>15,738,434</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Federal</strong></td>
<td><strong>477,169,162</strong></td>
<td><strong>66</strong></td>
</tr>
<tr>
<td>Industry</td>
<td>128,308,988</td>
<td>18</td>
</tr>
<tr>
<td>Foundations and other nonprofit</td>
<td>84,015,000</td>
<td>12</td>
</tr>
<tr>
<td>State, local, and foreign governments</td>
<td>28,495,198</td>
<td>4</td>
</tr>
<tr>
<td>MIT internal</td>
<td>10,165,571</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Non-Federal</strong></td>
<td><strong>250,984,757</strong></td>
<td><strong>34</strong></td>
</tr>
<tr>
<td>Campus Total</td>
<td><strong>728,153,919</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.
Department of Defense

Selected Projects

Study opens new realms of light-matter interaction
A new MIT study could open up new areas of technology based on types of light emission that had been thought to be "forbidden," or at least so unlikely as to be practically unattainable. The findings, based on a theoretical analysis, are reported in the journal *Science* in a paper by doctoral student Nicholas Rivera, Marin Soljačić, John Joannopoulos, and postdocs Ido Kaminer and Bo Zhen.

Interactions between light and matter, described by the laws of quantum electrodynamics, are the basis of a wide range of technologies, including lasers, LEDs, and atomic clocks. But from a theoretical standpoint, “Most light-matter interaction processes are ‘forbidden’ by electronic selection rules, which limits the number of transitions between energy levels we have access to,” Soljačić explains.

With this study, Kaminer says, “we demonstrate theoretically that these constraints can be lifted” using confined waves within atomically thin, 2D materials. “We show that some of the transitions which normally take the age of the universe to happen could be made to happen within nanoseconds.

The trick is, in effect, to “shrink” the light so it better matches the scale of the atom. The key to enabling a whole range of interactions is the use of a two-dimensional material called graphene, in which light can interact with matter in the form of plasmons, a type of electromagnetic oscillation in the material.

Kaminer predicts that this work “will serve as a founding piece for the next generation of studies on light-matter interactions” and could lead to “further theoretical and experimental advances in many fields which rely on light-matter interactions, including atomic, molecular and optical physics, photonics, chemistry, optoelectronics, and many others.”

The work was partly supported by the U.S. Department of Energy and the Army Research Office through the Institute for Soldier Nanotechnologies at MIT.

Engineers design programmable RNA vaccines
MIT engineers have developed a new type of easily customizable vaccine that can be manufactured in one week, allowing it to be rapidly deployed in response to disease outbreaks. So far, they have designed vaccines against Ebola, H1N1 influenza, and Toxoplasma gondii (a relative of the parasite that causes malaria), which were 100 percent effective in tests in mice.

The vaccine consists of strands of messenger RNA, which can be designed to code for any viral, bacterial, or parasitic protein. These molecules are then packaged into a molecule that delivers the RNA into cells, where it is translated into proteins that provoke an immune response from the host.

Daniel Anderson is the senior author of a paper describing the new vaccines in the *Proceedings of the National Academy of Sciences*. The project was led by postdocs Jasdev Chahal and Omar Khan; both are the first authors of the paper. Hidde Ploegh and Robert Langer are authors of the paper.

The vaccine is designed to be delivered by intramuscular injection, making it easy to administer. Once the particles get into cells, the RNA is translated into proteins that are released and stimulate the immune system. Significantly, the vaccines were able to stimulate both arms of the immune system—a T cell response and an antibody response. In tests in mice, animals that received a single dose of one of the vaccines showed no symptoms following exposure to the real pathogen—Ebola, H1N1 influenza, or Toxoplasma gondii.

The researchers believe that their vaccines would be safer than DNA vaccines, because unlike DNA, RNA cannot be integrated into the host genome and cause mutations.

The research was funded by the Department of Defense Office of Congressionally Directed Medical Research’s Joint Warfighter Medical Research Program, MediVector Inc., the Ragon Institute of MGH, MIT, and Harvard, and the Defense Threat Reduction Agency/Joint Science and Technology Office program in vaccines and pre-treatments.


Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2016
(Shown in descending order of expenditures)

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

In Fall 2015, the Department of Defense funded the primary appointments of graduate students with 284 research assistantships and 82 fellowships.

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

Department of Defense Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2012–2016

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<td>Constant dollars*</td>
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<td>124,490,282</td>
<td>126,703,928</td>
<td>131,624,119</td>
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*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2016 equaling 100.
MIT scientists find weird quantum effects, even over hundreds of miles

In the world of quantum, infinitesimally small particles, weird and often logic-defying behaviors abound. Perhaps the strangest of these is the idea of superposition, in which objects can exist simultaneously in two or more seemingly counterintuitive states. For example, according to the laws of quantum mechanics, electrons may spin both clockwise and counter-clockwise, or be both at rest and excited, at the same time.

The physicist Erwin Schrödinger highlighted some strange consequences of the idea of superposition more than 80 years ago, with a thought experiment that posed that a cat trapped in a box with a radioactive source could be in a superposition state, considered both alive and dead, according to the laws of quantum mechanics. Since then, scientists have proven that particles can indeed be in superposition, at quantum, subatomic scales. But whether such weird phenomena can be observed in our larger, everyday world is an open, actively pursued question.

Now, MIT physicists have found that subatomic particles called neutrinos can be in superposition, without individual identities, when traveling hundreds of miles. Their results, published in *Physical Review Letters*, represent the longest distance over which quantum mechanics has been tested to date.

“What’s fascinating is, many of us tend to think of quantum mechanics applying on small scales,” says David Kaiser. “But it turns out that we can’t escape quantum mechanics, even when we describe processes that happen over large distances. We can’t stop our quantum mechanical description even when these things leave one state and enter another, traveling hundreds of miles. I think that’s breathtaking.”

Kaiser is a co-author on the paper, which includes Joseph Formaggio, junior Talia Weiss, and former graduate student Mykola Murskyj.

This research was funded, in part, by the U.S. Department of Energy.


Department of Energy

Selected Projects

New method developed for producing some metals

The MIT researchers were trying to develop a new battery, but it didn’t work out that way. Instead, thanks to an unexpected finding in their lab tests, what they discovered was a whole new way of producing the metal antimony.

The discovery could lead to metal-production systems that are much less expensive and that virtually eliminate the greenhouse gas emissions associated with most traditional metal smelting. Although antimony itself is not a widely used metal, the same principles may also be applied to producing much more abundant and economically important metals such as copper and nickel, the researchers say.

The surprising finding is reported in the journal *Nature Communications*, in a paper by Donald Sadoway; postdoc Huayi Yin; and visiting scholar Brice Chung.

“We were trying to develop a different electrochemistry for a battery,” Sadoway explains, as an extension of the variety of chemical formulations for the all-liquid, high temperature storage batteries that his lab has been developing for several years. But the experiment didn’t go quite as planned. “We found that when we went to charge this putative battery, we were in fact producing liquid antimony instead of charging the battery,” Sadoway says.

For the material they were using, antimony sulfide, it turned out the electrolysis process worked very well in this “battery,” separating the metal out of the sulfide compound to form a pool of 99.9 percent pure antimony at the bottom of their cell, while pure sulfur gas accumulated at the top, where it could be collected for use as a chemical feedstock.

The research was funded by the U.S. Department of Energy, Advanced Research Projects-Energy (ARPA-E), and French energy company Total S.A. through the MIT Energy Initiative.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2016
(Shown in descending order of expenditures)

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

In Fall 2015, the Department of Energy funded the primary appointments of graduate students with 169 research assistantships and 20 fellowships.

Twenty-five 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 2016 equaling 100.
National Institutes of Health

Selected Projects

Why working the night shift can pose a cancer risk

A handful of large studies of cancer risk factors have found that working the night shift, as nearly 15 percent of Americans do, boosts the chances of developing cancer. MIT biologists have now found a link that may explain this heightened risk.

In humans and most other organisms, a circadian clock governed by light regulates the timing of key aspects of human physiology, by controlling cellular activities such as metabolism and division. In a study of mice, the MIT team found that two of the genes that control cells’ circadian rhythms also function as tumor suppressors. Loss of these tumor suppressors, either through gene deletion or disruption of the normal light/dark cycle, allows tumors to become more aggressive.

Former postdoc Thales Papagiannakopoulos is lead author of the study, which appears in Cell Metabolism. Tyler Jacks is the paper’s senior author. The research was funded by a National Cancer Institute Cancer Center Support Core Grant, the Lung Cancer Research Foundation, and the Koch Institute Frontier Fund.


Cancer-fighting bacteria

Researchers at MIT and the University of California at San Diego (UCSD) have recruited some new soldiers in the fight against cancer—bacteria. In a study published in Nature, the scientists programmed harmless strains of bacteria to deliver toxic payloads. When deployed together with a traditional cancer drug, the bacteria shrank aggressive liver tumors in mice much more effectively than either treatment alone. The new approach exploits bacteria’s natural tendency to accumulate at disease sites.

Sangeeta Bhatia and Jeff Hasty of UCSD, are the senior authors of the paper. Lead authors are UCSD graduate student Omar Din and former MIT postdoc Tal Danino, who is now an assistant professor at Columbia University.

In the study, the researchers delivered artificial genetic circuits into harmless strains of bacteria that allow the microbes to kill cancer cells in three different ways: destroy tumor cells by damaging their cell membranes, induce the cell to undergo programmed suicide, and release a protein that stimulates the body’s immune system to attack the tumor.

The researchers tested the bacteria in mice with a very aggressive form of cancer. On their own, they reduced tumor growth slightly, but when combined with a chemotherapy drug, they achieved a dramatic reduction in tumor size—much more extensive than if the drug was used on its own.

The study was funded by the San Diego Center for Systems Biology, the National Institute of General Medical Sciences, the Ludwig Center for Molecular Oncology at MIT, an Amar G. Bose Research Grant, the Howard Hughes Medical Institute, a Koch Institute Support Grant from the National Cancer Institute, and a Core Center Grant from the National Institute of Environmental Health Sciences.

http://bit.ly/2abuy0r

A new approach to chemical synthesis

MIT chemists have devised a new way to synthesize a complex molecular structure that is shared by a group of fungal compounds with potential as anticancer agents. Known as communesins, these compounds have shown particular promise against leukemia cells but may be able to kill other cancer cells as well.

The new synthesis strategy, described in the Journal of the American Chemical Society, should enable researchers to generate large enough quantities of these compounds to run more tests of their anticancer activity. It should also allow scientists to produce designed variants of the naturally occurring communesins, which may be even more potent.

Mohammad Movassaghi is the paper’s senior author. The study was conducted by graduate student Matthew Pompeo and former postdocs Stephen Lathrop and Wen-Tau Chang. The project was funded by the National Institutes of Health and the National Science Foundation.

http://bit.ly/1USTR15
Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2016
(Shown in descending order of expenditures)

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

In Fall 2015, the National Institutes of Health funded the primary appointments of graduate students with 156 research assistantships and 31 fellowships.

Ten current faculty or staff have received the NIH Director’s Pioneer Award. The recipients are Edward Boyden, Emery Brown, Arup Chakraborty, James Collins, Hidde Ploegh, Aviv Regev, Leona Samson, Alice Ting, Mehmet Yanik, and Feng Zhang.
NASA

Selected Projects

New technique may help detect Martian life

In 2020, NASA plans to launch a Mars rover that will be tasked with probing a region of the planet scientists believe could hold remnants of ancient microbial life. The rover will collect samples of rocks and soil, and store them on the Martian surface; the samples would be returned to Earth sometime in the distant future so that scientists can meticulously analyze the samples for signs of present or former extraterrestrial life.

As reported in the journal *Carbon*, MIT scientists have developed a technique that will help the rover quickly and noninvasively identify sediments that are relatively unaltered, and that maintain much of their original composition. Such “pristine” samples give scientists the best chance for identifying signs of former life, if they exist, as opposed to rocks whose histories have been wiped clean by geological processes such as excessive heating or radiation damage.

The team’s technique centers on a new way to interpret the results of Raman spectroscopy, a non-destructive process that geologists use to identify the chemical composition of ancient rocks. The 2020 Mars rover is equipped with SHERLOC (Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals), an instrument that will acquire Raman spectra from samples on or just below the Martian surface.

Research scientist Nicola Ferralis discovered hidden features in Raman spectra that can give a more informed picture of a sample’s chemical makeup, enabling scientists to more accurately and quickly evaluate and identify the most pristine, samples of rocks for further study.

This work was supported by Shell Oil Company and Schlumberger through the X-Shale Consortium under the MIT-Energy Initiative, and Extramural Research by Shell Innovation Research and Development, The Simons Foundation Collaboration on the Origins of Life, the NASA Astrobiology Institute, and the Max Planck Society.

First atmospheric study of Earth-sized exoplanets reveals rocky worlds

On May 2, 2016, scientists from MIT, the University of Liège, and elsewhere announced they had discovered a planetary system, a mere 40 light years from Earth, that hosts three potentially habitable, Earth-sized worlds. Judging from the size and temperature of the planets, the researchers determined that regions of each planet may be suitable for life. The scientists, led by first author postdoc Julien de Wit, came to their conclusion after making a preliminary screening of the planets’ atmospheres, just days after announcing the discovery of the planetary system.

In a paper published in *Nature*, that same group reports that the two innermost planets in the system are primarily rocky. The findings further strengthen the case that these planets may indeed be habitable. On May 4, the team pointed NASA’s Hubble Space Telescope at the system’s star, TRAPPIST-1, to catch a rare event: a double transit, the moment when two planets almost simultaneously pass in front of their star. Using Hubble, the team recorded a combined transmission spectrum of TRAPPIST-1b and c, meaning that as first one planet then the other crossed in front of the star, they were able to measure the changes in wavelength as the amount of starlight dipped with each transit. The data suggest that both transiting planets have more compact atmospheres, similar to those of rocky planets such as Earth, Venus, and Mars.

“With more observations using Hubble, and further down the road with NASA’s James Webb Telescope, we can know not only what kind of atmosphere planets like TRAPPIST-1 have, but also what is within these atmospheres,” de Wit says. “And that’s very exciting.”

This research was supported in part by NASA/Space Telescope Science Institute.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2016
(Shown in descending order of expenditures)

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

In Fall 2015, NASA funded the primary appointments of graduate students with 31 research assistantships and 22 fellowships.
National Science Foundation

Selected Projects

Replicating the connection between muscles and nerves
M.I.T. engineers have developed a microfluidic device that replicates the neuromuscular junction—the vital connection where nerve meets muscle. The device, about the size of a U.S. quarter, contains a single muscle strip and a small set of motor neurons. Researchers can influence and observe the interactions between the two, within a realistic, three-dimensional matrix.

The team’s results, published in Science Advances, may help scientists understand and identify drugs to treat amyotrophic lateral sclerosis (ALS), as well as other neuromuscular-related conditions. Sebastien Uzel led the work as a M.I.T. graduate student. Uzel’s coauthors include Roger Kamm and others.

This research was funded, in part, by the National Science Foundation.

Gravitational waves detected 100 years after Einstein’s prediction
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.

Gravitational waves carry information about their dramatic origins and about the nature of gravity that cannot otherwise be obtained. Physicists have concluded that the gravitational waves detected were produced during the final fraction of a second of the merger of two black holes to produce a single, more massive spinning black hole. This collision of two black holes had been predicted but never observed.

The first gravitational waves were detected on Sept. 14, 2015 by both of the twin Laser Interferometer Gravitational-Wave Observatory (LIGO) detectors, located in Louisiana and Washington, USA. The detectors picked up a signal of gravitational waves for a second time on Dec. 26, 2015.

The LIGO Observatories are funded by the National Science Foundation (NSF), and were conceived, built, and are operated by Caltech and M.I.T.

Scientists observe first signs of healing in the Antarctic ozone layer
Scientists at M.I.T. and elsewhere have identified the “first fingerprints of healing” of the Antarctic ozone layer. The team found that the ozone hole has shrunk by more than 4 million square kilometers—about half the area of the contiguous U.S.—since 2000. The team also showed for the first time that this recovery has slowed somewhat at times, due to the effects of volcanic eruptions. Overall, however, the ozone hole appears to be on a healing path. The findings were published in the journal Science. The lead author is Susan Solomon. Co-authors include research scientist Diane Ivy and researchers at the National Center for Atmospheric Research in Boulder, Colorado, and the University of Leeds in the U.K.

The researchers tracked the yearly opening of the Antarctic ozone hole in the month of September, from 2000 to 2015. They analyzed ozone measurements taken from weather balloons and satellites, as well as satellite measurements of sulfur dioxide emitted by volcanoes. They then compared their yearly ozone measurements with model simulations that predict ozone levels based on the amount of chlorine that scientists have estimated to be present in the atmosphere from year to year. The researchers found that the ozone hole has declined compared to its peak size in 2000, shrinking by more than 4 million square kilometers by 2015. They further found that this decline matched the model’s predictions, and that more than half the shrinkage was due solely to the reduction in atmospheric chlorine.

As chlorine levels continue to dissipate from the atmosphere, Solomon sees no reason why, barring future volcanic eruptions, the ozone hole shouldn’t shrink and eventually close permanently by midcentury.

This research was supported, in part, by the National Science Foundation and the U.S. Department of Energy.

Scientists observe first signs of healing in the Antarctic ozone layer


Gravitational waves detected 100 years after Einstein’s prediction

Scientists observe first signs of healing in the Antarctic ozone layer


Gravitational waves detected 100 years after Einstein’s prediction

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2016
(Shown in descending order of expenditures)

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

In Fall 2015, the National Science Foundation funded the primary appointments of graduate students with 301 research assistantships and 188 fellowships.

The National Science Foundation has awarded Faculty Early Career Development (CAREER) Awards to 158 current faculty and staff members.
Other Federal Agencies

Selected Projects

Assessing crop damage after extreme weather
In 2013, Typhoon Haiyan left more than 6,000 dead and 4 million homeless in the Philippines. The storm also obliterated thousands of hectares of crops, mostly rice, the staple food for most of the population. Host to multiple tropical cyclones per year, and a citizenry that consumes more rice than it produces, the Philippines has for years augmented its homegrown supply of rice with imports. But import orders must be modified on the fly when extreme weather events exact a heavier toll on production than expected.

In the aftermath of Haiyan, the Philippine government approved the import of an extra 355k metric tons of rice based on estimates of rice production damage and assessments drawn from time-consuming surveys in hundreds of villages. Seeking to enable a more rapid response, researchers have developed a method that can provide a more immediate and precise estimate of typhoon-inflicted rice damage in the Philippines.

Developed by research scientist Elodie Blanc and Eric Strobl of École Polytechnique, the method is described in the Journal of Applied Meteorology and Climatology. “Our method provides a faster, more accurate, and easier-to-obtain estimate of the impact of typhoons on rice production, and could empower governments in the Philippines and other tropical storm-prone nations to respond more quickly,” says Blanc, who is developing the technique for use in Taiwan and Burma. “Our full methodology could be applied not only to other countries but also to other crops.”

As climate change continues to increase the frequency and intensity of tropical cyclones and other extreme weather events, the researchers expect to see rising demand for their crop damage assessment technique.

The study was funded by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and other government, industry, and foundation sponsors of the Joint Program on the Science and Policy of Global Change.

Meeting climate goals through international carbon markets
Recognizing the substantial costs involved in addressing climate change through both mitigation and adaptation measures, the 2015 Paris Agreement stipulates that developed countries provide at least $100 billion a year in climate financing to developing countries, and support their transition to lower-carbon economies through international cooperation. One avenue for such cooperation is to link carbon markets—emissions trading systems that put a cap on carbon—in developed and developing regions.

This arrangement could boost the price of carbon in developing countries and thereby accelerate their efforts to shift away from carbon-intensive fuels. But studies show that it could also sharply reduce the carbon price in developed countries, thus shifting abatement from developed to developing countries.

This outcome could be prevented, however, if carbon-trading nations fine-tune the terms of engagement, according to a MIT Joint Program on the Science and Policy of Global Change study in Energy Economics.

Using the Joint Program’s Economic Projection and Policy Analysis (EPPA) model, principal research scientist Niven Winchester and his collaborators—lead author Claire Gavard, who conducted part of her doctoral research at the Joint Program, and Joint Program Deputy Director Sergey Paltsev—estimated the carbon-price and emissions-reduction impacts of a range of permit volume limits on emissions trading between selected countries.

“The opportunity to buy permits in China for $19 and sell them for $51 to the U.S. would present a strong financial incentive for China to link emissions trading markets with the U.S.,” says Winchester. “The U.S. would also benefit by taking advantage of low-cost emissions reductions elsewhere while still maintaining incentives to reduce emissions domestically.”

The EPPA model used in the study is supported by the U.S. Department of Energy, U.S. Environmental Protection Agency and other government, foundation and industrial sponsors of the Joint Program.

A few of the leading other federal agencies providing funding are: the Department of Transportation, the Department of Commerce, the U.S. Agency for International Development, and the Intelligence Advanced Research Projects Activity.

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<tr>
<th>Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2016</th>
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<td>(Shown in descending order of expenditures)</td>
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<tr>
<td>Center for Transportation and Logistics</td>
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<tr>
<td>Sea Grant College Program</td>
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<tr>
<td>Aeronautics and Astronautics</td>
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<tr>
<td>Urban Studies and Planning</td>
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<td>Computer Science and Artificial Intelligence Laboratory</td>
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<td>Civil and Environmental Engineering</td>
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<td>Sociotechnical Systems Research Center</td>
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<tr>
<td>Nuclear Science and Engineering</td>
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<tr>
<td>McGovern Institute for Brain Research</td>
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<tr>
<td>Mechanical Engineering</td>
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In Fall 2015, other Federal agencies funded the primary appointments of graduate students with 44 research assistantships and 6 fellowships.
Nonprofit Organizations

Selected Projects

Mixing topology and spin
In the pursuit of material platforms for the next generation of electronics, scientists are studying new compounds such as topological insulators (TIs), which support protected electron states on the surfaces of crystals that silicon-based technologies cannot. Dramatic new physical phenomena are being realized by combining this field of TIs with the subfield of spin-based electronics known as spintronics. The success within spintronics of realizing important magnetic technologies such as the spin valve have increased the expectations that new results in TIs might have near-term applications. However, combining these two research threads has relied on “shoehorning” magnetism by forcing magnetic atoms to partially occupy elemental positions in TIs or by applying a conventional magnetic field. Realizing an integrated material that is both intrinsically magnetic and has a topological character has proven more challenging.

Recently, a team of researchers based in the group of Joseph G. Checkelsky, and collaborators at the NIST Center for Neutron Research (NCNR), Carnegie Mellon University, and the Beijing Institute of Technology have experimentally demonstrated a “hybrid material” solution to this problem. They studied a compound of three elements, gadolinium, platinum and bismuth, known together as a ternary compound. In their compound, gadolinium supplies the magnetic order while the platinum-bismuth components support a topological electronic structure. These two components acting in concert make a correlated material that is more than the sum of its parts, showing quantum mechanical corrections to electrical properties at an unprecedented scale. Their results were reported in Nature Physics.

Funding sources for this research include the Gordon and Betty Moore Foundation EPIQS Initiative, the National Science Foundation, the STC Center for Integrated Quantum Materials, U.S. Army Research Laboratory, and the Bose Fellow Program at MIT.

http://bit.ly/2cVNIJx

A strategy for “convergence” research to transform biomedicine
What if lost limbs could be regrown? Or cancers detected early with blood or urine tests, instead of invasive biopsies? While such breakthroughs may sound futuristic, scientists are already exploring these and other promising techniques.

But the realization of these transformative advances is not guaranteed. The key to bringing them to fruition, a new report, Convergence: The Future of Health, argues, will be strategic and sustained support for “convergence”: the merging of approaches and insights from historically distinct disciplines such as engineering, physics, computer science, chemistry, mathematics, and the life sciences. The report was co-chaired by Tyler Jacks; Susan Hockfield; and Phillip Sharp and presented at the National Academies of Sciences, Engineering, and Medicine in June 2016.

The report draws on insights from several dozen expert participants at two workshops, as well as input from scientists and researchers across academia, industry, and government. Their efforts have produced a wide range of recommendations for advancing convergence research.

The report makes clear that, despite obstacles, this “third revolution” is already well underway. The report points to new federal initiatives that are harnessing the convergence research model to solve some of society’s most pressing health challenges. For example, the National Cancer Moonshot Initiative launched in 2016.

The report outlines major disease areas and promising convergence-based approaches to tackling them.

The report calls for a concerted joint effort by federal agencies, universities, and industry to develop a new strategic roadmap to support convergence-based research. The report also proposes new practices to foster “cultures of convergence” within academia.

Funding for the report was provided by the Raymond and Beverly Sackler Foundation, The Kavli Foundation, and the Burroughs Wellcome Fund.

http://bit.ly/2cVNIJx

## Nonprofit Organizations Campus Research Expenditures (in U.S. Dollars)
### Fiscal Years 2012–2016

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<tr>
<td>Campus research</td>
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<td>72,117,488</td>
<td>78,666,639</td>
<td>84,015,000</td>
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<td>Constant dollars*</td>
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<td>59,969,076</td>
<td>73,133,342</td>
<td>79,198,198</td>
<td>84,015,000</td>
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*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2016 equaling 100.

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### Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2016

(Shown in descending order of expenditures)

- Koch Institute for Integrative Cancer Research
- Economics
- Computer Science and Artificial Intelligence Laboratory
- Masdar
- Civil and Environmental Engineering
- McGovern Institute for Brain Research
- Mechanical Engineering
- Biological Engineering
- Research Laboratory of Electronics
- Simons Center For The Social Brain
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.

Over the past year, Lincoln Laboratory reached milestones in several areas:

- A prototype of a low-cost, multifunction phased array radar is expected to become the basis for upgrades to air traffic control and homeland protection radars across the country.

- Transitioned into operations, the Multi-look Airborne Collector for Human Encampment and Terrain Extraction (MACHETE), a 3D ladar system designed to uncover hidden activity in heavily foliated areas. MACHETE has already been used in more than 160 sorties overseas.

- A new space-based sensing capability will better protect U.S. systems.

- Demonstrated the first flight of a large number of self-organizing unmanned aerial vehicles for new defense system protection needs.

- A novel adaptive antenna array antenna will give aircraft an enhanced communications capability in highly contested electromagnetic environments.

- Demonstrated the largest short-wave-infrared focal plane array capable of detecting individual photons. This array will be used in new airborne and space-based sensor applications.

- New techniques for secure and resilient cloud computing were developed and demonstrated.

- Exploited Laboratory’s high-density, three-dimensional wafer-scale integration technology to develop novel circuits that convert electrical signals into optical signals for rapid data distribution.

- Three of Lincoln Laboratory's technologies were recognized with R&D 100 Awards, given by R&D Magazine to the year’s 100 most innovative technologies. Lincoln Laboratory has received 26 R&D 100 Awards over the past six years.
**Funding FY2015**
Total Funding = $937.3 million

**Breakdown of Laboratory Program Funding**

**Sponsor**
- Air Force: 24%
- DARPA: 4%
- MDA: 9%
- ASD Line: 4%
- Other DoD: 14%
- Other Government Agencies: 18%
- OSD Non-Line: 5%
- Army: 5%
- Navy: 7%
- Non-DoD: 10%

**Mission Area**
- Communications Systems: 21%
- Space Control: 14%
- Other: 1%
- Advanced Technology: 9%
- ISR Systems and Technology: 11%
- Tactical Systems: 13%
- Air, Missile, and Maritime Defense Technology: 14%
- Cyber Security and Information Sciences: 8%
- Homeland Protection and Air Traffic Control: 9%
- Other DoD: 14%
- Government Agencies: 18%
- Non-DoD: 10%

**Total Funding Fiscal Years 2011–2015**

- 2011: $785.7 million
- 2012: $861.8 million
- 2013: $719.3 million
- 2014: $851.3 million
- 2015: $845.8 million

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

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

Multi-look Airborne Collector for Human Encampment and Terrain Extraction

Capable of collecting unobscured 3D imagery from an altitude of 25 kft and at an incredible area coverage rate (400 km²/hr at 25 cm resolution), MACHETE (Multi-look Airborne Collector for Human Encampment and Terrain Extraction) can peek through openings in dense canopy to form detailed images of natural and man-made structures existing at and near the ground level, mapping out city-scale areas in minutes. For a heavily forested area with 90 percent canopy cover that is the size of Central Park, MACHETE can provide detailed images of every building, footbridge, and walkway below the canopy at 25 cm resolution in approximately five minutes.

The canopy can be digitally “defoliated” to reveal the structures underneath at any selected height above ground. Time-of-flight measurement is combined with pointing information of MACHETE’s gimbaled scanning system and the position of the airborne platform to produce a geolocated 3D point-cloud image. The imagery is color-coded to indicate differences in scene elevation, with color brightness indicating the intensity of the reflected light. Advanced onboard processing and analysis algorithms enable the classification of features of interest.

Real-time Open Systems Architecture for Reagan Test Site Sensor Systems

Lincoln Laboratory designed, developed, and implemented a new Real-time Open Systems Architecture (ROSA II) technology that is improving the efficacy of the radar and optical sensors at the Reagan Test Site on the Kwajalein Atoll in the Marshall Islands.

ROSA II extends the open concept to all sensor and control system software and offers a previously unachieved level of real-time data accessibility and system control, allowing for netcentric operation at the sensor and provides an ability to rapidly implement new software functions or to substitute existing functions from other systems built with ROSA II. It enables the interoperability of diverse hardware and software components, so systems are not constrained to only one operating platform or only system-specific components.
Major Technology Transfers

Advanced Technology
A world-leading superconducting microelectronic process was made available to industry performers.

Air Traffic Control
Lincoln Laboratory is supporting the transition of a prototype ground-based sense-and-avoid system to the U.S. Army. The system will undergo deployment to five Army Gray Eagle operational sites this year.

Future technology transfer will be supported on an annual basis. Decision support tools are being transferred into the Federal Aviation Administration’s Traffic Flow Management System through 2020. These tools provide 0–2-hour forecasts of convective weather impact on terminal arrival routes and use wind, ceiling, and visibility forecasts and airport-specific operating procedures to aid in setting airport arrival rate targets.

Communication Systems
Lincoln Laboratory transferred a software implementation of the Dynamic Link Exchange Protocol to a group of three companies developing advanced communication systems. The protocol, which is undergoing standardization in the Internet Engineering Task Force, an international community of network researchers, will provide improved queuing and flow control for wireless networks.

An advanced algorithm for fast computation of wireless communications interference in radio networks was transitioned into two commercial wireless network simulation software frameworks. These frameworks are widely used in commercial and defense industry communications engineering to model wireless systems and to evaluate the performance of network and routing protocols.

Intelligence, Surveillance, and Reconnaissance Systems and Technology
As part of its program for upgrading U.S. submarine sonars, Lincoln Laboratory transitioned adaptive beamforming, detection processing, and ranging algorithms, as well as improved collision warning indicators, to the Navy.

The Laboratory delivered to the Air Force Research Laboratory several advanced software capabilities to enhance processing, exploitation, and dissemination capabilities for Air Force Distributed Common Ground Systems.

Tactical Systems
The Laboratory has developed a tactical intelligence, surveillance, and reconnaissance sensor for small unmanned aerial vehicles (UAV). The sensor provides actionable information in real time, significantly improving the response time over currently fielded systems. The sensor has been integrated onto a tactical UAV platform in cooperation with industry partners, and hardened prototypes have been transitioned to the Army for operational use. Development is continuing to extend the payload for use on both moving and stationary platforms.
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 vehicles in tactical, regional, and homeland defense applications. Activities include the investigation of system architectures, development of advanced sensor and decision support technologies, development of flight-test hardware, extensive field measurements and data analysis, and the verification and assessment of deployed system capabilities. A strong emphasis is on rapidly prototyping sensor and system concepts and algorithms, and transferring resulting technologies to government contractors responsible for developing operational systems.

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 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 prototype components and systems designed to improve the security of computer networks, hosts, and applications. Efforts include cyber analysis; creation and demonstration of architectures that can operate through cyber attacks; development of prototypes that demonstrate the practicality and value of new techniques for cryptography, automated threat analysis, anti-tamper systems, malicious-code detection; and deployment of prototype technology to national-level exercises. Complementary advanced hardware, software, and algorithm technologies are developed for processing large, high-dimensional datasets from a wide range of sources. In the human language technology area, emphasis is placed on realistic data and experimental evaluation of techniques for speech recognition, dialect identification, speech and audio signal enhancement, and machine translation.

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 systems, and high-performance computing. By leveraging these disciplines, the Laboratory produces novel ISR system concepts for both surface and undersea applications. Sensor technology for ISR includes passive and active electro-optical systems, surface surveillance radar, radio-frequency geolocation, and underwater acoustic surveillance. 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 transitioned to industry and the user community.

Tactical Systems
Lincoln Laboratory assists the Department of Defense (DoD) in improving the development and employment of various tactical air and counterterrorism systems through a range of activities that include 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’s space surveillance system to meet the challenges of space situational awareness. The Laboratory works with systems to detect, track, and identify man-made satellites; collects orbital-debris detection data to support space-flight safety; performs satellite mission and payload assessment; and investigates technology to improve monitoring of the space environment, including space weather and atmospheric and ionospheric effects. The technology’s emphasis is the application of new components and algorithms to enable sensors with greatly enhanced capabilities and to support the development of netcentric processing systems for the Nation’s Space Surveillance Network.

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 radio frequency technology, and quantum information science.

Homeland Protection
The Nation’s security is supported by Lincoln Laboratory’s innovative technology and architectures that help prevent terrorist attacks within the United States, reduce the vulnerability of the nation to terrorism, minimize the damage from terrorist attacks, and facilitate recovery from either man-made or natural disasters. The broad sponsorship for this mission area spans the DoD, the Department of Homeland Security, and other federal, state, and local entities. Recent efforts include architecture studies for the defense of civilians and facilities, new microfluidic technologies for DNA assembly and transformation and for gene synthesis, improvement of the Enhanced Regional Situation Awareness system for the National Capital Region, the assessment of technologies for border and maritime security, and the development of architectures and systems for disaster response.

Aviation Research
Since 1971, Lincoln Laboratory has supported the Federal Aviation Administration (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 supports 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 netcentric data distribution; and the 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 Laboratory’s 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.

Projects supported by the Line are organized according to technology categories that are selected to address gaps in existing and envisioned mission areas. Nine technology categories were selected to include both core and emerging technology initiatives. Currently, five core-technology areas are 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 1,740 technical staff, 433 technical support personnel, 1,055 support personnel, and 520 subcontractors. Three-quarters of the technical staff have advanced degrees, with 42 percent 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 percent 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: 34%
- Computer Science, Computer Engineering, Computer Information Systems: 16%
- Biology, Chemistry, Meteorology, Materials Science: 10%
- Physics: 16%
- Mathematics: 7%
- Mechanical Engineering: 7%
- Aerospace/Astronautics: 5%
- Other: 5%

Academic Degrees Held by Staff

- Doctorate: 42%
- Bachelor’s: 20%
- Master’s: 36%
- No Degree: 2%
Lincoln Laboratory’s Economic Impact

During fiscal year 2015, the Laboratory issued subcontracts with a value of approximately $600 million. The Laboratory awarded subcontracts to businesses in all 50 states and purchased more than $351 million in goods and services from New England companies in 2015, with Massachusetts businesses receiving approximately $293 million. Economies in states as distant as California and Texas also realized significant benefits due to the Laboratory. More than 58 percent of Laboratory subcontracts were awarded to small businesses of all types in 2015.

Contract Award by Category of Business (FY2015)*

*As reported to the Defense Contract Management Agency (DCMA).
Lincoln Laboratory fiscal year runs concurrent with the U.S. Government fiscal year, October 1–September 30.
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 2015. Lincoln Laboratory expanded the number of noncredit courses organized and led by its technical staff members to seven activities. Many of this year’s IAP noncredit activities were held at Beaver Works.

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 to 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. In 2015, five VI-A students participated 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 2015, twelve undergraduates were hired as UROP interns and seven 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, students and 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 at the center of which is a project to develop technology that solves a real-world problem identified by Lincoln Laboratory researchers. 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. MIT undergraduate and graduate students participated in the Assistive Technologies Hackathon (ATHack) at Beaver Works. Teams of students prototyped engineering solutions to problems faced by the disabled, such as a voice-activated cane and a hands-free walker.

Beaver Works extends project-based learning to local K–12 schoolchildren. In 2015, 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**
Pacific Missile Range Facility, Kauai, Hawaii
Experimental Test Site, 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’ desires to help people in need and to motivate student interest in science, technology, engineering, and mathematics (STEM). The Laboratory accommodates an increasing number of outreach programs each year.

Lincoln Laboratory Outreach in 2015

Some of our most successful programs are listed below.

**LLRISE**

Nine technical staff members taught various portions of the fourth 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, MATLAB programming, electronics, and the principles of physics. Participants resided on the MIT campus, where they received advice on the college admissions process.

**LLCipher**

Lincoln Laboratory’s new 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 provide 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 14 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.

**Wearables Workshop**

Lincoln Laboratory’s Kristen Railey presented a full-day workshop to introduce high-school girls to engineering by having them make their own wearables—apparel and accessories that incorporate computer and electronic technologies. The girls left the workshop with 3D-printed bracelets but also with basic skills in computer-aided design (CAD), computer programming, and circuitry. The girls learned about the applications of 3D printers; attended a session on CAD software; and programmed light-emitting diodes for a shoe-wearable electronic circuit that they built.
Section 6
MIT and Industry

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MIT and Industry

Since its founding in 1861, MIT has fostered a problem-solving approach that encourages researchers to work together across departments, fields, and institutional boundaries. The resulting collaborations have included thousands of fruitful partnerships with industry.

- Industry sponsored R&D at MIT totaled $140.8 million in FY2016.

- Over 700 companies provided R&D/gift support to MIT; 40 companies funded $1 million+, 219 companies funded $100 thousand–$1 million.

Entrepreneurial Ecosystem

MIT also understands the fastest path from innovation to commercialization is often led by young, entrepreneurial start-up companies, and the Institute has taken great care to design and build a unique, highly effective entrepreneurial ecosystem. It brings the world’s best and brightest into a culture of “Mens et Manus,” i.e. “mind and hand” focused on discoveries of real, practical impact and strong commercial value.

MIT’s vibrant entrepreneurial ecosystem benefits from its historical entrepreneurial culture, supported by specialized entrepreneurship programs and classes, student clubs, and networking across all MIT departments and schools and between MIT and the surrounding entrepreneurship and venture capital community. Formal MIT institutions like the Technology Licensing Office, Venture Mentoring Service, and the Deshpande Center for Technological Innovation are committed to the continued health and growth of the MIT entrepreneurial ecosystem.

The substantial economic impact of MIT’s alumni entrepreneurs was quantified by a 2015 report on entrepreneurship and innovation that found:

- MIT alumni have launched 30,200 active companies, employing roughly 4.6 million people, and generating roughly $1.9 trillion in annual revenues—a figure greater than the gross domestic product (GDP) of the world’s 10th-largest economy.

- 25 percent of MIT alumni have founded companies, with more than 40 percent of these labeled as “serial entrepreneurs” (founding two or more companies).

- Alumni are engaged in entrepreneurship and innovation (E&I) at ever-increasing rates. In the 2000s, alumni launched around 12,000 new companies; halfway through the current decade, the number of new firms started has already reached 9,100.

Partnering at MIT

Industry partners at MIT are global industry leaders who understand that technological advantage and innovation are key drivers to their competitive advantage. These are leaders who have created and defined industries, who quickly grasp the implications of breakthrough technology. Industry managers engage fully in MIT’s collaborative, interdisciplinary culture, and join big thinkers who are perpetually focused on wringing practical applications from excellent ideas.

Strategic Partnerships

In 1994, MIT began to build new kinds of research partnerships, creating longer-term alliances with major corporations that would allow these companies to work with MIT to develop programs and strategies that address areas of rapid change. In return for their research and teaching support, the corporations share ownership of patentable inventions and improvements developed from the partnership. In a number of these alliances, funds are earmarked for specific education projects.
A selection of these partnerships are described below.

**ExxonMobil**
In 2014, ExxonMobil became a founding member of the MIT Energy Initiative (MITEI), a unique collaboration aimed at working together to advance and explore the future of energy. ExxonMobil has had a long and productive relationship with faculty and students at MIT, and in its most recent agreement 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. The agreement also establishes 10 graduate energy fellowship appointments each year at MIT (ExxonMobil Energy Fellows). These fellowships will support operating costs and expenses for talented graduate students while they pursue their selected areas of study and research.

**Novartis**
Novartis and MIT have launched a long-term research collaboration aimed at transforming the way pharmaceuticals are produced. The partnership, known as the Novartis-MIT Center for Continuous Manufacturing, will work to develop new technologies that could replace the conventional batch-based system in the pharmaceuticals industry—which often includes many interruptions and work at separate sites—with continuous manufacturing processes from start to finish. The Novartis-MIT Center for Continuous Manufacturing combines the industrial expertise of Novartis with MIT’s leadership in scientific and technological innovation.

**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. Research projects under the alliance are expected to focus on areas such as lighting for green buildings and cities; clinical decision support; clinical informatics; interventional guidance, planning, and assessment; and medical ultrasound, photonics, and bioinformatics.

**RIKEN**
RIKEN is a nonprofit corporation with financial support furnished by the Japanese government and industry. It has funded research at MIT in learning and memory, neuroscience of higher order cognition, and plasticity of the developing and mature brain. Since its 1998 “Agreement for Collaboration in Neuroscience Research, the fruitful RIKEN collaboration has created the RIKEN-MIT Neuroscience Research Center, the RIKEN Brain Science Institute (BSI), and the RIKEN-MIT Center for Neural Circuit Genetics, directed by Nobel Laureate Susumu Tonegawa.

**Samsung**
Samsung chose MIT for its energy research focus and the decision to embark on this collaboration was made in parallel with the establishment of its Advanced Materials Lab in Cambridge. Current project topics include energy storage, all-inorganic quantum dot photovoltaics, computational materials design (materials genome), and functional layer-by-layer synthesis.

**Tata**
The MIT Tata Center for Technology + Design was founded in 2012 with generous support from the Tata Trusts. The Center’s research and education mission is to develop solutions to challenges facing resource-constrained communities globally, with an initial focus on India. Center-affiliated faculty and graduate student Tata Fellows engage in hands-on projects, with an approach that is rigorous and relevant to societal, economic, environmental, and political factors. 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. See page 104 for more information.
Selected Projects

Desalination gets a graphene boost
A billion people around the world lack regular access to clean water, and that’s expected to more than double in the next 25 years. Jeffrey Grossman and the Grossman Group have demonstrated strong results showing that new filters made from graphene could greatly improve the energy efficiency of desalination plants and reduce costs. Grossman estimates the use of graphene filters would use 15 percent less energy for seawater and up to 50 percent less energy for brackish water. The Grossman Group is pursuing the challenge of creating high volumes of nonporous graphene membranes through chemical and thermal energy processes.

http://ilp.mit.edu/newsstory.jsp?id=21289

Leveraging digital technology to improve healthcare access, cost, and quality
As a serial entrepreneur and MIT researcher, Zen Chu embraces what he calls tectonic shifts in healthcare, not just the changing incentives in the United States but also consumer healthcare in emerging markets where smartphones and connectivity are increasingly ubiquitous. As the co-founder and lead faculty director of MIT Hacking Medicine, a program focused on healthcare transformation through technology, Chu convenes technologists, entrepreneurs, clinicians, and life scientists to review and assess new models and new ventures in digital healthcare at the core of these shifts. MIT’s Hacking Medicine Initiative applied the long history of hackathons in software and tailored it to the complexities and unique challenges of healthcare. Over 10,000 attendees at 40 events on 4 continents have learned the process of pitching healthcare problems, assembling teams around those problems, and attacking business models, experience design, and solutions with technology. As a result, Hacking Medicine has convened “a small army of some of the world’s best clinicians and health technologists” to judge and rate the best of the best apps, connected medical devices, and healthcare services.

http://ilp.mit.edu/newsstory.jsp?id=21964

Partnership of government, industry, and academia pursue integration of optical devices with electronics
MIT is a key player in a $600 million public-private partnership announced in 2015 that aims to spur the twin goals of improving integration of photonic systems while revitalizing U.S. manufacturing. MIT faculty manages important parts of the program: Michael Watts, an associate professor of electrical engineering and computer science, leads the technological innovation in silicon photonics. And Lionel Kimerling, the Thomas Lord Professor in Materials Science and Engineering, leads a program in education and workforce development. One expected impact of the new initiative is the development of a corridor along Interstate 90, from Boston to Rochester, New York, of industrial firms building on the base of new technology to develop related products and services, much as Silicon Valley emerged in California around companies such as Intel and their chip-making technology.

http://bit.ly/2d2ma1C

New institute will accelerate innovations in fibers and fabrics
An independent nonprofit founded by MIT was selected in 2016 to run a new, $317 million public-private partnership named the Advanced Functional Fabrics of America (AFFOA) Institute. The partnership is designed to accelerate innovation in high-tech, and U.S.-based manufacturing involving fibers and textiles. Yoel Fink, director of MIT’s Research Laboratory of Electronics (RLE), who will lead the new manufacturing initiative, says we are the dawn of a “fabric revolution.” New technology—some of it developed in Fink’s own laboratory—is making it possible to integrate many materials and complex functional structures into a fabric’s very fibers, and to create fiber-based devices and functional fabric systems. These new fabrics will do everything from storing energy to gathering “clinically meaningful information” about your health and where its heading.

MIT and Industry

Campus Research Sponsored by Industry

Industry Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2012–2016

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<tbody>
<tr>
<td>Campus research</td>
<td>109,744,829</td>
<td>106,447,700</td>
<td>112,379,455</td>
<td>119,238,077</td>
<td>128,308,988</td>
</tr>
<tr>
<td>Constant dollars*</td>
<td>114,910,250</td>
<td>109,633,200</td>
<td>113,962,442</td>
<td>120,043,783</td>
<td>128,308,988</td>
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*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2016 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2016
(shown in descending order of expenditures)

MIT Energy Initiative
Media Laboratory
Computer Science and Artificial Intelligence Laboratory
Chemical Engineering
Mechanical Engineering
Koch Institute for Integrative Cancer Research
School of Management
Biological Engineering
Aeronautics and Astronautics
Chemistry

MIT is a leader in conducting research sponsored by industry. Over 250 industrial sponsors supported research projects on the MIT campus in FY2016, with over $128 million in expenditures. Companies often join together in these collaborations to support multi-disciplinary research programs in a wide range of fields.
Managing the Industry/University Interface

Drawing on decades of successful industry collaboration, MIT has assembled a coordinated team of professionals who expertly manage the important industry/university interface, leveraging and exploiting proven pathways for two-way knowledge transfer.

Industrial Liaison Program
Officers at MIT’s Industrial Liaison Program (ILP) help 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 225 of the world’s leading companies partner with the Industrial Liaison Program to advance their research agendas at MIT, and ILP member companies account for over 40 percent of all single-sponsored research expenditures and corporate gifts/grants at MIT (FY2016).

Office of Corporate Relations
MIT’s Office of Corporate Relations (OCR), the organizational parent of the ILP, aids and directs companies interested in pursuing significant, multi-year, multi-disciplinary involvement with the Institute. OCR works with MIT senior administration, faculty, and company executives to structure and define individualized alliances that mutually benefit the company and MIT. The result is a holistic industry/university relationship that addresses broad needs and interests, from specific research projects and initiatives, to executive education, technology licensing, and recruitment.

Office of Sponsored Programs
The Office of Sponsored Programs’ mission is to conduct the centrally organized administrative, business, and financial functions related to award administration and to assist faculty, principal investigators, and their administrators in the identification of resources for and the management of individual sponsored projects consistent both with MIT’s academic and research policies and with the stewardship requirements of and obligations to external sponsors.

Technology Licensing Office
The MIT Technology Licensing Office (TLO) is a world class model of excellence in university technology licensing. Its staff is especially attuned to the needs of pre-competitive research and promotes an Intellectual Property protocol that accelerates commercialization, and, at the same time, honors MIT’s obligations to education and research. The TLO oversees a vibrant flow patenting/licensing activity.

<table>
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<tr>
<th>Technology Licensing Office Statistics for FY2016</th>
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<tbody>
<tr>
<td>Total number of invention disclosures:</td>
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<tr>
<td>Number of U.S. new utility patent applications filed:</td>
</tr>
<tr>
<td>Number of U.S. patents issued:</td>
</tr>
<tr>
<td>Number of licenses granted (not including trademarks and end-use software):</td>
</tr>
<tr>
<td>Number of options granted (not including options as part of research agreements):</td>
</tr>
<tr>
<td>Number of software end-use licenses granted:</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>
</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.

**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 Startup Exchange**

MIT Startup Exchange (STEX) connects industry to startups from across the MIT innovation ecosystem, fostering interactions that lead to strong partnerships. ILP members can engage the STEX community including 1000 active MIT-connected startup companies at all stages of development and representing seven technology clusters: ICT, Biotech, Nanotech, Energy Tech, Advanced Manufacturing, Healthcare, and Hybrid Innovation. STEX runs monthly workshops on topics in technology and innovation including robotics, mobility, biotech, energy, food, and cybersecurity. MIT STEX is a service of MIT’s Industrial Liaison Program (ILP).

**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.

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 School merges the power of Asian ambition with the best in Western education to produce Asia-ready change-makers and entrepreneurs. 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.

MIT and Masdar Institute Cooperative Program, United Arab Emirates
Since 2006, MIT has been collaborating and assisting the Masdar Institute of Science and Technology (Masdar Institute) to establish a graduate research university focused on alternative energy, sustainability, and advanced technology. Currently, Masdar Institute has a faculty body of 83 Assistant, Associate and Full Professors and over 400 graduate students.

MIT and Masdar Institute have collaborated on 72 research projects to date supporting Abu Dhabi’s goal of developing human capital for a diversified knowledge-based economy. By ensuring high-quality, graduate education and advanced research, Masdar Institute prepares a high-caliber workforce to keep pace with ever-increasing technological changes and a growing research and development culture. The Cooperative Program offers MIT and Masdar Institute faculty and students access to new talent, ideas, and rich research and educational collaborations.

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 109 for information on Singapore-MIT Undergraduate Research Fellowships.

http://smart.mit.edu/
Global Engagement

Singapore University of Technology and Design, Singapore
The MIT-SUTD Collaboration, which builds on more than a decade of MIT education and research activities in Singapore, is to date the largest and most complex university capacity-building endeavor in MIT's history.

The fifth cohort of students at the Singapore University of Technology and Design (SUTD) began their 3.5-year journey on May 16, 2016. Of the approximately 467 students, 38 percent were female, a percentage that is slightly below the previous years. There was also an increase of 81 students from the 2015 to the 2016 cohort. Once again MIT offered a winter program to 60 SUTD students. A third winter program in January 2017 is being planned again for 60 students. In this program, students from SUTD join MIT students for three weeks during IAP taking approximately 25-30 classes funded by the collaboration. All 87 of the contracted courses for development at MIT have been completed and transferred to SUTD. MIT is on track to complete its co-teaching obligation by the end of Summer 2016, when MIT faculty will have spent 40 two-week and 40 four-week residencies. The pillar head residencies will also be completed as of the end of Summer 2016. In 2016, MIT International Science and Technology Initiatives (MISTI) Singapore program sent 30 MIT students to SUTD to help with establishing clubs and extracurricular activities and leadership training. Summer 2016 will also mark the arrival to MIT of 34 students from SUTD for the fourth offering of a 10-week Global Leadership Program (GLP).

Current budgets for research at MIT in the MIT-SUTD collaboration run about $2 million per year for a total of $20 million over the 10-year research component contract. Approximately 57 faculty researchers and students at MIT are working on projects associated with the IDC. Two important hires were made to address the IDC’s future: Deb Payson, Director of Strategy and Outreach (February 2015), and Dr. Lennon Rodgers, Research Scientist (June 2015). It is hoped both hires will result in a more outward-facing IDC. This past year has seen progress toward developing an industry consortium, including two Industry Day forums where interested companies were invited for a day to learn more about the IDC.

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. MIT served as a key collaborator and advisor on programs, structures, policies, and operations in three key domains: research, education, and innovation/entrepreneurship. MIT helped establish the main elements of Skoltech’s educational programs, including a PhD program and Master of Science programs in IT, Energy, Space, Design and Manufacturing, and Biomedicine. MIT helped design and implement a faculty hiring and recruitment process as well as a student recruitment strategy and admissions process. MIT has hosted over 120 Skoltech Master’s students in Cambridge. Part of Skoltech’s effort to address specific real-world problems, which are also of high priority to the Russian Federation, is the establishment of a network of globally distributed Centers for Research, Education, and Innovation (CREIs). MIT designed and implemented a multi-stage submission and international peer-review process, and launched new MIT-led CREIs in Biomedicine, Electrochemical Energy Storage, and Energy Systems. Promoting innovation and entrepreneurship is central to Skoltech’s mission. Toward that end, MIT helped develop an entrepreneurship and innovation curriculum designed to provide foundational understanding in an action-based learning environment for Skoltech students, and helped build the administrative and operational foundations for knowledge transfer and commercialization of emerging technologies. The first phase of the collaboration ended in February 2016 and a new MIT Skoltech Program—reduced in scale and with a narrower focus on strategic advice and faculty-driven, collaborative research activities—launched immediately thereafter.

http://web.mit.edu/sktech/
Tata Center for Technology and Design, India
Now concluding its fourth year, the MIT Tata Center for Technology and Design provides holistic support—funding, education, and logistics—to MIT PIs applying their research to grand challenges in India and the developing world. Approximately 60 MIT faculty members from all five Schools have received support from the Center, and the Center has sponsored more than 100 graduate student Tata Fellows enrolled in Master’s and PhD programs across the Institute. These students, along with their faculty advisors, develop thesis projects that respond to large-scale opportunities to use technology and policy to improve the lives of people at the bottom of the economic pyramid. The researchers travel to India at least twice a year, generally during IAP and summer, to gather data, conduct field trials, and develop community connections. Researchers work closely with on-the-ground collaborators in the corporate, nonprofit, and government spheres.

This year, the Center’s project portfolio matured substantially, with several projects transitioning into commercialization or policy action and attracting follow-on funding. For example, a solar-powered water purification system using electrodialysis is being piloted in India and Gaza with substantial support from USAID; a team led by Professor James Wescoat has entered a formal collaboration with the Government of India to improve water supply management; and Khethworks, an agricultural company founded by graduates of the Tata program, is now headquartered in Pune, India. This year also saw the first annual Tata Center Symposium at MIT, bringing together the MIT community with influential visitors from India to explore areas of need and form new collaborations. The second, larger edition of the Symposium will be held in Fall 2016. The Tata Center adds twelve new projects to its portfolio in the 2016-17 academic year.

http://tatacenter.mit.edu/

Faculty and Research Collaboration
Accelerating Innovation in Brazil, Brazil
In 2014, the MIT Industrial Performance Center (IPC) launched a five-year research project, Accelerating Innovation in Brazil, which focuses on building greater innovation capacity in Brazil particularly as it relates to the new network of Institutes of Innovation created by SENAI, Brazil’s National Service for Industrial Training. Building upon the German Fraunhofer model, SENAI (the sponsor of the IPC research) 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 their relationships with firms, universities and other important actors within Brazil’s “innovation ecosystem” to provide insight into how to position the ISIs to support greater innovation in Brazil and encourage a more innovative, open, globally competitive economy.

Center for Clean Water and Clean Energy at MIT and KFUPM, Saudi Arabia
Technologies related to the production of fresh water and low-carbon energy are the focus of a research and educational partnership between MIT’s Department of Mechanical Engineering and King Fahd University of Petroleum and Minerals (KFUPM) in Dhahran, Saudi Arabia. The joint program operates through the Center for Clean Water and Clean Energy and focuses on topics such as desalination, solar energy, nanoengineered membranes, pipeline leak detection, and advanced manufacturing. The eight-year collaboration has included fifteen large-scale collaborative research projects, eleven education and curriculum development projects, and several administration development projects. Approximately 30 MIT professors have participated, along with 90 faculty at KFUPM, 260 MIT graduate students and postdocs and 60 at KFUPM. KFUPM faculty and graduate students have had the opportunity to do work at MIT, amounting to 140 visits. The project to date has produced more than 500 papers and 65 US patents. In 2009, the Center created the Ibn Khaldun Fellowship for Saudi Arabian Women which brings PhD holders to MIT for research with our faculty. The Center is directed by Professor John H. Lienhard V and co-directed by Professor Kamal Youcef-Toumi.
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, Cross-cloud: a decentralized architecture for social networks, 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, and video magnification and video comparison for sports, urban data analytics to improve mobility for growing cities in the context of mega events—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 eminent 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.

Hong Kong Innovation Node, Hong Kong
The MIT Hong Kong Innovation Node convenes students, faculty, and researchers from MIT to work on various entrepreneurial and research-based projects alongside students, faculty, alumni, entrepreneurs, and businesses based in Hong Kong. By combining resources and talent, the Innovation Node strives to help students to learn how to move ideas more rapidly from the lab to market.

The Innovation Node aims to be a collaborative space to connect the MIT community with unique resources—including advanced manufacturing capabilities—and other opportunities in Hong Kong and the neighboring Pearl River Delta. In June 2016, the MIT Hong Kong Innovation Node formally launched with MIT Kickstart, a unique hardware system accelerator program. The inaugural program brought together 12 MIT students with 12 students from universities throughout Hong Kong for an immersive week-long workshop led by a team of MIT faculty, alumni and local entrepreneurs.

MIT and the Instituto Tecnológico de Monterrey, Mexico
Launched in 2015, this is a partnership established between MIT and the Instituto Tecnológico de Monterrey with the goal of fostering exchanges and collaborations among researchers at both institutions focused on the general area of nanotechnology and nanoscience. The ultimate goal is to support the Tec in its quest to become a research university with global reach. 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 inaugural year, three faculty members and five postdoctoral researchers spent time at MIT working with MIT faculty in areas of telecommunications, biotechnology, microfluidics and nanofabrication. In the second cohort, one faculty member, two postdocs, three graduate students and two undergraduate students will participate in a wide range of research activities in visits that will span between 3 and 12 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, 46 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.
**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 well-designed programs 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. Moreover, MPP contributed to the strengthening of innovation and entrepreneurship at Portuguese universities through a variety of activities, including entrepreneurial education. The objectives of MPP’s second phase include the support of a higher education ecosystem connected to technology development and innovation, the promotion of close research collaborations involving students, faculty, and industry, and further development of trans-disciplinary innovation and entrepreneurship. By early 2016, MPP has enrolled 950 students in Portugal, supported 200 MPP students and scholars at MIT, and involved 270 faculty in Portugal as well as 80 faculty at MIT. Over the years, MPP has become a widely known success and a model for international alliances involving universities, industry, and government with the goal of increasing international competitiveness by fostering skill and knowledge creation and exchange, leading to innovation, entrepreneurship, and societal impact.

www.mitportugal.org

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**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 for establishing significant impact 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 as one of its goals to increase brand awareness of MIT in order to enhance connections with area alumni and create avenues for potential corporate partnerships and research collaborations in academic institutions in Latin America.

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, hosted by MITEI. Under the leadership of Roland Pellenq (CNRS Research Director 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 5 senior CNRS researchers, around 10 postdocs and students working with MIT faculty of various departments on exciting projects related to the fundamental physics of materials for energy and the environment ranging from cement, shale gas, nuclear waste to urban physics. The UMI is supported through the Laboratory of Excellence ICoME2 grant from the French NSF (3M euros grant for 4 years, with 2M€ allocated to the UMI).

Thanks to this first-of-a-kind institutional agreement between CNRS and MIT, the UMI has become an integral part of the intellectual research and educational environment of MIT. 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 dual affiliation of CNRS researchers as “Visiting Professors” allowed the integration into the educational landscape of MIT. Furthermore, the UMI with MIT faculty organizes each January the Marseille winter school (now part of the MIT IAP program) on the science and engineering of multi-scale porous materials. On the resource development side, the UMI has become a privileged point of contact for large French firms.

In sum, the UMI has been fully integrated at MIT as a highly productive research unit dealing with critical research issues required for the sustainable development of key industrial sectors. By bringing CNRS researchers to the problem-/solution-driven engineering science context of MIT, new “out-of-the-box” approaches are emerging of high economic, societal and ecological value; relevant for both the United States and France. The UMI is as much a window for France to US academia, as it is for MIT to France and Europe. The UMI has now entered its “Phase II” and a new agreement is expected during fall 2016.

Other Global Initiatives

Center for Advanced Urbanism
The overall goal of the MIT Center for Advanced Urbanism (CAU) is to establish a new theoretical and applied research platform to transform the quality of urban life. The Center is committed to achieving this goal via collaborative interdisciplinary research projects, intellectual discourse, leadership forums and conferences, publications, education of a new generation of leaders in the field, and a distinctive, highly influential presence at international gatherings focused on urbanism.

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.

Digital Learning

MITx and MIT OpenCourseWare represent MIT’s largest and most far-reaching international outreach programs. MITx on edX is the Institute’s interactive learning initiative that offers online versions of MIT courses on edX, a collaboration in online education between 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.

Since the first MITx course was offered in August 2012, there have been more than 4 million enrollments in MITx courses, with nearly 1.9 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

<table>
<thead>
<tr>
<th>Metric</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative total enrollment</td>
<td>4.0 million*</td>
</tr>
<tr>
<td>Cumulative total participation</td>
<td>2.3 million</td>
</tr>
<tr>
<td>Certificates of Completion</td>
<td>142 thousand</td>
</tr>
<tr>
<td>ID-verified Certificates</td>
<td>48 thousand</td>
</tr>
</tbody>
</table>

*1.9 million unique enrollments

MIT OpenCourseWare (OCW) is a free, open, publicly accessible web-based resource that offers high-quality educational materials from more than 2,350 MIT courses, reflecting the undergraduate- and graduate-level teaching in all five MIT schools and 33 academic units. This coverage in all disciplines makes OCW unique among open education offerings around the world. MIT continually updates OCW, adding new courses as they become available and refreshing existing courses with new materials. More than 1,000 MIT OCW courses have been independently translated into at least 10 other languages.

On average OCW attracts about 2.3 million visits per month, and to date more than 200 million people from virtually 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 astonishing results. Please see http://ocw.mit.edu/about/ocw-stories/ for inspiring examples.

International Study Opportunities

There are 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 educational experiences 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 the Imperial College London and the University of Tokyo. The Department of Political Science has an exchange program with Sciences Po in France.

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.

MIT-Madrid Program
The MIT-Madrid Program gives students the opportunity to study in Madrid for the spring term during their sophomore or junior year. Depending upon major and interests, students can choose engineering courses at the Universidad Politécnica de Madrid and/or science, humanities, arts, and social sciences courses at the Universidad Complutense de Madrid; instruction and coursework are in Spanish. In addition to academic courses, students can participate in an internship during this program.

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 excites them about research and they consider a career in research. Their research experiences are supplemented with numerous social activities that are arranged for them. 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 20,000 professionals from 70+ countries 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 98.

Other Study Abroad Options
MIT students may also apply for admission directly to foreign institutions that offer study abroad programs or to a study abroad program administered by another US institution or study abroad provider. Examples of such opportunities include l’École Polytechnique in France, the London School of Economics, Oxford University and other UK institutions, and a number of programs in China.
MIT International Science and Technology Initiatives

MIT International Science and Technology Initiatives (MISTI), MIT’s flagship international education program, connects MIT students and faculty with research and innovation around the world. Working closely with a network of premier corporations, universities and research institutes, MISTI matches over 800 MIT students with internship, teaching, research and entrepreneurial opportunities abroad each year. After several semesters of cultural and language preparation on campus, MISTI students participate in rigorous, practical work experience in industry and in academic labs and offices. Projects are designed to align the skills and interests of the student with the needs of the host. MISTI programs are available in Africa, Belgium, Brazil, Chile, China, France, Germany, India, Italy, Japan, Korea, Mexico, the Netherlands, Portugal, Russia, Singapore, Spain, and Switzerland.

Through the MISTI Global Seed Funds program (GSF), MISTI provides grants for MIT faculty to develop research collaborations with their counterparts in foreign institutions. All grantees are encouraged to include both undergraduate and graduate students in their projects. Taking advantage of synergies between their student programs and the seed funds, MISTI offers tailored training modules to help seed fund students derive the most benefit from their international experiences. MISTI GSF grants often lead to new pathways for participating students, who learn firsthand the importance of international networks in the context of their own research interests. Seed funds are currently offered in Argentina, Belgium, Brazil, Chile, China, France, Germany, Israel, Italy, Japan, Korea, Mexico, Peru, Spain and Turkey.

MISTI’s approach to international education builds on MIT’s distinctive traditions of combining classroom learning and hands-on experience in Undergraduate Research Opportunities (UROPs), cooperative programs with industry, practice schools, and internships. In contrast to other universities’ internationalization programs that mainly involve study abroad, MISTI matches individual students with work or research opportunities in their own fields.

http://misti.mit.edu

Here are a few examples from the more than 6,500 students MISTI has placed since it began by sending a handful of interns to Japan at the end of the 80s:

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

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

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

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

Physics major Jason Brylowski 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.
MISTI Programs and Start Year

- Arab World, 2014
- Belgium, 2011
- Brazil, 2009
- Chile, 2011
- China, 1994
- France, 2001
- Germany, 1997
- India, 1998
- Israel, 2008
- Italy, 1999
- Japan, 1983
- Korea, 2012
- Mexico, 2004
- Netherlands, 2012
- Portugal, 2014
- Russia, 2012
- Singapore, 2012
- South Africa, 2012
- Spain, 2006
- Switzerland, 2010

MISTI Global Seed Fund Projects by Country 2015–2016

- Mexico
- Italy
- Brazil
- France
- Israel
- Germany
- China
- Peru
- Belgium
- Japan
- United Kingdom
- Egypt
- Spain
- Australia
- Hong Kong
- Iceland
- Jordan
- New Zealand
- South Africa
- Switzerland
- Taiwan
- Turkey
- Singapore
- Uganda

MISTI Annual Internship Placements 1994–2016*

*MISTI year runs from September 1–August 31. 2016 represents the 2015–2016 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 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 2015 report, the number of international students enrolled in U.S. colleges during the 2014–2015 academic year reached a record high of 974,926 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 2014–2015 academic year, international students and their dependents contributed $30.5 billion to the U.S. economy through tuition, fees, and living expenses and support 373,381 jobs.
Global Engagement

International Undergraduate Students
Top Countries of Citizenship, 2015–2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>57</td>
</tr>
<tr>
<td>India</td>
<td>32</td>
</tr>
<tr>
<td>Canada</td>
<td>24</td>
</tr>
<tr>
<td>South Korea</td>
<td>24</td>
</tr>
<tr>
<td>Brazil</td>
<td>23</td>
</tr>
<tr>
<td>Thailand</td>
<td>20</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>18</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>12</td>
</tr>
<tr>
<td>Mexico</td>
<td>10</td>
</tr>
<tr>
<td>Turkey</td>
<td>10</td>
</tr>
</tbody>
</table>

International Graduate Students
Top Countries of Citizenship, 2015–2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>634</td>
</tr>
<tr>
<td>India</td>
<td>304</td>
</tr>
<tr>
<td>Canada</td>
<td>234</td>
</tr>
<tr>
<td>South Korea</td>
<td>187</td>
</tr>
<tr>
<td>France</td>
<td>92</td>
</tr>
<tr>
<td>Singapore</td>
<td>87</td>
</tr>
<tr>
<td>Taiwan</td>
<td>70</td>
</tr>
<tr>
<td>Russia</td>
<td>70</td>
</tr>
<tr>
<td>Brazil</td>
<td>69</td>
</tr>
<tr>
<td>Germany</td>
<td>68</td>
</tr>
</tbody>
</table>

International Students by Geographic Region of Country of Citizenship
1884–2016
Many international students remain in the U.S. after graduation. The graph below shows the post-graduation plans of international students graduating in 2015, as reported in a survey administered by MIT. Seventy-eight percent of international students plan to remain in the U.S. after graduation.

**Percentage of 2015 International Student Graduates Remaining in the U.S. by Degree and Post-Graduation Plans**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Graduate Study</th>
<th>Working</th>
<th>Graduate Study</th>
<th>Working</th>
<th>Working</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor’s</td>
<td>89%</td>
<td>88%</td>
<td>90%</td>
<td>69%</td>
<td>78%</td>
</tr>
</tbody>
</table>

**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 haute etudes internationals 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.

**Rafael del Pino, SM Management ’86**
After graduating from MIT, del Pino returned to the Ferrovial Group, a company founded by his father, where he became chief financial officer in 1989 and CEO in 1992. He was appointed chairman in 2000. During del Pino’s tenure as CEO and later as chairman, Ferrovial has been transformed from a mostly domestic, privately held construction company into an international leader in the development of private infrastructure, mainly toll roads and airports, with activity in more than 40 countries.

**Ilan Goldfajn, PhD Economics ’95**
Ilan Goldfajn is an economist whose career has spanned the public and private sectors. Since 2009, he has served as chief economist at Itaú Unibanco in Brazil, the largest Latin American bank and one of the fifteen largest banks worldwide, with over 100,000 employees and revenue of $72 billion in 2011. Prior to Itaú, Goldfajn was a founding partner at consulting firm Ciano Consultoria (2008 to 2009) and hedge fund Ciano Investimentos (2006 to 2008). From 2003 to 2006, he was chief economist and risk officer at the investment firm Gávea Investimentos.
Benjamin Netanyahu, SB Architecture 1975, SM Management 1976
Currently serving his second term as Prime Minister of Israel, Benjamin Netanyahu was born in 1949 in Tel Aviv, Israel and grew up in Jerusalem. He served as Israel’s ambassador to the United Nations from 1984 to 1988, during which time he led the effort to declassify the United Nations’ archive on crimes committed by Nazi Germany. Netanyahu, a member of the Likud party, was Israel’s Prime Minister from 1996 until 1999. During his first term as Prime Minister, Netanyahu implemented policy that combined fighting terror with advancement of the peace process. Its cornerstone was the conclusion of well-measured agreements with the Palestinians that insisted on reciprocity. During his three-year term, the number of terror attacks drastically decreased.

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 F. 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 and Cognitive Sciences ‘93
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 degrees 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. In August 2003, Tan won the Singapore presidential election in 2011 and is currently serving as the 7th President of Singapore.

Songyee Yoon, PhD Brain and 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 year July 1, 2015 through June 30, 2016, The International Scholars Office (ISchO) served 2,436 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 an increase of 1.4 percent over last year (2,403). According to the most recently published Institute of International Education Open Doors report (2015), MIT ranked 11th 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. The top ten countries of origin of the entire international scholar population in the U.S. are roughly the same. Scholars from these top 10 countries constituted nearly 65 percent of MIT’s international scholar population. Seventy-six percent of international scholars at MIT were men and 24 percent were women. The greatest number of international scholars came to join departments in the School of Engineering, followed by the School of Science, interdisciplinary laboratories and centers under the Vice President for Research, and the School of Architecture and Planning.

<table>
<thead>
<tr>
<th>Country</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>434</td>
</tr>
<tr>
<td>India</td>
<td>173</td>
</tr>
<tr>
<td>Canada</td>
<td>155</td>
</tr>
<tr>
<td>South Korea</td>
<td>149</td>
</tr>
<tr>
<td>Germany</td>
<td>139</td>
</tr>
<tr>
<td>Japan</td>
<td>128</td>
</tr>
<tr>
<td>France</td>
<td>110</td>
</tr>
<tr>
<td>Italy</td>
<td>106</td>
</tr>
<tr>
<td>Israel</td>
<td>105</td>
</tr>
<tr>
<td>Spain</td>
<td>93</td>
</tr>
</tbody>
</table>

International Scholars by Geographic Region, 2015–2016

- Asia: 42%
- Europe: 35%
- North America: 6%
- Middle East: 9%
- Mexico, Latin America & Caribbean: 6%
- Africa: 1%
- Oceania: 1%
Selected Projects

Can today’s EVs make a dent in climate change?
Could existing electric vehicles (EVs), despite their limited driving range, bring about a meaningful reduction in the greenhouse-gas emissions that are causing global climate change? Researchers at MIT have just completed the most comprehensive study yet to address this hotly debated question, and have reached a clear conclusion: Yes, they can.

The study, which found that a wholesale replacement of conventional vehicles with electric ones is possible today and could play a significant role in meeting climate change mitigation goals, was published in the journal *Nature Energy* by Jessika Trancik, along with graduate student Zachary Needell, postdoc James McNerney, and recent graduate Michael Chang SM ’15.

“Roughly 90 percent of the personal vehicles on the road daily could be replaced by a low-cost electric vehicle available on the market today, even if the cars can only charge overnight,” Trancik says, “which would more than meet near-term U.S. climate targets for personal vehicle travel.” Overall, when accounting for the emissions today from the power plants that provide the electricity, this would lead to an approximately 30 percent reduction in emissions from transportation. Deeper emissions cuts would be realized if power plants decarbonize over time.

The work was supported by the New England University Transportation Center at MIT, the MIT Leading Technology and Policy Initiative, the Singapore-MIT Alliance for Research and Technology, the Charles E. Reed Faculty Initiatives Fund, and the MIT Energy Initiative.


New system can rapidly switch glass from transparent to dark—and keep it that way without power
A team of researchers at MIT has developed a new way of making windows that can switch from transparent to opaque, potentially saving energy by blocking sunlight on hot days and thus reducing air-conditioning costs. While other systems for causing glass to darken do exist, the new method offers significant advantages by combining rapid response times and low power needs. Once the glass is switched from clear to dark, or vice versa, the new system requires little to no power to maintain its new state; unlike other materials, it only needs electricity when it’s time to switch back again.

The results are reported in the online journal *Chem*, in a paper by Mircea Dincă, doctoral student Khalid Al-Kaabi, and former postdoc Casey Wade.

The research was partly funded by an organization in a region where such light-blocking windows would be particularly useful: The Masdar Institute, based in the United Arab Emirates, through a cooperative agreement with MIT. The research also received support from the U.S. Department of Energy, through the Center for Excitonics, an Energy Frontier Center.


New microfluidic device offers means for studying electric field cancer therapy
Researchers at MIT’s research center in Singapore have developed a new microfluidic device that tests the effects of electric fields on cancer cells. They observed that a range of low-intensity, middle-frequency electric fields effectively stopped breast and lung cancer cells from growing and spreading, while having no adverse effect on neighboring healthy cells.

The device, about the size of a U.S. dollar coin, is designed to help scientists narrow in on safe ranges of electric fields to noninvasively treat breast, lung, and other forms of cancer. The results are published online in *Scientific Reports*.

The paper’s co-authors include Roger Kamm, research scientists Andrea Pavesi and Giulia Adriani, postdoc Majid Ebrahimi Warkiani, and student Andy Tay of the Singapore-MIT Alliance for Research and Technology (SMART). Senior research officer Wei Hseun Yeap and associate professor Siew Cheng Wong of the Singapore Immunology Network also contributed to the report. This research was supported, in part, by the National Research Foundation of Singapore through the SMART BioSystems and Micromechanics interdisciplinary research group.

http://bit.ly/2d3kx1B
### Campus Research Sponsored by International Organizations

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

#### Fiscal Years 2012–2016

<table>
<thead>
<tr>
<th>International Sponsor Type</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations and other nonprofits</td>
<td>25,025,346</td>
<td>29,381,412</td>
<td>35,830,415</td>
<td>36,301,791</td>
<td>33,597,572</td>
</tr>
<tr>
<td>Government</td>
<td>37,712,878</td>
<td>32,651,167</td>
<td>28,803,960</td>
<td>26,712,520</td>
<td>26,673,866</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>110,872,115</strong></td>
<td><strong>103,954,737</strong></td>
<td><strong>106,762,179</strong></td>
<td><strong>110,620,964</strong></td>
<td><strong>108,990,231</strong></td>
</tr>
</tbody>
</table>

#### Constant dollars*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>116,090,594</td>
<td>107,065,634</td>
<td>108,266,041</td>
<td>111,368,443</td>
<td>108,990,231</td>
</tr>
</tbody>
</table>

*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2016 equaling 100.
Section 8

Service to Local and World Communities

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Office of Government and
Community Relations 121
Abdul Latif Jameel Poverty Action Lab 122
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World Programs 124
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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. PKG Center programs 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.

The PKG Center goal is to enrich the MIT education for students through hands-on, real-world opportunities that complement the innovative culture of MIT. PKG Center 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 U.S. and abroad, working in sectors such as agriculture, water and sanitation, climate change, community development, assistive technology, education, environmental sustainability, food and agriculture, health and health technology, technology dissemination, and urban planning.

IDEAS Global Challenge

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

ReachOut Tim Tutors

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

http://web.mit.edu/mitpsc/
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 this past winter 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
ASB 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. We 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. FUP 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 and staff expertise, and volunteer engagement. In addition, OGCR collaborates with the MIT Priscilla King Gray Public Service 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 network of over 142 researchers from leading universities who use randomized evaluations to answer critical questions in the fight against poverty. J-PAL was founded on the belief that development programs can be made more effective, creating positive change in the lives of the poor, if policymakers have access to rigorous scientific evidence of what works.

J-PAL’s mission is to reduce poverty by ensuring that policy is informed by scientific evidence. We do this through three main activities: (1) increase scientific evidence on poverty reduction through randomized evaluations, (2) promote a culture of evaluations through training and facilitating the use of evidence in the policymaking process, and (3) encourage the use of rigorous research findings in the design and scale-up of poverty alleviation programs through outreach, promotion, and technical advising.

J-PAL was founded at MIT in 2003 as a research institute in the Department of Economics. In addition to its headquarters at MIT, J-PAL has expanded to six regional offices hosted by local universities in Africa (University of Cape Town), Europe (Paris School of Economics), Latin America (Pontificia Universidad Católica de Chile), North America (MIT), South Asia (Institute for Financial Management & Research), and Southeast Asia (University of Indonesia). Within each region, J-PAL works across eight sector areas, including Agriculture, Crime & Criminal Justice, Education, Environment & Energy, Finance & Microfinance, Health, Labor Markets, and Political Economy & Governance.

Research
J-PAL affiliates have conducted more than 775 randomized evaluations in over 60 countries. Recent research by J-PAL affiliates includes: an evaluation by Banerjee (MIT), Duflo (MIT), Glennerster (J-PAL), and Kinnan (Northwestern) on the impact of increased access to microcredit on the economic and social well-being of women and their families in India; a six-country study by Banerjee (MIT), Duflo (MIT), Goldberg (IPA), Karlan (Yale), Osei (University of Ghana), Pariente (Princeton), Shapiro (Princeton), Thuysbaert (Ghent University), and Udry (Yale) that found that a comprehensive livelihood program for the poor was a cost-effective and lasting way to boost livelihoods, income, and health; and an evaluation by Olken (MIT), Onishi (World Bank), and Wong (World Bank) that found that community block grants improved health and education in Indonesian villages, and adding performance incentives sped up improvements in health.

Capacity Building
J-PAL also aims to increase the capacity of governments, NGOs, and other organizations to produce their own evidence to inform effective development policy. J-PAL has equipped more than 7,630 practitioners with the expertise to conduct their own rigorous evaluations through training courses and joint research projects.

Policy Outreach
J-PAL affiliates and staff analyze and disseminate research results and build partnerships with policymakers to ensure that policy is informed by evidence and to scale up programs that are found to be highly effective. Such programs have included environmental audit reforms, school-based deworming, remedial education, free insecticidal bed nets, chlorine dispensers for safe water, skills training for police officers, conditional community block grants, building stable livelihoods for the ultra-poor, and improved distribution of subsidized rice. Programs that were found to be successful by J-PAL affiliates and then scaled up in different parts of the world have reached over 300 million people.

https://www.povertyactionlab.org/
Service to Local and World Communities

J-PAL North America

J-PAL North America (NA), one of J-PAL's six regional offices, is also based at MIT. J-PAL NA collaborates with decision-makers in local, state, and federal government, and with social organizations, to inform policy with scientific evidence, conduct trainings, and institutionalize impact evaluation. J-PAL NA's work spans several areas including: Crime Prevention, Education, Energy Conservation, Financial Literacy, Health Care Delivery, Housing Mobility, Labor Markets, and Political Participation. Recently, J-PAL NA launched its new State and Local Innovation Initiative and Health Care Delivery Innovation Competition, which each award selected agencies or organizations with connections to researchers, ongoing technical assistance, and funding to implement randomized evaluations concerning critical policy issues. J-PAL affiliates are conducting or have completed 149 randomized evaluations in the region. J-PAL NA is led by two Co-Scientific Directors: Amy Finkelstein (MIT) and Lawrence Katz (Harvard University).

Local Programs

Amphibious Achievement

Amphibious Achievement is an MIT student group that mentors high school students in the Boston-Cambridge area in both athletics and academics. Under the guidance of MIT student coaches/tutors, Amphibious Achievers train to row and swim competitively while also working on critical reading techniques, math problem solving, and grammar comprehension in an SAT-based curriculum.

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/

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/
Fly-by-Wire Project with Quinsigamond Community College

The Office of Digital Learning, through its Strategic Educational Initiatives unit, is taking the lead in developing collaborations with community colleges. These projects include curriculum development in areas such as advanced manufacturing and online learning using edX and other MIT technologies. The design of these projects reflects the MIT mens et manus philosophy of blending online/virtual instruction with hands-on learning. The Fly-by-Wire project is a collaboration between MIT, Quinsigamond Community College (MA), and Arapahoe Community College (CO). Adaptive assessments will be provided to students in college algebra, CAD (computer aided drafting), and accounting, where students will be given supplemental questions depending on their responses to previous questions. All questions will be linked to a learning outcome map, which provides the pathways for student knowledge.

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 Priscilla King Gray Public Service 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.

Massachusetts Community College Project

The Office of Digital Learning, through its Strategic Educational Initiatives unit, is taking the lead in developing collaborations with community colleges. These projects include curriculum development in areas such as advanced manufacturing and entrepreneurship, and online learning using edX and other MIT technologies. The design of these projects reflects the MIT mens et manus philosophy of blending online/virtual instruction with hands-on learning. With funding from the federal Trade Adjustment Assistance Community College and Career Training (TAACCCT) Grant Program, ODL is working with 15 Massachusetts community colleges to develop blended courses in advanced manufacturing. Other collaborations are in the proposal or design stages.

MIT-Woodrow Wilson Academy of Teaching and Learning

The MIT pK-12 Action Group in ODL, with collaborators across MIT, is designed to combine MIT’s mens et manus approach to learning with recent breakthroughs in cognitive science and digital learning to help develop and support excellent STEM (Science, Technology, Engineering, Math) teachers and school leaders. The pK-12 Action Group was launched through the work of a faculty group, facilitated by ODL, which articulated the foundational principles for this effort: To change the world through learning with access to quality STEM education for all, and to change the world of learning through rigorous research. The pK-12 Action Group has been bootstrapped by $9.9 million in seed funding from the Woodrow Wilson National Fellowship Foundation for collaboration aimed at supporting teachers in their efforts to use emerging digital learning tools and environments, especially in STEM areas. The effort will promote new ideas, technologies, and curricula along with research related to educator preparation with a focus on STEM subjects for students from pre-kindergarten through the senior year of high school. The Woodrow Wilson Academy will open its doors in June 2017 to its first matriculating class of 25 students.

World Programs

Comprehensive Initiative on Technology Evaluation

The Comprehensive Initiative on Technology Evaluation (CITE) at MIT is the first-ever program dedicated to developing methods for product evaluation in global development. CITE evaluates products’ suitability, scalability, and sustainability, and seeks to integrate these criteria to develop a deep understanding of what makes products successful in emerging markets. CITE’s evaluations provide evidence for data-driven decision-making by development workers, donors, manufacturers, suppliers, and consumers themselves. CITE is a five-year program funded by USAID’s Global Development Lab and led by the Department of Urban Studies and Planning.

http://cite.mit.edu/
Connected Learning Initiative
Connected Learning Initiative (CLIx) is a bold and innovative collaboration between the Tata Groups (Tata Trusts, Tata Institute of Social Sciences Center for Education Innovation and Action Research) and MIT. Its goal is to improve the professional and academic prospects of high school students in underserved communities in India. CLIx aims to impact approximately 1,000 schools, 165,000 students, and 4,400 teachers in four states during 2015–2017. The expected outcomes are to raise social capital and expand educational opportunities for India’s youth substantially and positively and to arrive at a model that can have global relevance.

D-Lab
MIT D-Lab is building a global network of innovators to design and disseminate technologies that meaningfully improve the lives of people living in poverty. The program’s mission is pursued through interdisciplinary courses (2,019 developed to date, about a dozen offered each year), technology development, and community initiatives, all of which emphasize experiential learning, real-world projects, community-led development, scalability, and impact assessment. Founded by Amy Smith, Senior Lecturer in Mechanical Engineering, D-Lab has developed a range of technologies and processes including community water testing and treatment systems, human powered agricultural processing machines, medical and assistive devices for global health, and clean-burning cooking fuels made from waste. All D-Lab classes and projects are connected to communities around the world in countries including Brazil, Nicaragua, Honduras, Guatemala, El Salvador, Haiti, Ghana, Lesotho, Nigeria, Tanzania, Uganda, Zambia, Cambodia, Nepal, India, and the Philippines. In addition to its course offerings and fieldwork, D-Lab is home to research groups including the Biomass Fuel and Cookstoves Group, the Mobile Technology Group, and the Off-Grid Energy Group. D-Lab has also spearheaded an initiative called Lean Research, promoting principles for human-centered research.

D-Lab Scale-Ups
D-Lab Scale-Ups was established in 2011 to identify and support technologies with potential for wide-scale poverty alleviation. The program includes an accelerator for MIT social entrepreneurs, a technical assistance program, research and development, and collaboration with industry. As of 2014, the Scale-Ups Fellowship program has supported 2,316 social entrepreneurs working in sectors including health care, waste recycling, water sanitation, solar energy, and agriculture. The Scale-Ups fellows have launched ventures in less-industrialized markets in Africa, Central and South America, and Asia. Scale-Ups’ technical assistance program for agricultural waste charcoal briquette enterprises in East Africa is facilitated by the Harvest Fuel Initiative, a collaborative effort by D-Lab and New York-based nonprofit The Charcoal Project. Research and development work focuses on solar lighting, biomass fuel and cookstoves, water transportation and storage, and agriculture. In the fall of 2014, D-Lab Scale-Ups launched the Practical Impact Alliance at MIT to promote collaborative action and shared learning among corporations, academic institutions, social ventures, and nongovernmental organizations in order to scale market-driven poverty solutions worldwide. Each year since 2012, Scale-Ups has lead the organization of the MIT Scaling Development Ventures conference.

http://d-lab.mit.edu/scale-ups/overview/
International Development Innovation Network
The International Development Innovation Network (IDIN) is building a diverse, international network of innovators to define development problems, prototype solutions to these challenges, perform comparative evaluations, move the most promising solutions forward, and incubate ventures to disseminate the solutions. At the core of IDIN is a network of approximately 54,200 inventors, technologists, and social entrepreneurs from almost 530 countries around the world. IDIN is supporting and building this network through hands-on design summits, focused entrepreneurship training modules, micro-grants, and networking within and outside the network. IDIN also includes research, monitoring, and evaluation functions to document and assess its work to ensure that best practices are identified and supported. In addition to MIT, IDIN consortium institutions include Olin College of Engineering, Colorado State University, University of California-Davis, Kwame Nkrumah University of Science and Technology (Ghana), Singapore Polytechnic, the ECHO East Africa Impact Center (Tanzania), and the National Technology Business Center (Zambia), as well as three IDIN innovation centers in Brazil, Uganda, and Tanzania.

[http://d-lab.mit.edu/idin/](http://d-lab.mit.edu/idin/)

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

[http://legatum.mit.edu/](http://legatum.mit.edu/)
Selected Projects

**MIT-USAID program releases technology evaluation of water test kits**

How do you know your water is clean and safe to drink? Whether you live in Flint, Michigan, or a half a world away in northwest India, many families don’t have a good answer to this question.

MIT researchers have launched a report evaluating water test kits in Ahmedabad, India, where water-testing technologies are widely used by local governments and nonprofits, but are not yet available at the household level. The report, *Streamlining a Methodology for Product Evaluation: Water Test Kits in India*, 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 U.S. Agency for International Development (USAID) and led by a multidisciplinary team of faculty, staff, and students at MIT.

Launched in 2012, CITE is a pioneering program dedicated to developing methods for product evaluation in global development. CITE researchers evaluate products from three perspectives, including suitability, scalability, and sustainability.

In India, 91 million people lack access to an improved drinking water source, putting them at risk for waterborne diseases. Without access to reliable, low-cost water testing labs, many development organizations and governments have turned to portable water test kits as a stopgap solution for testing community water quality, said CITE Water Test Kit Evaluation lead Jennifer Green.

In addition to Green, co-authors on the report include Innocent Tumwebaze, Jonars Spielberg, Linda Annala, Madhi Zarghami, Sara Lynn Pesek, Sydney Beasley, and Vihar Parikh. CITE conducted its research in partnership with local Indian universities including the Indian Institute of Management, Ahmedabad and TERI University, New Delhi.

**Art and science merge in a disaster readiness haven**

People walking by MIT’s Building 9 pause to contemplate the white plastic structure that appears to be part bench and part tower. This unit, a PREPHub, contains amenities for short-term responses to emergencies.

The PREPHub, a project of MIT’s Urban Risk Lab, seeks to increase preparedness for crises that disrupt a city’s functioning. Led by Miho Mazereeuw, the project is the demonstration of a completely off-grid facility that could help a city provide post-emergency services to citizens.

In the current PREPHub model, a pedaled generator will enable people to recharge batteries or cell-phones; an embedded webcam will let people take “selfies” and send those snapshots to relatives and social media services as evidence of their well-being; and an annunciation system can alert people to dangers or direct them to a shelter. “The ultimate goal is to have a network of PREPHubs in any disaster-vulnerable city that wants one, with hubs close enough together for anyone to be able to walk to one within 10 minutes,” says Mazereeuw.

The PREPHubs are envisioned as community resources during ordinary times. “As PREPHubs will be deployed in communities before a disaster, it is imperative that each important post-disaster function be useful in everyday scenarios. This everyday use will communicate the post-disaster functionality, making sure that the hubs are well known, well used, and well maintained landmarks all the time, allowing them to perform when needed the most after a disaster strikes,” says Mazereeuw.

The next steps in realizing the PREPHub vision are to extend the services provided by the units and to interest urban communities in the concept of a web of hubs useful for citizens both before and after a disaster. To that end, Lincoln Laboratory is researching how technologies in which it has deep experience can be utilized aboard a hub, and the Urban Risk Lab is connecting with San Francisco to install a prototype there.


http://bit.ly/2dfsRMt