MIT Briefing Book

Massachusetts Institute of Technology

2007

Researched and written by a variety of MIT faculty and staff, in particular members of the Provost's Office/ Institutional Research, Office of the President, Office of Sponsored Research, and Student Financial Services; and the MIT Washington Office. Special thanks to Carla Lane who researched and prepared many of the research summaries.

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MIT and Massachusetts

People

Total MIT-affiliated people in state	36,000+
Employees:	13,000
Cambridge campus	(10,200)
Lincoln Laboratory	(2,800)
Students	10,206
Alumni/ae in Massachusetts	19,972

Economic

Total MIT expenditures in FY 2006	$2.18 billion
Federal Research Expenditures:	
Cambridge campus (MIT FY 2006)	$461 million
Lincoln Laboratory (Federal FY 2006)	$631 million
Non-Federal Research Expenditures:	
Cambridge campus (MIT FY 2006)	$113 million
Lincoln Laboratory (Federal FY 2005)	$5 million
Payroll, including Lincoln Laboratory (FY 2006)	$815 million

MIT Technology Licensing Office (TLO)

TLO Statistics for FY 2006

Total Number of Invention Disclosures	523
Number of US Patents Filed (including provisionals, follow-ons, etc.)	321
Number of US Patents Issued	121
Number of Licenses Granted (not including trademarks and end-use software)	97
Number of Trademark Licenses Granted	23
Number of Software End-Use Licenses Granted	27
Number of Options Granted (not including options as part of research agreements)	24
Number of Companies Started (venture capitalized and/or with minimum of $50K of other funding)	23

MIT Facts and History

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MIT Facts and History

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

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

MIT's commitment to innovation has led to a host of scientific breakthroughs and technological advances. Achievements of the Institute's faculty and graduates have included 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 made possible the development of digital computers. Exciting areas of research and education today include neuroscience and the study of the brain and mind, bioengineering, energy, the environment and sustainable development, information sciences and technology, new media, financial technology, and entrepreneurship.

University research is one of the mainsprings of growth in an economy that is increasingly defined by technology. In its 1997 study, the first national examination of a research university's economic impact, the BankBoston Economics Department found that MIT graduates had founded 4,000 firms that translated their knowledge into products, services, and jobs. In 1994, these firms employed more than one million people and generated worldwide revenues of $232 billion.

MIT has forged educational and research collaborations with universities, governments, and companies throughout the nation and 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.

Students

The Institute's student body of 10,206 is highly diverse. Students come from all 50 states, the District of Columbia, five territories and dependencies, and 110 foreign countries. Forty-five percent of the undergraduates and 17 percent of graduate students are members of US minority groups. The Institute's 2,518 international students make up 8 percent of the undergraduate and 36 percent of the graduate population. Foreign countries with the largest enrollment at MIT are China, with 304 students; Korea, 231; India, 225; Canada, 208; Japan, 93; France, 92; Taiwan, 70; Singapore, 66; Greece, 62; and Thailand, 61

Student Profile (2005-2006)

Undergraduate	4,066	
Graduate	6,140	
Total	10,206 students	
Undergraduate	43 percent female	57 percent male
Graduate	29 percent female	71 percent male

In 2006, 44 percent of MIT's first-year students (who submitted their class standing) were first in their high school class; eighty-nine percent ranked in the top five percent.

Members of US Minority Groups: 2,850

	Undergraduate	Graduate
African American	235	114
Asian American	1,078	707
Hispanic American	460	176
Native American	63	17
	1,836 (45%)	1,014 (17%)

(These figures may not precisely reflect the population because they are self-reported, and not all students choose to provide this information.)

Degrees

In 2005-2006, MIT awarded 3,198 degrees:
- 602 Doctoral degrees
- 1,457 Master's degrees
- 10 professional engineer degrees
- 1,129 bachelor of science degrees

Alumni

MIT's 117,000 alumni are connected to the Institute through graduating class events, departmental organizations, and over 90 local clubs. More than 8,000 volunteers offer their time, financial support, and service on committees and on the MIT Corporation, the Institute's board of trustees. MIT graduates hold leadership positions in industries and organizations around the world. About 84 percent of MIT's alumni live in the United States.

Faculty, Staff, and Trustees

MIT's faculty is renowned for its dedication to teaching and discovery. Together, faculty, staff and administration constitute a strong organization supporting education and research.

The Institute is headed by President Susan Hockfield, who reports to the board of trustees, which is known as the Corporation. This group includes approximately 75 leaders in education, industry, science, engineering and other professions. There are approximately 20 emeritus members.

Faculty/Staff 2005-2006

Faculty	992
Other academic and instructional staff	784
Research staff and research scientists (includes Postdoctoral positions)	3,549
Administrative staff	2,310
Support staff	1,637
Service staff	843
Medical	147
Total Campus Faculty and Staff	10,262

In addition, 600 graduate students serve as teaching assistants or instructors, and 2,400 graduate students serve as research assistants.

MIT Lincoln Laboratory employs about 2,750 people, primarily at Hanscom Air Force Base in Lexington, Massachusetts.

Faculty Profile

74 percent are tenured

Awards and Honors of Current Faculty and Staff

- 7 Nobel Prizes
- 8 National Medals of Science
- 19 MacArthur Fellowships
- 7 Gairdner Awards
- 1 National Book Award
- 1 Pulitzer Prize in Music
- 1 Pulitzer Prize in General Non-Fiction
- 1 Pulitzer Prize in Local, General or Spot News Reporting
- 61 members of the National Academy of Sciences
- 63 members of the National Academy of Engineering
- 22 members of the Institute of Medicine
- 117 members of the American Academy of Arts and Sciences

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 interdisciplinary programs offer degrees. Many inter-departmental programs, laboratories and centers cross traditional boundaries and encourage creative thought and research.

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

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

School of Humanities, Arts, and Social Sciences
Anthropology
Comparative Media Studies
Economics
Foreign Languages and Literatures
History
Linguistics and Philosophy
Literature
Music and Theatre Arts
Political Science
Science, Technology, and Society
Writing and Humanistic Studies

Sloan School of Management
Management Science
- Finance
- Information Technologies
- Marketing Science
- Operations Research

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

Interdisciplinary Educational Programs
Computational and Systems Biology
Computation for Design and Optimization
Harvard-MIT Division of Health Sciences and Technology
Leaders for Manufacturing
Operations Research
MIT-Woods Hole Joint Program in Oceanography and Applied Ocean Science and Engineering
Women's Studies

Major Research Laboratories, Centers, and Programs

In addition to teaching and conducting research within their departments, MIT faculty, students and staff work in MIT's interdisciplinary laboratories and centers. These include:

Broad Institute
Center for Biomedical Engineering
Center for Biomedical Innovation
Center for Cancer Research
Center for Environmental Health Sciences
Center for Innovation in Product Development
Center for International Studies
Center for Materials Science and Engineering
Center for Real Estate
Center for Technology, Policy, and Industrial Development
Center for Transportation Studies
Clinical Research Center
Computer Science and Artificial Intelligence Laboratory
Deshpande Center for Technological Innovation
Earth System Initiative
Francis Bitter Magnet Laboratory
Haystack Observatory
Institute for Soldier Nanotechnologies
Kavli Institute for Astrophysics and Space Research
Laboratory for Electromagnetic and Electronic Systems
Laboratory for Energy and the Environment
Laboratory for Information and Decision Systems
Laboratory for Manufacturing and Productivity
Laboratory for Nuclear Science
Materials Processing Center
McGovern Institute for Brain Research
Media Laboratory
Microsystems Technology Laboratories
Nuclear Reactor Laboratory
Picower Institute for Learning and Memory
Plasma Science and Fusion Center
Research Laboratory of Electronics
Sea Grant College Program
System Design and Management Program

MIT Lincoln Laboratory
MIT operates Lincoln Laboratory in Lexington, Massachusetts as an off-campus Federally Funded Research and Development Center focused on technologies for national security.

Academic and Research Affiliations

Alliance for Global Sustainability
Established in 1995, the Alliance for Global Sustainability (AGS) is an international partnership among MIT, the Swiss Federal Institute of Technology, the University of Tokyo, and Chalmers University of Technology in Sweden. AGS brings together scientists, engineers and social scientists from government, industry, and other organizations to address the environmental issues that affect social and economic progress. With research focused on six sectors – energy, mobility, water, urban systems, cleaner technologies, and climate change – AGS advances the understanding of complex global problems and develops policies and practices that are urgently needed to solve them.

Cambridge-MIT Institute
The Cambridge-MIT Institute (CMI) is a collaboration between the University of Cambridge and MIT. Funded by British government and industry, CMI's mission is to enhance competitiveness, productivity, and entrepreneurship in the United Kingdom. CMI supports student and faculty exchanges, educational innovation, and research partnerships between MIT and Cambridge faculty, particularly in the area of knowledge exchange among universities, government and industry. CMI also works with other UK universities to share best practices and innovative approaches to education.

Cross-Registration at Other Institutions
MIT has cross-registration arrangements with several area schools, enabling qualified MIT students to take courses at Harvard University, Boston University's African Studies Program, Brandeis University's Florence Heller Graduate School for Advanced Studies in Social Welfare, Massachusetts College of Art and the School of the Museum of Fine Arts, and Tufts University's School of Dental Medicine. MIT also has junior year abroad and domestic year away programs where students may study at another institution in the US or abroad.

Charles Stark Draper Laboratory
Founded as MIT's Instrumentation Laboratory, Draper Laboratory became an independently operated, nonprofit research and educational organization in 1973. MIT and Draper Laboratory still collaborate in areas such as guidance, navigation and control; computer and computational sciences; data and signal processing; material sciences; integrated circuitry; information systems; and underwater vehicle technologies.

Global Enterprise for Micro-Mechanics and Molecular Medicine
Known by its acronym GEM4, this enterprise brings together engineers and life scientists from around the world to apply the advances of engineering, science, and nanotechnology to global medical challenges. Leveraging its members' strengths in bioengineering, biomedicine, computational systems biology, immunology, nanotechnology, and clinical and experimental medicine, this collaboration addresses infectious diseases like malaria; genetic diseases like sickle cell anemia; cancers; cardiovascular diseases; and environmental health issues. Joining MIT in GEM4 are Thailand's Chulabhorn Institute, Georgia Institute of Technology, Harvard School of Public Health, the Institut Pasteur in France, Johns Hopkins University, Max Planck Institute in Germany, the National University of Singapore, and the University of Illinois.

Howard Hughes Medical Institute

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. Eleven HHMI investigators hold MIT faculty appointments.

Idaho National Laboratory (INL)

Created in 2005 by the US Department of Energy, the Idaho National Laboratory (INL) includes the visionary proposal for the National University Consortium (NUC) – five leading research universities from around the nation whose nuclear research and engineering expertise are of critical importance to the future of the nation's nuclear industry. MIT will initially lead the NUC team, whose goal is collaborative, coordinated nuclear research and education, accomplished in conjunction with the Center for Advanced Energy Studies (CAES). The NUC partners will establish the university-based Academic Centers of Excellence (ACE) to collaborate with CAES research programs and the collocated research centers of CAES. The NUC consists of MIT, Oregon State University, North Carolina State University, Ohio State University, and the University of New Mexico.

Magellan Project

The Magellan Project is a five-university partnership assembled to construct and operate 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. Other projects include the search for black holes, investigate galaxy collisions, and map the large-scale structure of the universe. Collaborating with MIT in the Magellan Project are the Carnegie Institution of Washington, Harvard University, and the Universities of Arizona and Michigan.

MIT-Portugal Program

MIT and the Portuguese Ministry of Science, Technology and Higher Education have announced plans to enter into a long-term collaboration to significantly expand research and education in engineering and management across many of Portugal's top universities. The wide-ranging initiative will be the broadest of its kind ever undertaken by the government of Portugal, and will include the participation of more than 40 MIT faculty from all five schools at the Institute. The MIT-Portugal Program will undertake research and education in several focus areas, and will give MIT an opportunity to gain insight into the planning, design, and implementation of transportation, energy, manufacturing, and bioengineering systems in Portugal.

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

MIT and the Woods Hole Oceanographic Institution jointly offer Doctor of Science and Doctor of Philosophy degrees in chemical oceanography, marine geology, marine geophysics, physical oceanography, applied ocean science and engineering, and biological oceanography. They also offer Master's and professional degrees in some disciplines.

Naval Construction and Engineering (Course 2N)
The graduate program in Naval Construction and Engineering at MIT is intended for active duty officers in the US Navy, US Coast Guard, and foreign navies that have been designated for specialization in the design, construction, and repair of naval ships. The curriculum prepares Navy, Coast Guard, and foreign officers for careeers in ship design and construction, and is sponsored by Commander, Naval Sea Systems Command.

ROTC (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 ROTC unit. Today, MIT's Air Force, Army, and Navy ROTC programs also serve students from Harvard and Tufts Universities; the Air Force and Army programs also include Wellesley College students. These programs enable students to become commissioned military officers upon graduation and may provide scholarships. Over 12,000 officers have been commissioned from MIT, more than 150 of whom have achieved the rank of general or admiral.

Singapore-MIT Alliance
The Singapore-MIT Alliance (SMA) is an innovative engineering education and research collaboration of three premier academic institutions: MIT, National University of Singapore and Nanyang Technological University. SMA promotes global education and research in engineering and the life sciences through distance education. Offering graduate degrees in five engineering disciplines and one life science discipline, SMA is the largest interactive distance education collaboration in the world. More than 50 MIT faculty members and 50 from the Singapore universities participate in SMA's programs.

Singapore-MIT Alliance for Research and Technology Center
MIT and the National Research Foundation of Singapore have announced plans to establish a major new research center in Singapore in 2007. The Singapore-MIT Alliance for Research and Technology (SMART) Center will be MIT's first such research center of its kind outside of Cambridge, MA, and MIT's largest international research endeavor ever. The SMART Center will serve as an intellectual hub for interactions between MIT and global researchers in Singapore, and will allow faculty, researchers, and graduate students from MIT to collaborate with their counterparts from universities, polytechnics, research institutes, and industry in Singapore and Asia.

Synthetic Biology Engineering Research Center
Five MIT researchers are among the pioneers behind a new research center in synthetic biology. The Synthetic Biology Engineering Research Center (SynBERC) was established in 2006 and is managed via the California Institute for Qualitative Biomedical Research. In addition to MIT, participating universities are the University of California at Berkeley; Harvard University; the University of California at San Francisco; and Prairie View A&M University. SynBERC's foundational research will be motivated by pressing biotechnology applications.

Wellesley-MIT Exchange Program
Through this program, students may cross-register for any courses at the other school, expanding the educational opportunities for participating students. Through the Wellesley Education Department, students also earn Massachusetts certificates to teach a number of courses at the elementary and secondary level.

Whitehead Institute for Biomedical Research
An independent basic research and teaching institution affiliated with MIT, the Whitehead Institute conducts research in developmental biology and the emerging field of molecular medicine. Faculty at the Whitehead Institute teach at MIT, and MIT graduate students conduct research and receive training in Whitehead Institute laboratories.

Advances in Education

MIT has long maintained that professional competence is best fostered by coupling teaching with research and by focusing education on real-world 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 curricula 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 bestselling textbooks of all time, such as *Economics* by Paul A. Samuelson and *Calculus and Analytic Geometry* by George Thomas. Following are some notable MIT teaching milestones since 1969, when humans, including MIT alumnus Buzz Aldrin, first landed on the moon:

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. About 2,800 MIT students participate in UROP annually.

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.

1971: MIT holds its first Independent Activities Period (IAP), a January program that emphasizes creativity and flexibility in teaching and learning. Almost 800 activities were offered in 2005, including design contests, laboratory projects, workshops, field trips and courses in practical skills.

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 US.

1981: MIT launches Project Athena, a $70-million program to explore the use of computers in education. Supported by Digital Equipment Corporation and IBM, and joined by MIT language and computer science faculty join in 1983, the Project pioneers a new generation of language learning tools.

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.

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

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 in 1969.

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 multi-media archive for studies of Shakespeare's plays.

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.

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

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.

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: To provide a model for sharing of knowledge to benefit all humankind, MIT launches OpenCourseWare, a program that makes materials for nearly all of its courses freely available on the web.

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

2001: MIT's Earth System Initiative launches Terrascope, a freshman course where students work in teams to solve complex problems such as 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 introduces 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 Computational and Systems Biology program (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 PhD program that will give them the tools for treating biological entities as complex living systems.

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, ranging from computational biology to airline scheduling to telecommunications design and operations.

MIT Research Firsts

The following are selected research achievements of MIT faculty over the last four decades:

1969: Ioannis V. Yannas begins work on developing 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.

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 received 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 earned Ting the 1976 Nobel Prize in Physics, points to the existence of one of the six postulated types of quarks.

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

1976: Har 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' 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 and is still in widespread use today.

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

1981: Alan Guth publishes "Inflationary Universe," the first satisfactory model of the universe's development in the first 10^{-32} seconds after the Big Bang.

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

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

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

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

1990: Building on the discovery of the metathesis – the process of cutting carbon-carbon double bonds 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 widely used for efficient and environmentally friendly production of pharmaceuticals, fuels, and synthetic fibers. 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.

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 post-doctoral 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.

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: 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, headed by Matthew Wilson and Nobel laureate Susumu Tonegawa, demonstrate with new genetic and multiple-cell monitoring technologies how animals form memory about new environments.

1997: MIT physicists create the first atom laser, a device which 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, aging in certain human cells.

1998: An interdisciplinary team of MIT researchers, led by Yoel Fink, John Joannopoulos, and Edwin L. Thomas, invent the "perfect mirror," which offers radical new ways of directing and manipulating light. Applications range from a flexible light guide for surgery to new devices for optical communications.

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

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

1999: NASA launches the Chandra X-ray Observatory. Half the scientific instruments in Chandra were designed and built at the Kavli Institute for Astrophysics and Space Research.

2000: Scientists at the Whitehead/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. The first application was for a device used in pain management.

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 is providing practical data for understanding and evaluating IT's business and economic effects, which will enable us taking 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 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 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: MIT researchers develop a way to use RNA interference to silence genes. The new approach will allow scientists to shut down disease-causing genes, such as those involved in cancer, high cholesterol, type 1 diabetes, and rheumatoid arthritis. It can also be used to make cells immune to viral diseases such as AIDS.

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 (LDX), 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 abundant 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: Marc A. Baldo, electrical engineering and computer science professor and Shuguang Zhang of MIT's Center for Biomedical Engineering, develop a spinach-based solar cell by stabilizing spinach proteins so they can survive without water and salt and attaching them to a piece of glass coated with a thin layer of gold. The resulting 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, professor of electrical engineering and computer science, and Tim Swager, professor of chemistry, develop a semiconducting polymer that is able to detect the presence of TNT vapor even at the concentration of parts per billion.

2006: Better lithium-ion batteries, solid-state batteries and new materials that could make rechargeable batteries for electric cars cheaper and safer are among MIT's most recent battery innovations. MIT battery researcher Donald R. Sadoway, the John F. Elliott Professor of Materials Science, has said that eliminating all liquid from solid-state batteries could double or triple their capacity over the best existing commercial batteries. Sadoway has worked with Gerbrand Ceder, the R.P. Simmons Professor of Materials Science and Engineering, on new battery materials that could be used for electrodes on rechargeable batteries.

2006: MIT scientists have harnessed the construction talents of tiny viruses to build ultra-small "nanowire" structures for use in very thin lithium-ion batteries. By manipulating a few genes inside these viruses, the team was able to coax the organisms to grow and self-assemble into a functional electronic device. The goal of the work, led by MIT Professors Angela Belcher, Paula Hammond and Yet-Ming Chiang, is to create batteries that cram as much electrical energy into as small or lightweight a package as possible. The batteries they hope to build could range from the size of a grain of rice up to the size of existing hearing aid batteries.

Federal Research Support

2 Federal Research Support

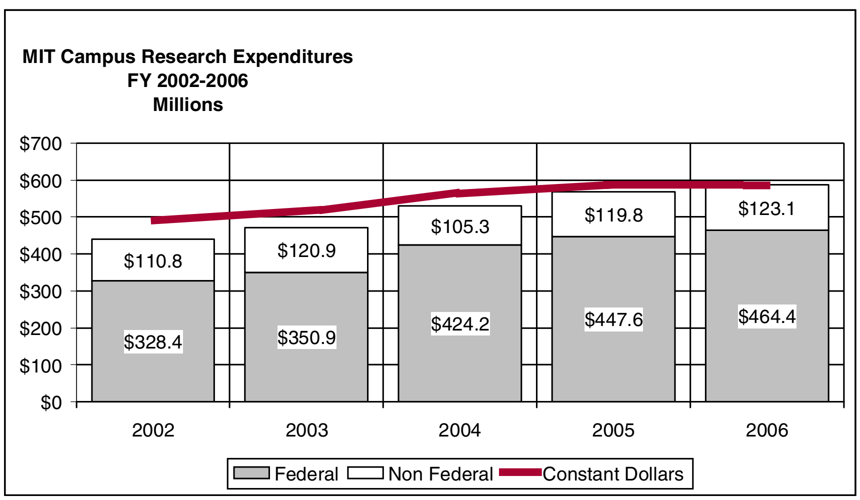
Campus Research

The Massachusetts Institute of Technology is one of the world's leading research universities. The Institute 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 (FFRDC) in Lexington.

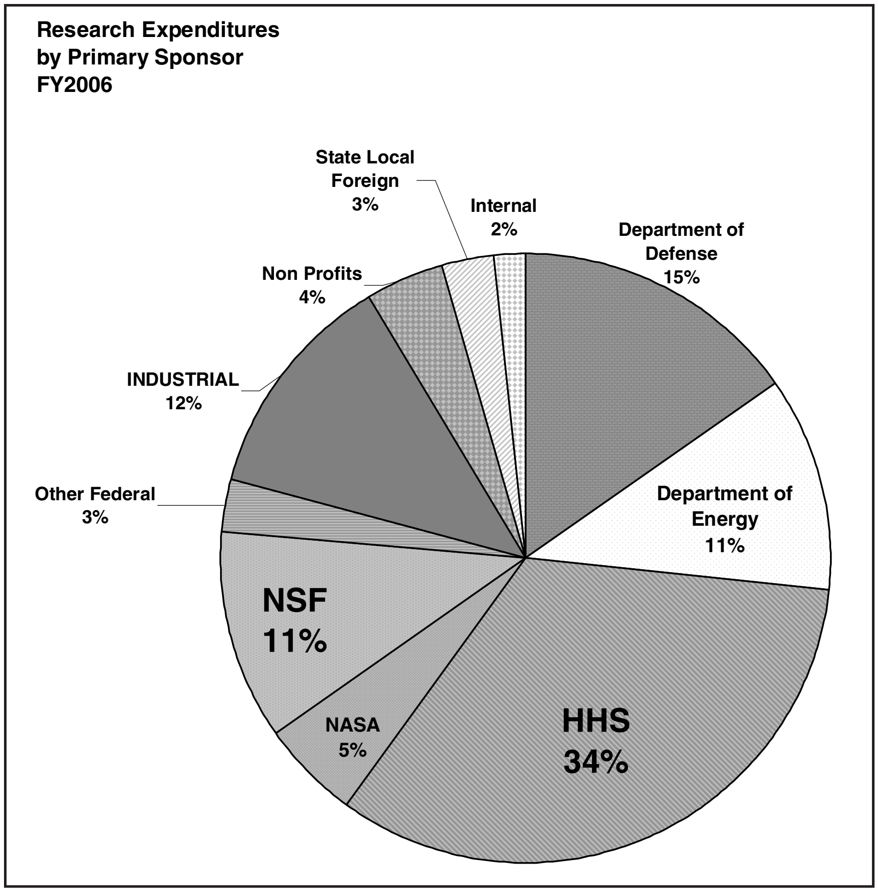
MIT pioneered the federal/university research relationship starting in World War II. Initially called upon by the federal government to serve the national war effort, that relationship has continued into the present day, helping MIT fullfill its original misssion of serving the nation and the world.

All federal research on campus is awarded competitively, based on the scientific and technical merit of the proposals. In FY 2006, there were approximately 2,600 active research projects and about 600 members of research consortiums.

The bar graphs for the campus research support that follow show the amount MIT expended by fiscal years (July 1 – June 30). The red line represents an adjustment for inflation, based on 2006 dollars, using the Consumer Price Index for all Urban Consumers (CPI-U) as the deflator.



Campus Research Sponsors
FY 2005



Major Sponsor	FY 2006 Research Expenditures	% of Total
Department of Defense	$89,552,000	15%
Department of Energy	$67,265,000	11%
HHS	$195,573,000	34%
NASA	$31,229,000	5%
NSF	$65,163,000	11%
Other Federal	$15,570,000	3%
Total Federal Research	*$464,351,000*	*79%*
State, Local, & Foreign Govts.	$15,136,000	3%
Foundations and Nonprofits	$24,833,000	4%
Industrial	$72,743,000	12%
Internal	$10,432,000	2%
Total Non-Federal Research	*$123,145,000*	*21%*
Total Research Expenditures	**$587,496,000**	**100%**

These figures do not include expenditures for MIT Lincoln Laboratory. Information for Lincoln Laboratory begins on page 2-16.

Federal research expenditures include all primary contracts and grants, including sub-awards from other organizations where the federal government is the original funding source.

Department of Defense
Selected Current Projects

Improving the Detection of Explosives

MIT scientists have developed a new semiconducting polymer that is able to detect the presence of TNT vapor even at the concentration of parts per billion. The polymer's molecules emit light when exposed to ultraviolet light. If TNT vapor is present, however, it binds to the molecules and extinguishes the emission. In comparison with most commercially-available systems which can sense only TNT particles, this new technology offers a much more powerful defense against threats like improvised explosive devices or explosives hidden in cargo. The new polymer is the work of Timothy Swager of the Department of Chemistry, Vladimir Bulovic of Electrical Engineering and Computer Science, and their team of researchers at MIT's Institute for Soldier Nanotechnologies (ISN). They are working now on similar molecules that can sense other explosives, minute amounts of nerve agents, or nitrous oxide levels in human breath, an indicator of physiological condition. ISN is a university-affiliated research center funded by the US Army Research Office.

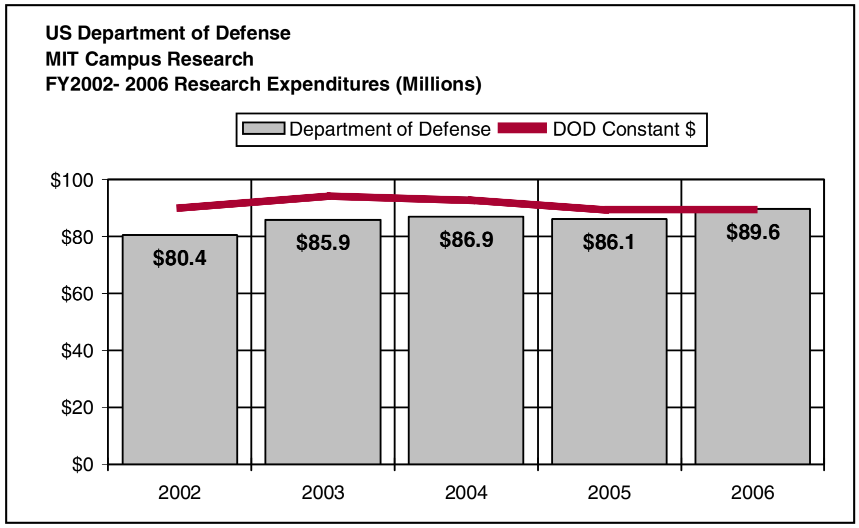
Nature Gives a Lesson in Armor Design

Sea shells provide extraordinary protection – stiff, strong and yet lightweight – for the small soft-bodied creatures like sea snails that live in perilous ocean environments. Now teams of ISN researchers, directed by Christine Ortiz of the Department of Materials Sciences and Engineering and Mary Boyce of Mechanical Engineering, are unravelling the source of the strength of nacre – the shell's mother-of-pearl inner lining. Composed of ceramic calcium carbonate and a flexible biopolymer, two relatively weak materials, nacre gets its strength as millions of ceramic plates, each a few nanometers in size, are stacked and then glued together with thin biopolymer layers. The teams are studying the nanoscale behavior of the adhesion forces that bind these elements together with such resiliance. Understanding nature's nanoscale structural principles will help engineers design better body armor for soldiers, police officers, rescue workers, and other people in dangerous situations. It will also shed light on the problem of creating durable composites that can withstand high forces in water. The work is supported by the US Army Research Office.

Atom Interferometry on Atom Chips

Operating without reference to external objects, inertial navigation systems can operate in the most remote places, whether deep in the oceans or on the far side of the moon. Sensors based on ultracold atoms could exceed the performance of the mechanical and laser gyroscopes and weights on springs that primarily comprise today's inertial sensors. The wave nature of ultracold atoms makes it possible to determine their position interferometrically; and because their waves are much shorter then those of light, they indicate their position with much greater accuracy. The atom "optics" currently under development tend to rely on bulky, expensive equipment. With funding from the Defense Advanced Research Projects Agency, physicists Wolfgang Ketterle, winner of the 2001 Nobel Prize in Physics, and David Pritchard have taken on the challenge of harnessing matter-wave interferometry in a useful, compact, and portable device. Their focus is on integrating the technologies necessary to cool atoms down to nanokelvin temperatures and placing these sensors on a miniaturized system. They are aiming for an error rate of less than 10 meters after an hour of navigation.

Department of Defense



Department of Defense funding in FY 2006 was $89.6 million, not including expenditures at MIT Lincoln Laboratory, a DOD FFRDC.

Leading Departments, Centers and Laboratories Receiving DOD Support (FY 2006)
Computer Science & Artificial Intelligence Laboratory
Microsystems Technology Laboratories
Department of Aeronautics & Astronautics
Department of Materials Science and Engineering
Haystack Observatory

In 2005-2006, 277 graduate students held research assistantships and 3 held fellowships from DOD as their primary funding source.

Department of Health and Human Services
Selected Current Projects

Nanotechnology Comes to Cancer Research

Nanotechnology has demonstrated great promise in cancer research and treatment, from the fabrication of nanoparticles for delivering drugs and imaging agents to the implantation of tiny sensors for early detection and monitoring. With a National Cancer Institute grant establishing the MIT-Harvard Center of Cancer Nanotechnology Excellence, an interdisciplinary team of MIT and Harvard researchers has launched a number of projects to rapidly advance the application of these technologies. One project, led by MIT chemical and biomedical engineer Robert Langer, who is internationally recognized for advancements in drug delivery systems, and Omid Farokhzad of Harvard Medical School, focuses on using nanoparticle "homing devices" that will transport time-released anti-cancer drugs directly to prostate cancer cells. The technology also has the advantage of avoiding the toxic side effects of current cancer therapies, which attack healthy as well as diseased cells. Another project, led by biologist and Nobel laureate Phillip Sharp, is exploring the use of nanomaterials to deliver short interfering RNAs (siRNAs) to the genes associated with lethal cancers. siRNAs are tiny sequences of RNA that, when introduced into a cell, silence the targeted gene. Although potentially very powerful cancer-fighting tools, siRNAs remain difficult to dispatch to tumor cells. With its goal of mastering the technology of siRNA delivery, this project has the potential to open up a broad range of new cancer therapies.

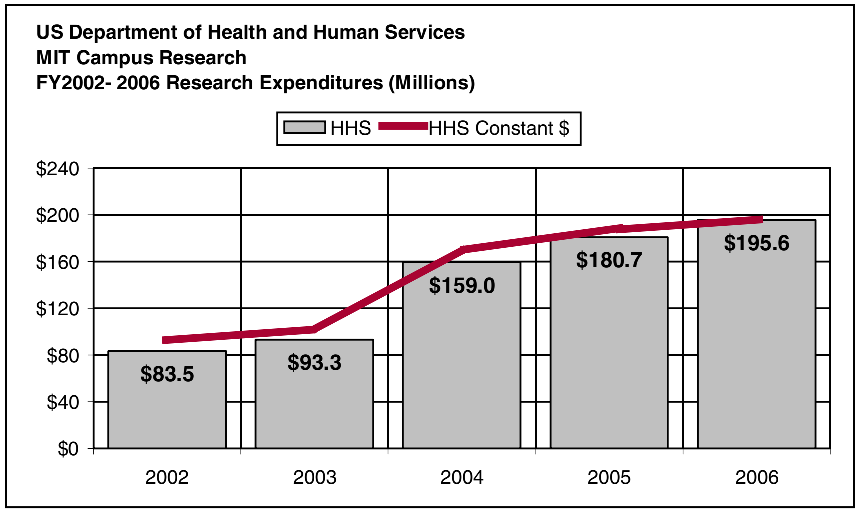
What's Controlling the Gene?

With more and more success in determining the genomes of everything from yeast to humans, scientists now are able to turn their attention to finding out how the genetic sequences work. Key to this understanding are the gene regulators, the molecules that bind to a DNA region and switch the gene on or off. Many diseases, such as type 2 diabetes and cancer, are associated with mutated gene regulators. Given the vastness of the genome, however, and the gene regulators' fleeting activity, these crucial mechanisms have been hard to find. Now a group of researchers at MIT and the Whitehead Institute of Biomedical Research has developed a method for scanning an entire genome and quickly identifying the regulators' precise landing sites. As a result, they can now begin to understand how genes and their regulators interact. Richard Young of the Department of Biology, David Gifford of Electrical Engineering and Computer Science, and Ernest Fraenkel of the Whitehead Institute and the Computer Science and Artificial Intelligence Laboratory are leading this effort. Young and Gifford also have appointments at the Broad Institute. Their work is supported by the National Institutes of Health.

Neuroscience and Aging

A research project funded by the National Institute on Aging is illuminating the effects of aging and neurodegenerative diseases on memory. Taking advantage of recent advances in brain imaging, neuroscientist Suzanne Corkin is studying how changes in brain structure and function correlate to behavioral changes. This project is among the first to use such a multi-dimensional approach and will lead to a better understanding of the effects of aging and age-related diseases, such as Alzheimer's and Parkinson's, on the brain.

Department of Health and Human Services



Department of Health and Human Services funding in FY 2006 was $195.6 million.

Leading Departments, Centers, and Laboratories Receiving Health and Human Services Department Support (FY 2006)
Broad Institute
Department of Biology
Center for Cancer Research
Department of Chemistry
Picower Center for Learning & Memory

NIH
In the 2005-2006 academic year, 41 postdoctoral and 7 pre-doctoral MIT fellows held NIH fellowship awards. 211 graduate students held research assistantships and 84 held fellowships as their primary support by NIH. Currently there are 18 active NIH training grants supporting over 70 MIT graduate students and 6 postdoctoral fellows.

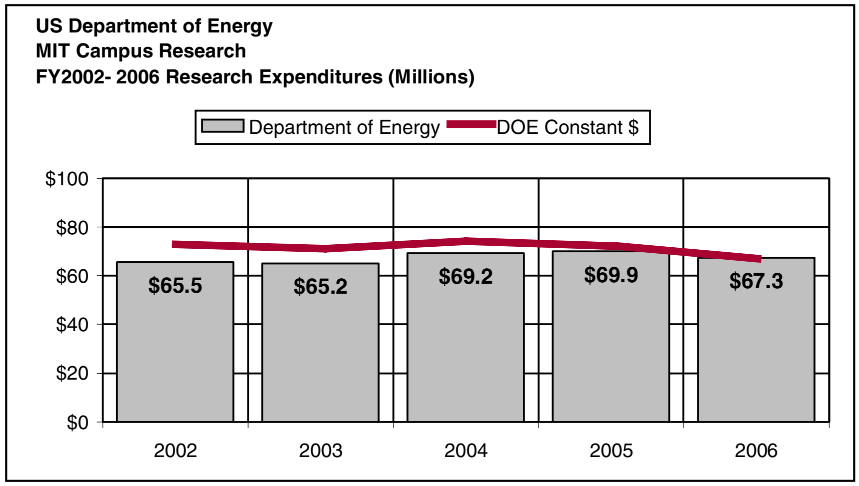
Department of Energy
Selected Current Projects

The Second Wireless Revolution
The solid state amplifiers that the nation's roughly 200,000 wireless base stations now use to communicate with cell phones and other electronic devices are costly. Generating excessive heat, they require bulky cooling equipment and also need large backup batteries. Chiping Chen and a team of researchers in MIT's Plasma Science and Fusion Center are developing an alternative – the first radio frequency (RF) power amplifier, which combines vacuum tube technology with an elliptical, or "ribbon," electron beam, another recent MIT breakthrough. Much more efficient for RF amplification than the one-dimensional electron beam that conventional vacuum electron devices emit, the device requires less energy than both the vacuum tubes and the solid-state transistors which replaced them in many applications. These amplifiers are smaller, generate less heat, require smaller backup batteries, and cost thousands of dollars less than solid-state amplifiers. With the potential to reduce the cost of delivering voice and data from the current 50 cents to five cents per megabyte, they could save consumers hundreds of billions of dollars over the next 20 years. The technology has a range of applications, extending from communications (telephone, broadband, and satellite) to defense and scientific research. The work is funded by the Department of Energy, the Air Force Office of Scientific Research, and the MIT Deshpande Center for Technological Innovation.

Looking for the Stuff of the Universe
Although physicists understand a lot about the protons, neutrons, and electrons that make up conventional atomic matter, these particles in fact constitute only about four percent of the universe's total mass and energy. The composition of the other 96 percent is a mystery: 73 percent is the "dark energy" that accounts for the accelerated expansion of the universe, and 23 percent is "dark matter," measured from its gravitation pull on ordinary matter. Now, researchers from MIT's Department of Physics and Laboratory of Nuclear Science and the Department of Physics at Boston University are helping to solve part of this mystery by designing an experiment that will enable them to observe dark matter particles as they interact with ordinary matter. They are constructing a chamber filled with a dilute gas whose atoms will act as targets for dark matter particles. When one hits a gas atom, the atom recoils and bumps into another one, causing them to lose electrons. The chamber will convert these electrons into visible light detectable by a video camera, which then will provide an actual image of the dark matter interaction. The project is supported by the Department of Energy and the Kavli Institute for Astrophysics and Space Research.

High-Efficiency Annular Fuel for Light Water Reactors
For more than 30 years, light water nuclear reactors have been powered by thin solid cylindrical fuel rods that are cooled externally by flowing water. Now, Mujid Kazimi and Pavel Hejzlar of the Department of Nuclear Science and Engineering are developing a ring-shaped design. Since it can be cooled both internally and externally, this new shape will increase the surface-to-volume ratio of the fuel, and allow a higher power density while reducing the heat flow to the coolant. Kazimi and Hejzlar estimate that this advance could translate into roughly a 10 percent reduction in the cost of nuclear power. They also are investigating technologies for manufacturing annular fuel. Their work is supported by the Department of Energy, Office of Nuclear Energy. Kazimi directs MIT's Center for Advanced Nuclear Energy Systems.

Department of Energy



Department of Energy funding in FY 2006 was $67.3 million, not including expenditures at MIT Lincoln Laboratory, a DOD FFRDC.

Leading Departments, Centers, and Laboratories Receiving Department of Energy Support (FY 2006)
Plasma Science and Fusion Center
Laboratory for Nuclear Science
Department of Earth, Atmospheric, and Planetary Sciences
Department of Nuclear Science and Engineering
Nuclear Reactor Laboratory

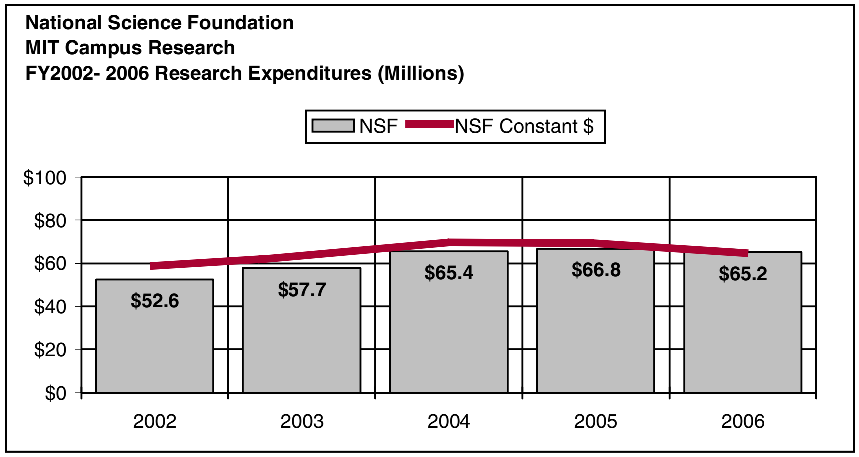
In 2005-2006, 126 graduate students held research assistantship positions that were primarily funded by DOE.

National Science Foundation
Selected Current Projects

Omniguide
Using minimally invasive procedures, a surgeon removes almost totally obstructive growths from a patient's larynx and trachea. Although such surgery once required general anesthesia, this time the patient is fully awake and able to go home when the operation is completed. The enabling technology, Omniguide, is a new class of high-bandwidth photonic fibers that use omni-directional reflection to shoot light quickly and efficiently around sharp corners in small spaces as well as over long distances. The fibers evolved from the discoveries of an interdisciplinary team of MIT researchers, including Materials Science and Engineering Professors Yoel Fink and Edwin Thomas and Physics Professor John Joannopoulos. Providing fast, high-bandwidth capacities, in addition to reducing the risks and costs of many surgeries, Omniguide could also lead to the significant miniaturization of integrated optical devices. This work is funded by the Center for Materials Science and Engineering through the National Science Foundation, the US Department of Energy, and the US Army Research Office.

Clearing Up Foggy Windows
Led by Michael Rudner, a team of scientists in the Department of Materials Science and Engineering have developed a polymer coating that can create glass surfaces – for eyeglasses, camera lenses, ski goggles, bathroom mirrors, and car windows – that never fog. Unlike anti-fog technologies currently available, such as sprays which must constantly be reapplied or glass with titanium dioxide which only works if ultraviolet light is present, this new coating remains stable for long periods, doesn't require light to be activated, and can be applied to any surface. Fogging occurs when tiny droplets of water condense and scatter light in random patterns so objects on the other side can't be clearly distinguished. The new polymer causes the water droplets to flatten and merge into a uniform sheet rather than countless individual light-scattering spheres, thus allowing light to pass through with no distortion or interruption. The same coatings can also be engineered to reduce glare and maximize the amount of light that goes through, thus improving the effectiveness of greenhouses and solar cell panels. So far, the coating is more durable on glass than plastic materials, so Rubner and his colleagues are working on processes to optimize its effectiveness on all surfaces. The research is being funded by the National Science Foundation and DARPA.

Laser Interferometer Gravitational-Wave Observatory (LIGO)
The world's largest optical instrument, the Laser Interferometer Gravitational-Wave Observatory (LIGO), helps scientists observe events in the universe not observable by any other means. The LIGO team at MIT (at the Kavli Institute) and its counterpart at Caltech, are working to directly observe gravitational waves (as faint ripples) in the fabric of space-time believed to be produced by the graviational effects of black holes, collisions, and other violent events. Although never directly observed, the existence of these ripples were predicted by Albert Einstein as part of his general theory of relativity. This project is being funded by the National Science Foundation and headed by a team from the California Institute of Technology and MIT.



National Science Foundation funding in FY 2006 was $65.2 million.

Leading Departments, Centers, and Laboratories Receiving National Science Foundation Support (FY 2006)

Computer Science and Artificial Intelligence Laboratory
Department of Earth, Atmospheric, and Planetary Sciences
Kavli Institute for Astrophysics and Space Research
Media Laboratory
Haystack Observatory

NSF

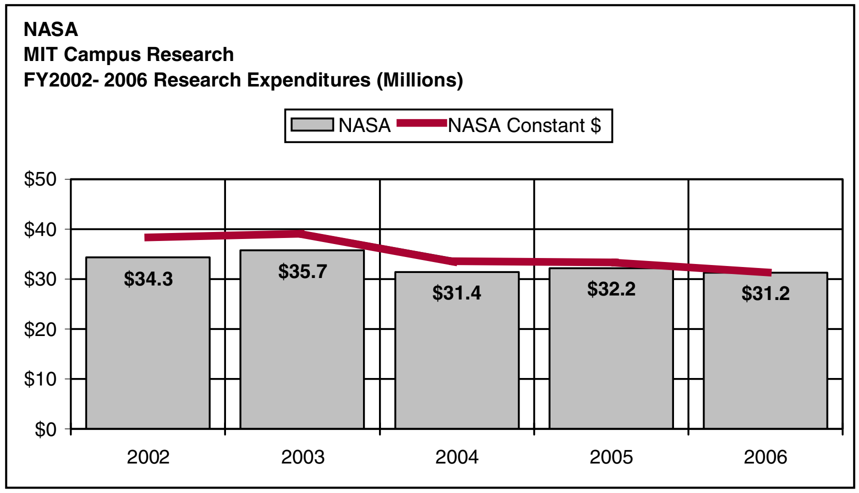
During the 2005-2006 academic year, MIT had 207 active NSF Fellows and 300 graduate research assistants who received their primary funding from NSF grants. In 2005, NSF awarded a total of 1,024 fellowships, of which 99 awardees (10%) indicated that MIT was their institution of choice. In addition, 44 holding baccalaureate degrees from MIT were offered NSF graduate fellowships.

NASA
Selected Current Projects

Probing the Violent Universe
The Chandra X-ray Observatory, launched in July 1999, is one of NASA's major astronomical satellites. X-rays mark the most energetic phenomena in the universe including black holes, highly active stars, supernovae and their remnants, quasars, and the ten million degree gas that permeates clusters of galaxies. Chandra carries by far the best X-ray telescope ever built, one capable of making images at X-ray wavelengths that are comparable to those made by the best ground-based optical telescopes in visible light. MIT's Kavli Institute for Astrophysics and Space Research (formerly the Center for Space Research) built two of the four scientific instruments that record the radiation focused by the telescope. A great majority of the observations performed with Chandra use one or both of these instruments, which were developed over more than a decade using technological advances made both on campus and at MIT Lincoln Laboratory. The specialized, X-ray sensitive Charge Coupled Devices (CCDs) and the periodic, submicron structures at the cores of these instruments remain unique in the world. They provide astronomers with orders of magnitude improvements in imaging and spectroscopic sensitivity. MIT's own researchers continue to use Chandra to probe the violent universe and also participate in the Chandra X-ray Center, which operates the observatory from Cambridge, MA.

Weather, Climate Change and Searching for Life on Mars
Currently operating in Mars orbit on the Mars Global Surveyor spacecraft is a joint MIT-NASA instrument that is mapping changes in the seasonal frost cap of Mars. On the Mars Reconnaissance Orbiter spacecraft an MIT-led investigation is collecting data to study the internal structure, CO_2 cycle, and atmospheric density of Mars. A joint study by MIT and Harvard Medical School is designing a protoype of a device to attempt to detect Earth-like life on Mars or other space-environments. The device is being designed to fly on a future planetary lander or rover.

Mapping the Moon
Two experiments co-led by MIT on the Lunar Reconnaissance scheduled to launch in 2008 will be used to globally map the Moon. The first is a multi-beam laser altimeter that will produce a better map of the topography of the Moon than exists for Earth. The second is a small device that will enable the spacecraft to be tracked by an Earth-based laser. This system will aid in the construction of a precise latitude-longitude grid for the Moon and, in addition, demonstrate technological features important for future interplanetary optical communication.



NASA funding for FY 2006 was $31.2 million (excluding Lincoln Labs).

Leading Departments, Centers, and Laboratories Receiving NASA Support (2006)

Kavli Institute for Astrophysics and Space Research
Department of Aeronautics and Astronautics
Department of Earth, Atmospheric, and Planetary Sciences
Division of Health Sciences and Technology
Haystack Observatory

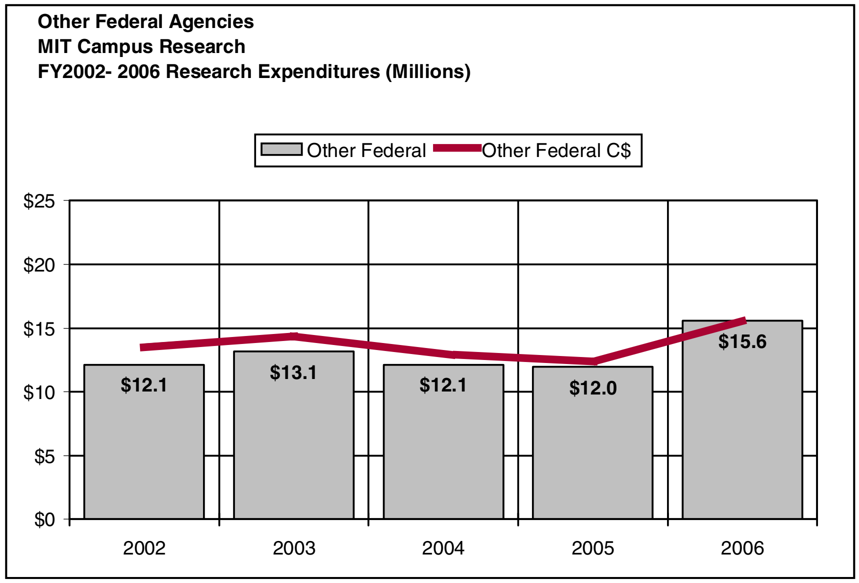
In 2005-2006, 67 graduate students held research assistantship positions that were primarily funded by NASA.

Other Federal Agencies
Selected Current Projects

Keeping the Noise Down
The demand for air travel is predicted to double over the next 20 years. Yet, with key airports operating at full capacity, aircraft noise in these mostly urban areas is a major barrier to service growth. Is there any way to design an airplane whose noise is imperceptible outside the boundaries of the airport and no longer so detrimental to people living, working, or going to school close to the flight paths? This is the challenge researchers from MIT, the University of Cambridge, and many parts of the civil aerospace and aviation industry are addressing in the Silent Aircraft Initiative, launched in 2003 by the Cambridge-MIT Institute (CMI). Exploring the design of the three major aircraft noise sources – the engines, the undercarriage, and the airframe, researchers are exploring such options as putting the engines above the aircraft, so the body itself shields the ground from noise; embedding them in long, muffled ducts; and designing an advanced engine located inside the airframe. They also are addressing technologies that will improve the integration of the airframe and the propulsion system. In addition, the team is assessing the economic implications of silent aircraft for both airlines and regional economies. The work is funded by the NASA Langley Research Center and CMI.

. . . While Keeping Down the Pollution and the Cost
Under the leadership of Aeronautics and Astronautics Professor John-Paul Clarke, a team of researchers has developed a new landing procedure that reduces noise, cuts pollution, and shortens flight time. In traditional approaches, planes begin their descent many miles from the runway, spending substantial time at relatively low altitudes. Furthermore, the planes move down in steps, which require noisy engine thrusts every time they level out. The new system, which uses sophisticated avionics that enable pilots on their final approach to guide their planes directly to the correct radio beam, keeps a plane at cruise altitude until it is relatively close to the airport. At this point, the plane makes an even, continuous descent to the runway, appreciably reducing noise, burning less fuel and emitting fewer fumes. Because the aircraft maintains higher speeds and takes a more direct path to the runway, the system also reduces flight time. The team demonstrated the approach's effectiveness in a two-week test at Louisville Regional Airport; and it now is conducting research to adapt and test the procedure for airports with heavier traffic volume and greater aircraft diversity. The Louisville test was funded by Congress, with additional support from UPS, Boeing, regional traffic control centers, MIT, the Federal Aviation Administration and NASA. In 2003, MIT was designated an Air Transportation Center of Excellence for Aircraft Noise and Aviation Emissions Mitigation, created by the FAA. Clarke is the center's director.

Other Federal Agencies



The funding from other federal agencies in FY 2006 was $15.6 million, not including expenditures at MIT Lincoln Laboratory, a DOD FFRDC.

Leading Departments, Centers, and Laboratories Receiving Other Federal Agency Support (FY 2006)
Computer Science and Artificial Intelligence Laboratory
Department of Aeronautics and Astronautics
Center for Transportation Studies
Sea Grant
Broad Institute

For 2005-2006, 38 research assistantships and 5 fellowships were awarded to MIT graduate students by Other Federal Agencies as their primary funding source.

MIT Lincoln Laboratory at Hanscom Air Force Base Lexington, Massachusetts

MIT Lincoln Laboratory is a federally funded research and development center (FFRDC) operated by the Massachusetts Institute of Technology under contract with the Department of Defense (DoD). Three areas constitute the core research and development conducted at the Laboratory: sensors, signal processing, and communications, all supported by a broad research base in advanced electronics.

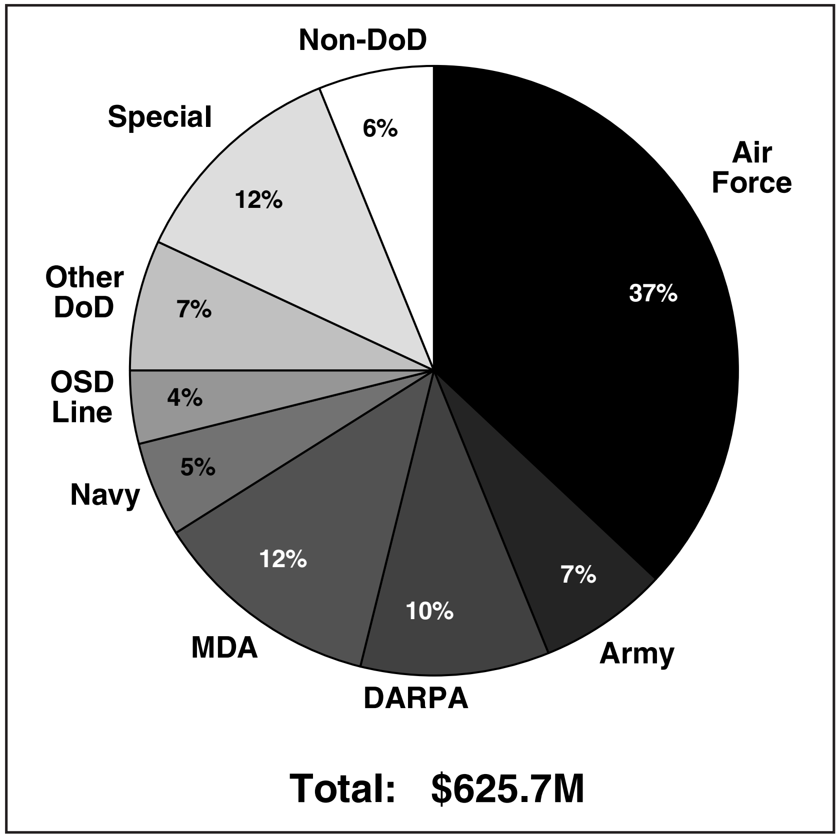
Since its establishment in 1951, MIT Lincoln Laboratory's mission has been to apply "technology in support of national security." Research at the Laboratory focuses on national security projects involving surveillance technology, biological-chemical defense, communications and information technology, and advanced electronics technology. 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.

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.

On the occasion of its 50th anniversary, Lincoln Laboratory received the Secretary of Defense Medal for Outstanding Public Service (as it did on the occasion of its 25th anniversary).

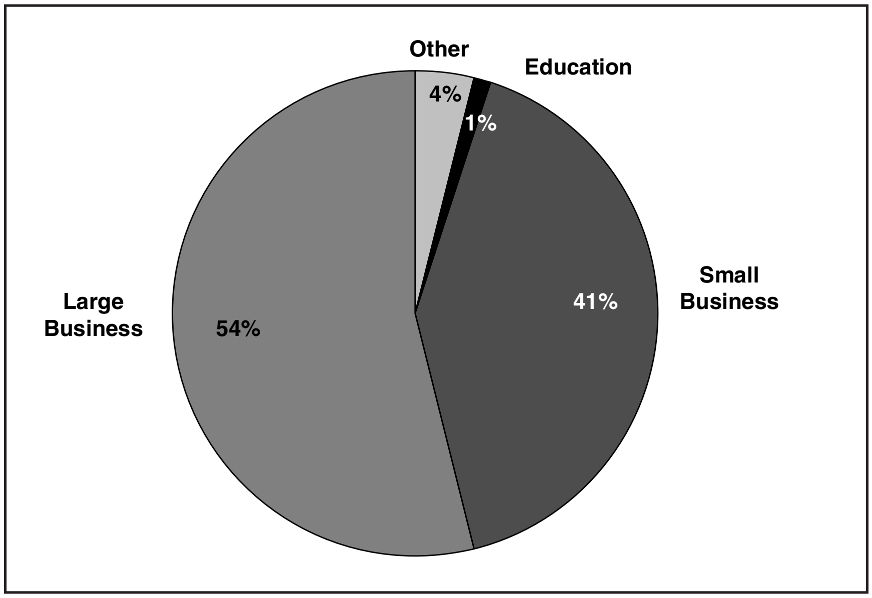
MIT Lincoln Laboratory Financial Data

Federal FY06 Funding by Sponsor



MIT Lincoln Laboratory's Economic Impact

The Laboratory has generated and supported a range of national business and industrial activities. The charts below show the Laboratory's economic impact by business category and state.



Type	Federal FY06	$M Amount
Large Business		120.6
Small Business		90.8
Education		3.0
Other		8.2
Total		222.6

	Federal FY06	$M
Top Five States:		
Massachusetts		132.6
Virginia		18.0
Pennsylvania		11.7
California		11.2
Texas		7.4
Other New England States:		
New Hampshire		5.2
Connecticut		3.4
Rhode Island		1.2
Maine		0.2
Vermont		0.06

MIT Lincoln Laboratory Mission Areas

Air and Missile Defense

MIT Lincoln Laboratory missile defense programs focus on investigating new system architectures, advanced sensor technology, flight-test hardware, decision algorithms, and field measurement systems. A strong emphasis is placed on the transfer of technology to government contractors.

Selected Current Projects

Programs are emerging to develop new radar open systems architectures for phased-array radars. The Laboratory will be creating the next-generation software and hardware architecture for missile defense X-band radars. This work will include developing new digital beamsteering and beamforming subcomponents and testing existing X-band phased-array hardware.

The Laboratory is prototyping an overarching discrimination architecture. This architecture, which will undergo future testing in the Pacific region, is being designed to allow the fusion of multiple sensor data and the coordination of target identification among multiple sites. The Laboratory will also be developing a bistatic, ultra-wideband receiver array at the Reagan Test Site (RTS) at Kwajalein. The receiver array will collect over 12 GHz of radar bandwidth for target identification with advanced processing.

MIT Lincoln Laboratory's air defense program focuses on the detection, location, identification, and engagement of airborne vehicles. Activities include the investigation of new system architectures, development of advanced sensor and decision support technologies, development of flight-test hardware, extensive field measurements and data analysis, and the rapid prototyping of sensor and system concepts. The Laboratory also has an active program in homeland air defense.

Selected Current Projects

A test campaign conducted at the Air Force Research Laboratory's Ipswich antenna test range demonstrated the feasibility of improvements to the bandwidth and interference mitigation of the Navy's Cooperative Engagement Capability. A bandwidth improvement of 10x over the current capability and a 1000x improvement in jammer and multipath suppression were demonstrated.

MIT Lincoln Laboratory performed a number of air defense analyses, including a study of the effectiveness of US systems for the Pacific Command, an analysis of future airborne electronic systems for the Air Force, and an assessment of US advanced technology development programs. The Laboratory also developed a six-degree-of-freedom flyout simulation of an important threat system, designed an integrated-air-defense-system model, and performed extensive testing of surveillance radar systems.

Communications and Information Technology

The goal of the Communications and Information Technology mission is to enhance the national global defense communications network (space, air, land, and sea) with special emphasis on theater tactical mobile users. To accomplish this, MIT Lincoln Laboratory identifies, develops, and demonstrates new mission-driven architectures, component designs, and network applications, and then transfers this technology to industry.

Selected Current Projects

MIT Lincoln Laboratory expertise and hardware are integral to the payload checkout and space segment integration for two new military satellite systems, the Wideband Gapfiller and Advanced EHF, due to launch in FY08, and a third military system in development, Transformational Communications, due to launch in FY14. The Laboratory is providing “gold standard” test equipment, design standard validation, and performance analyses in support of factory, launch site, and early on-orbit development testing.

Lincoln Laboratory is integrating the enabling technology for air, vehicle, and ground gateway software configurable network nodes. Key hardware programs include developing low-profile array antennas for aircraft, testing wideband air-to-air and air-to-space lasercom links. Key applications work includes evaluating host and network protection strategies, refining screening mechanisms for malicious code, and delivering speaker and language recognition algorithms. The Laboratory is applying similar technologies to NASA’s space communications programs.

Tactical Surveillance Technology

The Tactical Surveillance Technology mission focuses on sensor technology, techniques for processing and exploiting sensor data, embedded hardware and software, and experimentation to assess the impact and utility of the technology in an operational context. Recent efforts directed at counterterrorism are focused on the need for an effective, agile response to elusive threats, including vehicles concealed by natural or urban clutter.

Selected Current Projects

MIT Lincoln Laboratory is investigating various techniques to address counterterrorism. The Laboratory is working with the Defense Advanced Research Projects Agency to ascertain if the integration of multiple modalities and sensors leads to a capability for effectively tracking and locating items of interest. The Laboratory is also investigating mounting passive antennas on an unmanned air vehicle to enable the accurate location of the source of an adversary’s communications. Other programs seek to demonstrate signal processing technologies for a hovering unmanned vehicle to detect personnel walking in the open or under foliage cover. Similar objectives are being pursued utilizing high-resolution, 3D ladar systems based on very sensitive avalanche photodiode arrays.

Lincoln Laboratory is developing a vehicle-mounted sensor for detecting roadside improvised explosive devices (IEDs); this sensor was tested successfully at the Yuma, Arizona, IED Test Facility. The Laboratory is also demonstrating active laser-radar technologies integrated with electro-optics sensing for better determination of disturbances on the ground that could indicate the presence of an IED.

A new focus for undersea operations is on physics-based algorithms to separate submerged vehicles from the abundant surface contacts experienced in shallow-water operations. Lincoln Laboratory will be developing a cryo-cooled solid state laser as a track illuminator laser for the Airborne Laser program, providing higher capabilities in power in a reduced form factor.

Space Control

The Space Control mission focuses on detection, tracking, and identification of satellites; satellite mission and payload assessment; and environmental monitoring. The Space-Based Visible payload continues to demonstrate space surveillance from a space-based platform, illustrating the utility of visible-band data for midcourse missile defense. Environmental monitoring research is investigating space weather, atmospheric and ionospheric effects, satellite sensor design, and asteroid detection.

Selected Current Projects

The development of the Space Surveillance Telescope hardware is being completed and will be installed for test at White Sands, New Mexico. An improved antenna at the Millstone field site in Westford, Massachusetts, is scheduled for installation, and the low-power, W-band transmitter will be installed. Once the transmitter is operating to the low-power mode, in early FY08, radar images of low-altitude satellites can be acquired.

Sensor operations are focused on operating remote sensors from the Laboratory's campus in order to build an expanded space situational awareness picture. A major demonstration of the capability of the Extended Space Sensor Architecture is scheduled during the year.

Advanced Electronics Technology

A central thrust of MIT Lincoln Laboratory's work is the application of advances in electronics technology to solving defense problems. Multidisciplinary teams undertake research and development to improve sensors and communication and surveillance systems. Programs range from the invention and implementation of unique, specialized devices and circuits to the support of system-insertion and technology-transition. Areas of excellence include:

- imaging focal planes
- silicon circuit technology, including 3D integration
- compressive signal-intercept receivers
- optical lithography
- diode and solid state lasers
- thermophotovoltaic and thermoelectric devices
- a requisite infrastructure of materials growth, chemical analysis/ synthesis, and device/circuit design, test, and packaging facilities.

Selected Current Projects

Work in Advanced Electronics Technology is widely varied. In the electro-optical area, techniques for growing semiconductor epitaxial layers are being developed to improve quality and to create new device structures. Quantum electronics work is on application-specific solid state lasers and laser-based subsystems for tactical and strategic defense applications. Spectroscopic techniques for bioagent detection are also being engineered.

Submicrometer technology investigations continue on semiconductor microstructures, materials, and microfabrication techniques, including high-resolution lithography. Also within this area, chemical sensors, molecular electronics, and microphotonic devices are being investigated.

Substantial progress continues with high-performance photodetector arrays in which each pixel is sensitive to a single photon. Extensions to larger arrays, longer wavelengths, and more sophisticated per-pixel readout circuits have all been achieved and have expanded applications toward photon-counting passive imaging and high-rate optical communication.

Biological and Chemical Defense

The Biological and Chemical Defense mission is to develop technical and system-scale measures for negating the effectiveness of biological and chemical weapons. Early efforts concentrated on defending against biological-aerosol attacks on deployed military forces. The focus has expanded to potential attacks on food, air, and water, as well as on fixed assets. Efforts now include defense against chemical weapons as well as the use of chemistry to enhance biological methods. Moreover, efforts in environmental sensing have expanded significantly into related medical-defense areas, including both rapid identification and antimicrobials.

Selected Current Projects

Project work continues in developing and transitioning bioaerosol sensing technologies. Testing activities continue with Spectral Sensing of BioAerosols (SSBA) and with major facility integrations. New work includes defense of the military mail distribution system, with emphasis on decision support and introduction of advanced technology. MIT Lincoln Laboratory will begin development of a chemical and biological defense strategy for a net-centric battlefield. New projects involve antimicrobials, bioaerosol simulants, chemical standoff sensing, and nanotechnology.

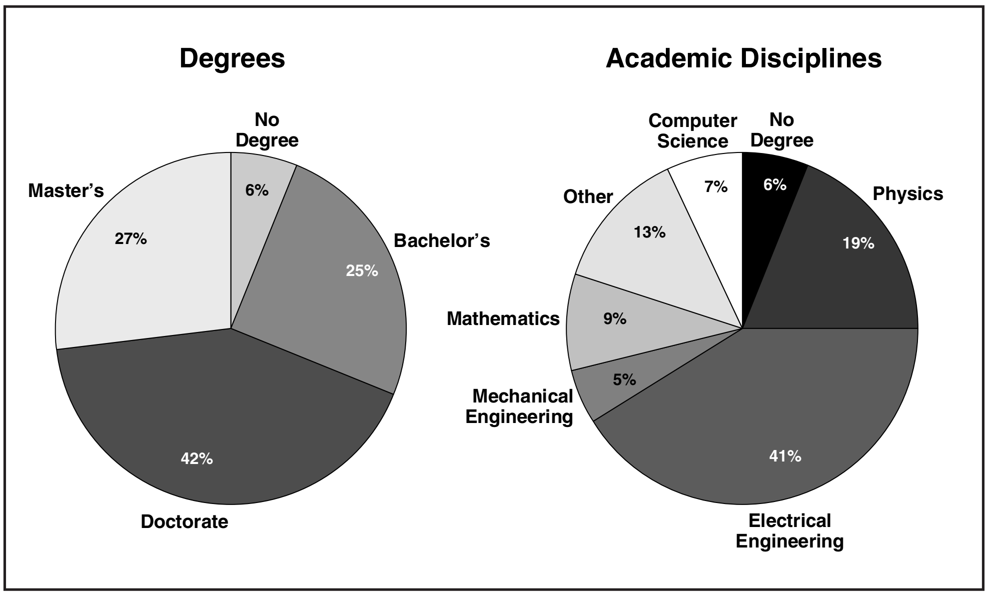
The Laboratory field-demonstrated the world's first detect-to-warn biological identification sensors, providing warning of low-level attacks in less than two minutes with exceptional sensitivity and false-alarm performance. Lincoln Laboratory has so far developed assays for nine high-threat agents.

MIT Lincoln Laboratory Staff

Approximately 1,500 technical staff are involved in research programs. Nearly two-thirds have advanced degrees, with 42% 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 50 of the nation's top technical universities, with 65-75% of new hires coming directly from universities. Lincoln Laboratory augments its campus recruiting by developing long-term relationships with research faculty and promoting fellowship and summer intern programs.

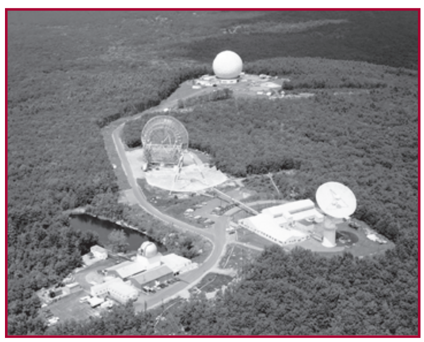
Technical Staff Profile



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



Reagan Test Site
Kwajalein, Marshall Islands

Other Sites
- **Pacific Missile Range Facility, Kauai, HI**
- **FAA Test Site, Albuquerque, NM (and others)**
- **White Sands Missile Range, Socorro, NM**

Current Federal Issues

3

Current Federal Issues

Trends in Federal Research Funding

Research universities, such as MIT, are primarily engaged in developing fundamental knowledge in science, engineering, and the social sciences. Over the past 60 years, the federal government has become vital in supporting this research. At colleges and universities in FY04, 75.2% of R&D expenditures were made in support of basic research activities while 24.8% of the funds were associated with applied research and development. In terms of total R&D expenditures at colleges and universities, the federal government was the source of 63.8% of funding, followed by institutional funds (18.1%), state and local governments (6.6%), and industry (4.9%).[1] The immediate impact of the federal investment in university research is impressive, funding the discovery of new knowledge and training the next generation of scientists and engineers.

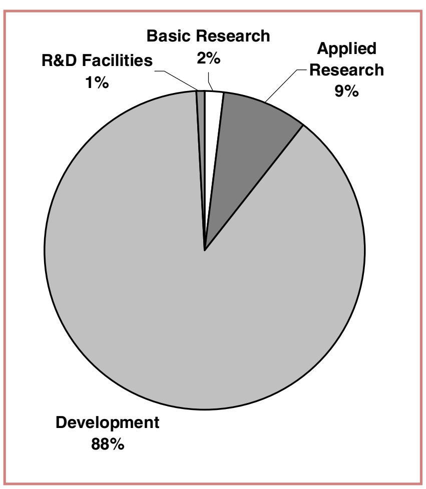
The President's FY07 $2.7 trillion budget proposed $1.029 trillion in total discretionary spending. Of the discretionary spending proposed, the President requested $136.9 billion to fund federal research and development accounts. Of that, $78.4 billion (57%) was allocated to defense R&D and $58.5 billion (43%) to non-defense R&D. In contrast to the $26.8 billion spent on non-defense basic research, defense basic research received $1.5 billion.

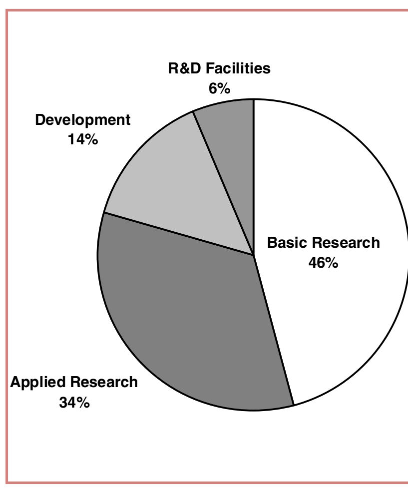
Federal Defense R&D by Character of Work, FY2007 Budget (in $million)

Basic Research	1,456
Applied Research	6,889
Development	69,463
R&D Facilities	607

Federal Non-Defense R&D by Character of Work, FY2007 Budget (in $million)

Basic Research	26,746
Applied Research	19,773
Development	8,314
R&D Facilities	3,665





Federal research funding in the physical sciences and engineering has been flat in inflation adjusted dollars for more than a decade.[2] Federal funding of research in the physical sciences, as a percentage of GDP, was 45% less in FY 2004 than in FY 1976.[3] The amount invested annually by the US federal government in research in the physical sciences, mathematics, and engineering combined equals the annual increase in US health care costs incurred every 20 days.[4]

The National Institutes of Health (NIH) is the second largest supporter of R&D in the federal government, after the Department of Defense[5]. After a successful period of increased NIH funding, which allowed the agency to greatly increase its research capacity and capabilities, recent budgets have not managed to keep pace with inflation. This erosion of purchasing power is putting pressure on the number of grants awarded, NIH fellowships, and other vital parts of the life science research infrastructure. If the out-year budget projections found in the FY07 NIH budget hold, NIH funding would decline steadily from $28.6 billion in FY07 to $27.5 billion in 2010 before a slight rebound to $27.9 billion in 2011. NIH R&D would fall 12.1 percent in real terms over five years.[6] Because of these flat to declining budget trends, NIH projects that it will fund only 19 percent of all research project grants (RPG) applications in 2006 and 2007.[7]

Given the current rate of spending (discretionary and non-discretionary), the level of revenues, and the looming demographic changes, the pressures on the federal budget are going to increase. Federal research and development funding will be competing with other priorities for diminishing resources. In some appropriations accounts, it is likely that various science accounts will be forced to struggle against each other for funding.

In his 2006 American Competitiveness Initiative, President Bush called for increases in three areas which support research in the physical sciences: the National Science Foundation, the Department of Energy's Office of Science, and the National Institute of Standards and Technology. The future funding increases outlined in the ACI are a solid step toward healthy, sustainable investments in basic research, but non-ACI agencies should not be forgotten. Federal research funding is a solid investment in future economic and national security.

Improving National Competitiveness and Innovation

One of MIT's most distinguished economists, Robert Solow, was one of the first growth economists, challenging the static model of classical economics and its explanation of economic growth as derived from capital supply and labor supply. He found that over time, more than half of US economic growth in the previous five decades had come from technological innovation.

Professor Solow won the Nobel Prize in 1987 for his work, but as a nation, we are only now beginning to grasp the implications of his analysis. If we accept Professor Solow's argument that growth stems from technological innovation, then how we as a nation organize and support science and technology becomes critically important.

MIT President, Susan Hockfield recently discussed the historical backdrop to the developments in federal innovation and competitiveness investments[1]:

> During WWII, MIT's Vannevar Bush became science advisor to President Roosevelt. Under his leadership, science and technology were integrated, sheltered under a single, flexible organizational umbrella. The "R" of research and the "D" of development were truly connected, and the results were remarkable. Much of modern electronics has flowed from work at the Radiation Laboratory set up at MIT to develop radar, and Los Alamos in its turn followed the same model.
>
> At the end of the war, Bush wrote the most famous polemic in the history of US science: "Science, The Endless Frontier." There, he argued that the federal government should not abandon the great system of scientific advance set up during the war. Instead, it should hold onto a residual role – the funding of basic research.
>
> …The model that Vannevar Bush created has been enormously productive. The federal government supported basic scientific research that industry could not, and those federal investments fueled the emergence of the modern American research university, which integrates research and teaching and has become the envy of the world. But Bush worked in a very different context from our own. The economy of the late 1940s was a corporate economy characterized by mass production, by great national markets, by national factory systems, and by scale, not product individualization. The corporations that dominated that economy were interested in incremental rather than radical innovation; technology was not intended to be, as we now put it, "disruptive," and we built great industry lab systems to support incremental innovation.

> …Our mass-production economy is being superseded by a knowledge economy based on information technology. The models are very different. That mass-production economy was both hierarchical and bureaucratic. The emerging economy based on information is – so far, at least – flat and collaborative, and relies on networks.
>
> …This new economy, based on information technology, is driven by startups and entrepreneurs who seek not incremental innovation but radical breakthroughs. It relies on new sources of capital - venture capitalists, angel investors, and IPOs. And it is also forcing a new kind of research organization, one that is less integrated into established enterprises, and increasingly virtual. In yet another manifestation of the tendency towards disaggregation, the great industrial labs are being redefined when they are not actually swept away. And with this change, the university has stepped into a much more central role in the innovation system. Fortunately for our nation and our economy, a number of US universities were ready for this change in research organization.
>
> …Universities themselves fit the emerging organizational and entrepreneurial models of the knowledge-based economy: they are relatively flat, their research cadres are relatively non-hierarchical and collaborative, and they are built around knowledge networks. Our task now is to intensify the creative relationships we have already built with the knowledge-based economy – to create new, connected models that supplement the long-established pipeline model.

As our economy has grown and strengthened, the rest of the world has been observing our success and making plans to emulate our methods and models.

- The share of leading-edge semiconductor manufacturing capacity owned or partly owned by US companies today is half what it was as recently as 2001.[2]
- During 2004, China overtook the United States to become the leading exporter of information technology products, according to the OECD.[3]
- In South Korea, 38% of all undergraduates receive their degrees in natural science or engineering. In France, the figure is 47%, in China, 50%, and in Singapore 67%. In the United States, the corresponding figure is 15%.[4]
- In 2005, only four American companies ranked among the top 10 corporate recipients of patents granted by the United States Patent and Trademark Office.[5]
- Estimates of the number of engineers, computer scientists, and information technology students who obtain 2-, 3-, or 4-year degrees vary. One estimate is that in 2004, China graduated about 350,000 engineers, computer scientists, and information technologists with 4-year degrees, while the United States

graduated about 140,000. China also graduated about 290,000 with 3-year degrees in the same fields, while the United States graduated about 85,000 with 2- or 3-year degrees.[6] Over the past 3 years alone, both China[7] and India[8] have doubled their production of 3- and 4-year degrees in these fields, while the US[9] production of engineers is stagnant and the rate of computer scientists and information technologists doubled.

As is noted in the National Academies Report, *Rising Above the Gathering Storm*:[10]

> Having reviewed trends in the United States and abroad, the committee is deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength. We strongly believe that a worldwide strengthening will benefit the world's economy – particularly in the creation of jobs in countries that are far less well-off that the United States. But we are worried about the future prosperity of the United States. Although many people assume that the United States will always be a world leader in science and technology, this may not continue to be the case inasmuch as great minds and ideas exist throughout the world. We fear the abruptness with which a lead in science and technology can be lost – and the difficulty of recovering a lead once lost, if indeed it can be regained at all…
>
> Although the US economy is doing well today, current trends in [the criteria multinational companies use in determining where to locate their facilities and the jobs that result] indicate that the United States may not fare as well in the future without government intervention. This nation must prepare with great urgency to preserve its strategic and economic security. Because other nations have, and probably will continue to have, the competitive advantage of a low wage structure, the United States must compete by optimizing its knowledge-based resources, particularly in science and technology, and by sustaining the most fertile environment for new and revitalized industries and the well-paying jobs they bring. We have already seen that capital, factories, and laboratories readily move wherever they are thought to have the greatest promise of return to investors.

These ideas are further bolstered in the President Bush's FY 2007 American Competitiveness Initiative (ACI):[11]

> Keeping our competitive edge in the world economy requires focused policies that lay the groundwork for continued leadership in innovation, exploration, and ingenuity. America's economic strength and global leadership depend in large measure on our Nation's ability to generate and harness the latest in scientific and technological developments and to apply these developments to real world applications. These

applications are fueled by: scientific research, which produces new ideas and new tools that can become the foundation for tomorrow's products, services, and ways of doing business; a strong education system that equips our workforce with the skills necessary to transform those ideas into goods and services that improve our lives and provide our Nation with researchers in the future; and an environment that encourages entrepreneurship, risk taking, and innovative thinking.

MIT and other research universities in the United States have a key role in ensuring our national competitiveness. Federal agencies, state and local governments, and industry count on colleges and universities to discover new knowledge that leads to revolutionary products, methods, and ideas while training the next generation of scientists and engineers. Universities, industry, and the federal government together have helped to create the strongest, most resilient economy in the world. With proper investment and sound policies, we can maintain our global lead as the rest of the world increases its capabilities to compete with us.

Managing Export Controls

Export control laws have for many years been a mechanism to control the transfer of goods having military applications; in the late 1970s they also became a means to limit the export of goods or technologies having commercial value.

Export of military hardware and technical data is controlled by the International Traffic in Arms Regulations (ITAR) dating back to 1954, while the export of commodities of commercial interest (and the technical data related to their design, manufacture and utilization) is controlled by the Export Administration Regulations (EAR) from 1979. The ITAR are administered and enforced by the Department of State, whereas the EAR are under the Department of Commerce.

Increased national attention to export controls occurred in the early 1980s with concerns about technology transfers to the Soviet Union. University reaction led to a set of changes and a status quo we have lived with ever since. In 1999, concerns about transfer of missile and satellite technology to China rekindled national attention to export controls, and the climate chilled further after September 11, 2001. Now many federal agencies, as well as industries, are incorporating export control language into research grants and contracts. But even without such language, export controls are the law, and we all must obey them (the law, and the penalties, cover individuals as well as institutions).

What is controlled?
Generally speaking the ITAR and EAR regulate items and materials (equipment, biologicals, chemicals), and information (technical data, including "services" associated with the controlled items and materials). In addition to more obvious military hardware, the ITAR controls all satellites, including research satellites, associated equipment, and some devices with military applications like accurate GPS equipment

and even research submersibles. EAR controls a long list of equipment, for example high bandwidth oscilloscopes, large fermenters, certain microprocessors, and encryption software. Both regulations control chemical weapons, conventional chemicals, select biological agents and toxins, and certain other hazardous chemicals and biologicals.

What is an export?

The term export, as used in export control regulations, has an expansive meaning. The transfer of actual goods between countries (whether the transfer abroad is to a US citizen or a foreign national) is controlled, as well as the disclosure or transfer of certain technical information to a US citizen abroad or to a "foreign person" abroad or even within US borders. The term "foreign person" essentially includes anyone who is not a US citizen or permanent resident (although for some purposes, citizens of certain countries may be exempt). As is evident in many instances, export is defined so that it could preclude the participation of foreign graduate students or post-docs in research that involves covered technology, without first obtaining license from the appropriate government agency.

The Fundamental Research Exemption

Since 1985, the federal government's policy, as articulated by President Reagan's National Security Decision Directive, NSDD-189, has exempted most university research from the export control regulations.

> NSDD-189 (issued in1985 and reaffirmed in 2001)
>
> 'Fundamental research' means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.
>
> It is the policy of this Administration that, to the maximum extent possible, the products of fundamental research remain unrestricted. It is also the policy of this Administration that, where the national security requires control, the mechanism for control of information generated during federally-funded fundamental research in science, technology, and engineering at colleges, universities and laboratories is classification. No restriction may be placed upon the conduct or reporting of federally-funded fundamental research that has not received national security classification, except as provided in applicable US Statutes.

Both the ITAR and EAR contain specific language exempting fundamental research and, in the case of EAR, instruction in catalogued courses in universities from export controls, and in the case of ITAR basic math and science commonly taught in schools.

Under the current interpretation of the fundamental research exemption, universities can continue to carry out research without export control licenses provided that the research is openly published and shared broadly. Note that any research involving proprietary information or other publication restrictions or participation restrictions may remove the fundamental research exemption. The decision about whether export control licenses are needed are made at MIT after discussions with our Office of Sponsored Programs.

The fundamental research exclusion applies literally to information (but not to export controlled materials or items) resulting from or arising during basic and applied research in science and engineering conducted at an accredited institution of higher education located in the United States that is ordinarily published and shared broadly within the scientific community and that is not specifically restricted. This exclusion does not permit the transfer of export-controlled information, materials, or items abroad, even to research collaborators, except under very limited circumstances.

Deemed Exports

Much of the recent concern over export controls centers around the concept of “deemed export.” “Deemed” exports are transfers of controlled technology to foreign persons, usually in the US, where the transfer is regulated because the transfer is “deemed” to be to the country where the person is a citizen. Most of MIT’s research and interactions with students, postdocs, visitors, and colleagues are covered by the fundamental research exemption.

However, a recent set of reports by the Inspectors General (IG) of several federal agencies have put the spotlight on deemed exports at universities, as well as at national labs and in industry. MIT, together with other major research universities and organizations like the American Association of Universities, are actively involved in discussions with these agencies to clarify the implications of the IG reports. We are hopeful that the spirit of NSDD 189 will prevail and create a sound, workable process. The Department of Commerce has recently announced an advisory committee to review these issues.

Welcoming International Students and Scholars

The United States presently enjoys a system of higher education that is the envy of the world. This premier position allows us to attract the most talented, most driven and highly motivated international students and scholars in the world. We benefit from the presence of these students and scholars in myriad ways. These benefits can be difficult to quantify; in this brief analysis, we use the perspective of MIT's experience over the past 150 years to evaluate the contributions that our international student and scholar population makes to us and to our nation.

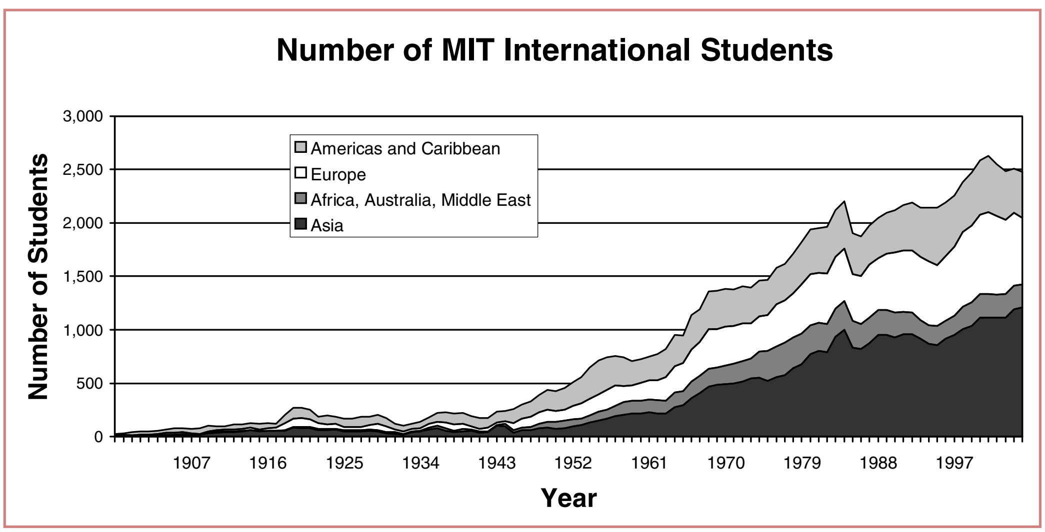
A Century of International Students

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 across the globe throughout the nineteenth century. By 1900, some 50 foreign-born students had traveled to Massachusetts for study; however, the numbers of international students only really began to grow after the Second World War, when an influx of these students began in earnest. The rapid rise of international students from East Asia, led by China, changed the demographics of this group beginning in the 1950s. The change in immigration law in 1965 opened up the doors to a steadily rising influx of international talent.

World events and political decisions have always had a strong impact on immigration. We see this in MIT's international student population as well. World wars curtail the flow of students while peacetime pressures, such as changing immigration laws (1965), the demise of the iron curtain, the Vietnam War protests (1968), and the Asian financial crisis (1997), cause their respective ebbs and surges.

The Best and Brightest International Students and Scholars – Global Contributors

The United States has been the destination of choice for international students and scholars for the past 50 years. Just as MIT's experience shows, the number of foreign students has risen steadily since the 1970s, and last year, according to the Institute for International Education, there were more than 500,000 international students enrolled in U.S. colleges and universities and over 80,000 professionals who came as international teachers and researchers (see www.opendoors.iienetwork.org).



One might ask what becomes of the international students we recruit and train. We are aware of the great contributions immigrants make to our culture and the leadership roles those who are educated in the United States often assume. For example, consider the extraordinary contributions these MIT international alumni and scholars have made to their home countries, the US, and the world:

Luis Alberto Ferré
SB, SM – Mechanical Engineering – 1924, 1925
Following graduation, Ferré joined his father as a junior engineer in the family business, the Puerto Rico Iron Works. With his brothers he built an enterprise that contributed to the industrialization of the country and its infrastructure. In 1952 Ferré was elected to the Puerto Rico House of Representatives, and in 1968 became the country's second elected governor, the position he held until 1972. Ferré served on numerous commissions and foundations dedicated to strengthening relations between Puerto Rico and the United States.

Kenan Sahin, Turkey
SB 1963, MIT PhD 1969
Dr. Sahin is founder of Kenan Systems, which developed one of the key productivity advances in computer software, and provides software products for business management and decision support to single- and multi-service communications and energy companies worldwide. Kenan Systems was merged into Lucent Technologies, and Dr. Sahin served as Vice President for Software Technologies at Lucent. Dr. Sahin is the founder and president of TIAX LLC.

Sanjay E. Sarma, India
University of California, Berkeley, PhD, 1995
Carnegie Mellon University, ME, 1992
Indian Institute of Technology, Kanpur, B Tech, 1989
Sanjay Sarma is the Cecil and Ida Green Associate Professor of Mechanical Engineering at MIT. He cofounded the Auto-ID Center, an unusual cooperative effort between academia and global companies to develop the Electronic Product Code (EPC), a system for identifying objects and sharing information about them securely over the Internet.

Koffi Annan, Ghana
MS Management – 1972
Kofi Annan, the seventh Secretary-General of the United Nations, 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 études internationals in Geneva, and earned his MS 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. Kofi Annan and the United Nations were the recipients of the 2001 Nobel Peace Prize.

Tony Tan, Singapore
SM – Physics – 1964
Following his degrees from MIT and his PhD from the University of Adelaide in applied mathematics, Tan taught mathematics at the University of Singapore. Tan was elected to the Parliament in 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 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 Co-ordinating Minister for Security and Defense.

Of the 61 MIT-affiliated Nobel Prize winners (including faculty, researchers, alumni and staff), one-third were foreign born.[1] International faculty recruited through international searches for tenure-track positions remain in the US to teach the next generation of American cancer researchers, physicists, biomedical engineers, business leaders, and computer scientists.

Looking beyond MIT, it is estimated that some 20 current and 165 former heads of government received some part of their education in the United States.[2]

Our current visa system is predicated on applicants demonstrating that they have no intent to immigrate. Thus, officially we want them to come here, pursue their studies and research, and then to return to their home country.

This appears to have some merit if one holds the view that to remain in this country, these highly educated immigrants would compete for jobs with domestic candidates. It is also true, however, that those who remain in the US contribute greatly to our community, our economy, and our science and technological leadership.

Many of our international graduates return to their home country. While they are not directly contributing to our economy, in today's global environment the alumni are contributing to our economies and those of others both directly and indirectly. In addition, those who return and gain positions of leadership are more likely to share our values and to try to emulate our technical and business structures. This level of diplomacy may be far more important than we can imagine.

Footnotes

Trends in Federal Research Funding

[1] National Science Foundation, *Survey of Research and Development Expenditures at Universities and Colleges, Fiscal Year 2004*, 2006.
[2] American Association for the Advancement of Science. 2006. R&D Budget Policy Program, Guide to R&D Funding Data – Historical Data. Available at: http://www.aaas.org/spp/rd/guihist.htm
[3] American Association for the Advancement of Science. 2004. “Trends in Federal research by Discipline, FY 1976-2004.” October. Available at: http://www.aaas.org/spp/rd/disc04tb.pdf and http://www.aaas.org/spp/rd/discip04c.pdf
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[7] American Association for the Advancement of Science. 2006. “AAAS Report XXXI: Research and Development FY 2007.” Available at: http://www.aaas.org/spp/rd/07pch8.htm

Improving National Competitiveness and Innovation

[1] “The University in the U.S. Innovation System.” April 26, 2006. Bernard L. Schwartz Forum on U.S. Competitiveness in the 21st Century. The Brookings Institutions, Washington, D.C. Available at: http://web.mit.edu/hockfield/speech-brookings.html
[2] Semiconductor Industry Association. 2005. “Chosing to Compete.” December 12. Available at: http://www.sia-online.org/downloads/FAD%20’05%20-%20Scalise%20Presentation.pdf.
[3] OECD. 2005. “China Overtakes U.S. As World’s Leading Exporter of Information Technology Goods.” December 12. Available at : http://www.oecd.org/document/60/0,2340,en_2649_201185_35834236_1_1_1_1,00.html. The main categories included in OECD’s definition of ICT (information and communications technology) goods are electronic components, computers and related equipment, audio and video equipment, and telecommunication equipment.
[4] Analysis conducted by the Association of American Universities. 2006. National Defense Education and Innovation Initiative. Based on data in National Science Board. 2004. Science and Engineering Indicators 2004 (NSB 04-01). Arlington, VA: National Science Foundation. Appendix Table 2-33. For countries with both short and long degrees, the ratios are calculated for both short and long degrees as the numerator.
[5] US Patent and Trademark Office. 2006. USPTO Annual List of Top 10 Organizations Receiving Most U.S. Patents. January 10, 2006. See http://www.uspto.gov/web/offices/com/speeched/06-03.htm
[6] G. Gereffi and V. Wadhwa. 2005. Framing the Engineering Outsourcing Debate: Placing the United States on a Level Playing Field with China and India. http://memp.pratt.duke.edu/downloads/duke_outsourcing_2005.pdf
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[8] National Association of Software and Service Companies. 2005. Strategic Review 2005., India. Chapter 6. Sustaining the India Advantage. Available at http://www.nasscom.org/strategic220.asp
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[11] Executive Office of the President, Domestic Policy Council and Office of Science and Technology Policy. 2006. “American Competitiveness Initiative: Leading the World in Innovation.” Available at: http://www.whitehouse.gov/stateoftheunion/2006/aci/

Welcoming International Students and Scholars

[1] A list of Nobel Prize winners with MIT affiliations can be found at the following Website: http://web.mit.edu/ir/pop/awards/nobel.html

[2] *"Foreign Students On Campus, An Asset to our Nation,"* Immigration Policy Focus, Vol. 2, Issue 1, American Immigration Law Foundation, 2003.

MIT and Industry

4

MIT and Industry

Fostering Innovation

Dedicated from its founding to addressing practical problems, MIT has a long tradition of collaboration with industry. Creating jobs, companies, and even new industries, these partnerships are a vital engine in the country's innovation system – the alliance of industry, universities, government, and labor that develops new knowledge and technologies, educates a highly-skilled work force to apply them, and produces the next generation of researchers to continue the process of discovery and development. The system turns out a continuous stream of new products and services, which in turn advance our economy and improve our lives.

MIT's interactions with industry bring real-world technology and management issues into our research laboratories and our teaching. They keep the faculty and students current, grounded, and forward-looking. Maintaining strong, productive industrial alliances is an Institute priority.

Sponsored Research
MIT hosts more industry-sponsored research than any other university in the nation. More than 400 corporations supported research projects on the MIT campus in FY 2005, with expenditures exceeding $65 million. Companies often join together in these collaborations to support multi-disciplinary research programs in a wide range of fields.

Licensing Inventions
In FY 2006, MIT filed 321 US patents, and was issued 121. There were 523 invention disclosures, 97 licenses granted, 23 trademark licenses granted, and 27 software end-use licenses granted. In each of the past five years, we have had over 100 US patents issued to us and we have signed 60-100 option and license agreements. A small percentage of inventions are suitable for start-ups as they open entirely new fields or introduce new approaches. MIT has long been famous as a source of start-up technology, and 23 new companies were formed around MIT licenses in 2006. While university technology licensing obviously has a significant economic impact in terms of bringing new technologies to market, creating companies and jobs, and increasing tax revenues, many of these products do not achieve significant sales until three to five years after the license is signed.

Benefits to the National Economy

In 1997, the BankBoston Economics Department released a pioneering case study of MIT's impact on the nation's economy. The study found that MIT graduates, faculty, and staff had established 4,000 firms which in 1994 alone employed at least 1.1 million people and generated $232 billion in world sales. MIT-related jobs existed in every state in the union, with more than 2,400 headquartered outside of the Northeast. If MIT-related companies formed a nation, in 1994 they would have ranked as the world's 24th largest economy, with "a little less than the GDP of South Africa and more than the GDP of Thailand," the study noted.

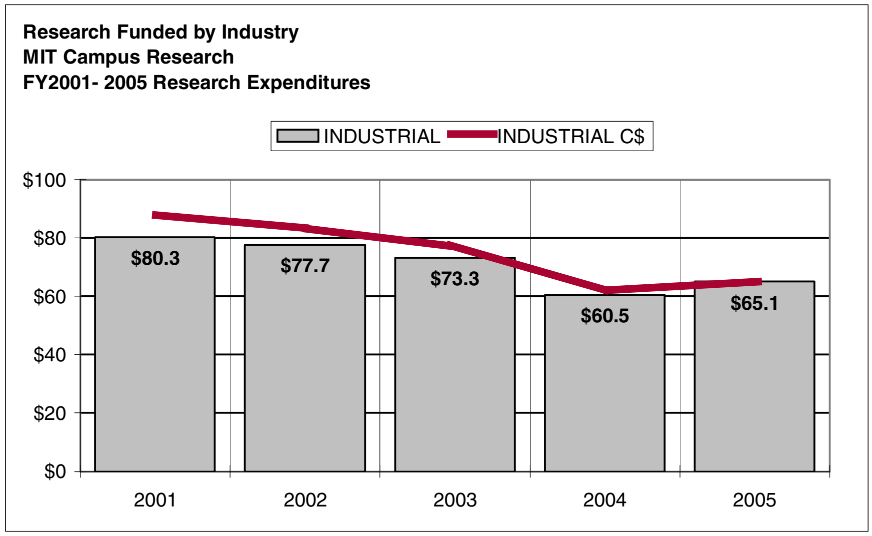
The study reported that MIT-related companies had a major presence in the San Francisco Bay area (Silicon Valley), southern California, the Washington-Baltimore-Philadelphia belt, the Pacific Northwest, the Chicago area, southern Florida, Dallas and Houston, and the industrial cities of Ohio, Michigan, and Pennsylvania. The five states benefiting most from MIT-related jobs were California (162,000), Massachusetts (125,000), Texas (84,000), New Jersey (34,000) and Pennsylvania (21,000).

Thirteen other states had more than 10,000 MIT-related jobs: from west to east, Washington, Oregon, Colorado, Kansas, Iowa, Wisconsin, Illinois, Ohio, Virginia, Georgia, Florida, New York, and Connecticut. Another 25 states had between 1,000 and 9,000. Only seven low-population states and the District of Columbia had fewer than 1,000 jobs created by MIT companies.

The study also reported that these companies were "not typical of the economy as a whole; they tend to be knowledge-based companies in software, manufacturing (electronics, biotech, instruments, machinery) or consulting (architects, business consultants, engineers). These companies have a disproportionate importance to their local economies because they usually sell to out-of-state and world markets, and because they so often represent advanced technologies." Other industries represented included manufacturing firms in chemicals, drugs, materials, and aerospace, along with companies in energy, publishing, and finance.

Looking at employment figures around the world, the study found that MIT-related firms in Massachusetts had created 353,000 jobs outside the US; those in California had created 348,000 outside the country. MIT people had created 220 companies abroad that employed 28,000 people worldwide.

Research Funded By Industry



Industry funding in FY 2005 was $65.1 million.

Leading Departments, Centers, and Laboratories Receiving Industry Support (FY 2005)
Computer Science and Artificial Intelligence Laboratory
Media Laboratory
Department of Management
Department of Mechanical Engineering
Department of Chemical Engineering
Laboratory for Energy & The Environment
Microsystems Technology Laboratories
The Broad Institute

Service to Industry

Deshpande Center for Technological Innovation

The Deshpande Center for Technological Innovation nurtures marketable inventions by engaging industry to spark inventions that solve existing needs, and by funding proof-of-concept explorations with Ignition Grants. The Center fuels market-driven innovation by funding research with Innovation Grants, getting the business community involved at an early stage to help shape the direction of research, and by educating the research community about commercialization. It also implements innovation in the marketplace by catalyzing collaborations, directing researchers to appropriate business and entrepreneurial resources, and serving as a liaison between MIT and the local business community.

The Industrial Performance Center

The Industrial Performance Center supports interdisciplinary research and education aimed at understanding and improving industrial productivity, innovation, and competitiveness. Faculty and students from all five MIT schools participate in its programs. Since its founding in 1992, the Center has conducted research at more than 1,000 firms in major manufacturing and service industries in both advanced and emerging economies.

Leaders for Manufacturing

Leaders for Manufacturing (LFM) is an educational and research program that the MIT Sloan School of Management and the School of Engineering conduct in partnership with more than 25 global manufacturing and operations companies. The program educates new leaders in manufacturing and operations, and advances the understanding of manufacturing and operations principles. LFM views these two functions in the broadest sense, from product concept through delivery. Its 24-month program leads to two Master of Science degrees – one in engineering and the other in management. Students work with faculty in both schools and take part in activities that include six-month internships at partner companies.

MIT Center for Biomedical Innovation

An Institute-wide collaboration of faculty from the MIT Schools of Engineering, Management, and Science, the Harvard-MIT Division of Health Sciences & Technology, and their counterparts from government and industry, the MIT Center for Biomedical Innovation addresses the challenges of translating advances in the life sciences more efficiently and safely, from the laboratory to the public. The center provides a “safe harbor” in which major players across the biomedical spectrum –from medical researchers to federal regulators, payers, and experts in finance and marketing – can better appreciate each other’s concerns and communicate and collaborate more effectively.

MIT International Science and Technology Initiatives

The MIT International Science and Technology Initiatives program (MISTI) enlarges students’ opportunities for international learning through on-campus resources and internships in foreign companies and laboratories; supports faculty collaborations with researchers abroad; and works with corporations, government, and nonprofit organizations to promote international industry, education, and research. About 150 students participate annually in MISTI internships, preparing for their stay abroad with integrated courses in foreign languages and cultures. MISTI programs are organized by region. The first one established, MIT Japan, today is the largest center of applied Japanese studies for scientists and engineers in that country. Other programs are in China, France, Germany, India, and Italy. MISTI also supports conferences and workshops that promote international learning and research at MIT, and provides training for corporations.

MIT Sloan Fellows Program in Innovation and Global Leadership
The MIT Sloan Fellows Program in Innovation and Global Leadership is a 12-month, full-time program for high-potential mid-career managers with strong technical and entrepreneurial backgrounds. Integrating management, technology, innovation, and global outreach, the program provides students with a rigorous academic curriculum, frequent interaction with international business and government leaders, and an exchange of global perspectives that enable them to develop their capacities as global innovators. The program attracts people from all over the world from a wide variety of for-profit and nonprofit industries, organizations, and functional areas. Students can earn an MBA, an MS in management, or an MS in the management of technology.

Office of Corporate Relations
MIT's Office of Corporate Relations promotes creative collaboration among MIT, industry, and government. Its Industrial Liaison Program enables member firms to draw upon MIT expertise to inform their own technology strategies, and at the same time helps faculty members stay abreast of the latest industrial developments.

Professional Education Programs
To meet the industries' need to bring large groups of employees up to speed in new or evolving areas of knowledge, in 2002 the MIT School of Engineering established its Professional Education Programs (PEP). An extension of MIT's Professional Institute (see below), PEP offers Internet-based courses that employees can participate in at their home institutions without traveling to Cambridge. MIT faculty also work with corporations to design customized curriculums that meet their specific needs, including those that integrate management with technological advances.

Professional Institute
Founded in 1949, MIT's Professional Institute (PI) brings more than 600 technical, scientific, business, and government professionals from around the world to campus each year for two- to five-day courses that allow them to develop working knowledge in rapidly evolving technologies, industries, and organizational structures. PI's more than 40 courses, which can involve lectures, discussions, readings, interactive problem solving, and laboratory work, cover a broad range of topics, such as hydrologic modeling, bioinformatics, nanostructured fluids, supply chain network optimization, scientific marketing, and high-speed videography. Recent PI participants include employees from Amgen, Archer Daniels Midland, Johns Hopkins Applied Physics Lab, Kimberly-Clark Corporation, Nagoya City University, San Mateo County Transit District, Delft University of Technology, and the US Department of Defense.

System Design and Management

System Design and Management (SDM) educates engineering professionals in the processes of engineering and designing complex products and systems, and gives them the management skills they need to exercise these capacities across organizations. Sponsored by the MIT School of Engineering and the Sloan School of Management, the program offers a joint Master's degree from both schools. Students can pursue these degrees either on campus or through a hybrid on-campus/off-campus curriculum that uses video conferencing and web-based instruction. This flexibility has made it possible for people like a captain in the United States Army commanding a division in Iraq, a captain in the Hellenic Air Force, or a General Electric aerospace engineer in Cincinnati to take advantage of SDM's technical, engineering, and management breadth. More than 50 companies and organizations from a wide range of fields have sponsored students in this program.

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.

DuPont

Established in 2000 and extended in 2005, the DuPont MIT Alliance (DMA) brings together each institution's strengths in materials, chemical, and biological sciences to develop new materials for bioelectronics, biosensors, biomimetic materials, alternative energy sources, and other high-value substances. DuPont also works with MIT's Sloan School of Management to define new business models for these emerging technologies. Among DMA's accomplishments are a device for the tissue-like culturing of liver cells that provides a medium for testing the toxicity of new pharmaceuticals. Another is the development of a material similar to the water-repellent surfaces of lotus leaves, which has potential for applications like self-cleaning fabrics, water-repellent windshields, and plumbing that resists the growth of harmful bacteria. To date, MIT and DuPont scientists have applied for more than 20 patents based on their research. In its second stage, DMA is moving into nanocomposites, nanoelectronic materials, alternative energy technologies, and next-generation safety and protection materials.

Ford Motor Company

Since it was launched in 1997, the Ford-MIT Alliance has joined MIT and Ford researchers on a wide range of education and research projects that emphasize environment and design. Built on a long history of working together, the alliance grew from a recognition that changes brought about by globalization and the impact of advanced information technologies require new models of university/industry collaboration. The more than 80 research projects supported by the Ford-MIT Alliance include climate and environmental research, the development of cleaner engine and fuel technologies, computer-aided design, and automobile voice recognition systems, such as the one MIT and Ford researchers are now working on to allow drivers to direct their autos' navigation systems by speaking, rather than by entering the information with keystrokes.

Hewlett-Packard Company
With the ultimate goal of expanding the performance and flexibility of the commercial, educational, and personal services that digital information systems provide, Hewlett-Packard and MIT established an alliance in 2000 to investigate new architectures, devices, and user interfaces, and to develop new ways to create and handle digital information. The HP/MIT Alliance has helped launch Dspace, the MIT Libraries' pathbreaking digital archive which opens up the intellectual output of MIT faculty and research staff to researchers around the world. It also supports the MIT Ultra-Wideband group, which is advancing UWB communication, and the MIT Center for Wireless Networking, which explores ways to expand the capabilities of wireless appliances and the networks and server architectures that they use.

Microsoft Corporation
Called iCampus, the Microsoft/MIT collaboration supports projects among Microsoft researchers and MIT students, faculty, and staff that advance IT-enabled teaching models and learning tools for higher education. Established in 1999, iCampus has funded dozens of faculty and student projects. Among its products are a new course in introductory physics (see **Studio Physics**, p. 1-12); a web-accessible microelectronics teaching laboratory (see **WebLab**, p. 1-12); and a new tool for environmental researchers in the field – an electronic notebook that makes it possible to streamline data collection and improve its accuracy. This breakthrough was the product of a student-designed course set up with iCampus funding specifically for developing a software application that would enable environmental scientists to dispense with paper notebooks, gather data electronically, integrate it with environmental and GPS sensors, and carry out computations in the field. The tool also lets them transmit data wirelessly to a remote server, where not only are their records invulnerable to the hazards of wind, water and other factors that make data collection in the field so precarious, but also are readily available to other researchers.

Pirelli Labs
Working on the MIT campus and in Pirelli Laboratories near Milan, scientists from both organizations are collaborating on a new generation of nanotechnology integrated optical systems. By miniaturizing the components and using all of the wavelengths available in a fiber optic cable to maximize the amount of data transmitted on each fiber, this technology will both dramatically reduce manufacturing and delivery costs and make it possible to provide enormous broadband capacity to consumers. The collaboration's ultimate goal is to provide residential subscribers highest-quality broadband telecommunications services and much lower cost.

Project Oxygen Alliance
A partnership among MIT Computer Science and Artificial Intelligence Laboratory and six corporations – the Acer Group, Delta Electronics, Hewlett-Packard, Nippon Telegraph and Telephone, Nokia, and Philips – Project Oxygen's goal is to make computation and communication resources as abundant and as natural to use as oxygen. Working also with support from the Defense Advanced Research Projects Agency, the project seeks to free people from computer jargon, keyboards, mice and other specialized devices they rely on now for access to computation and communication. The researchers are creating, for example, speech and vision technologies that enable humans to communicate

as naturally with computers as they do with people. They are developing centralized networks and robust software/hardware architectures that can adapt to mobile uses, currently available resources, and varying operating conditions. Researchers also are at work devising security and privacy mechanisms that safeguard personal information and resources.

Quanta Computing
In today's computing environment, people using personal service technologies have to navigate among an array of devices – from cell phones to computers to personal digital assistants. In 2005, MIT and Quanta Computing established Project TParty to address this complexity. Engineers from Quanta are collaborating with researchers from MIT's Computer Science and Artificial Intelligence Laboratory to design new platforms for computing and communication, reengineer and extend the underlying technical infrastructures, create new interfaces, and explore new ways of imaging, accessing, and integrating information. Their goal is to design new products that will make the personal use of computer technologies much easier and more productive.

Selected Current Campus Projects

Closing in on Bionic Speed
Robots have the potential to go where it is too hot, too cold, too remote, too small or too dangerous for people to perform any number of important tasks, from repairing water leaks to stitching blood vessels together. Now MIT researchers, led by Sidney Yip, professor of nuclear engineering and materials science and engineering, have proposed a theory that might eliminate an obstacle to achieving these goals – the limited speed and control of the "artificial muscles" that make these robots move. Today, engineers construct robotic muscles from polymers that carry an electric current, which are triggered by activating waves called "solitons." Proposing a model that explains how these waves work, Xi Lin, a postdoctoral associate in Yip's lab, has developed an understanding which will permit engineers to design lighter, much more flexible polymers. Able to transmit the wave much more quickly, they can make the robot muscles move 1,000 times faster than those of humans. This work was supported by Honda R&D Co., Ltd., and DARPA.

Sharper Image
Researchers in MIT's Computer Science and Artificial Intelligence Laboratory have developed a technique for taking some of the blur out of snapshots. Rob Fergus, a postdoctoral associate in the lab of computer science professor William Freedom, presented the method at the recent Siggraph 2006 conference in Boston. When pictures are taken with lightweight, digital cameras, often the hands holding the camera shake, blurring the resulting images. Using software to remove the blur is the goal of scientists, but it's difficult without knowing how the camera was moving. Knowing that objects tend to have statistically distinctive patterns of light and dark with sharp changes at the edges, Fergus developed software which measures the light-to-dark gradients in a photo and compares them with preprogrammed values to estimate how the camera moved, and then reconstructs the image. The process takes 10 to 15 minutes, and although the resulting images are not perfect, the method has provided serviceable versions of photos that were previously unusable.

Undergraduate Financial Aid

5 Undergraduate Financial Aid

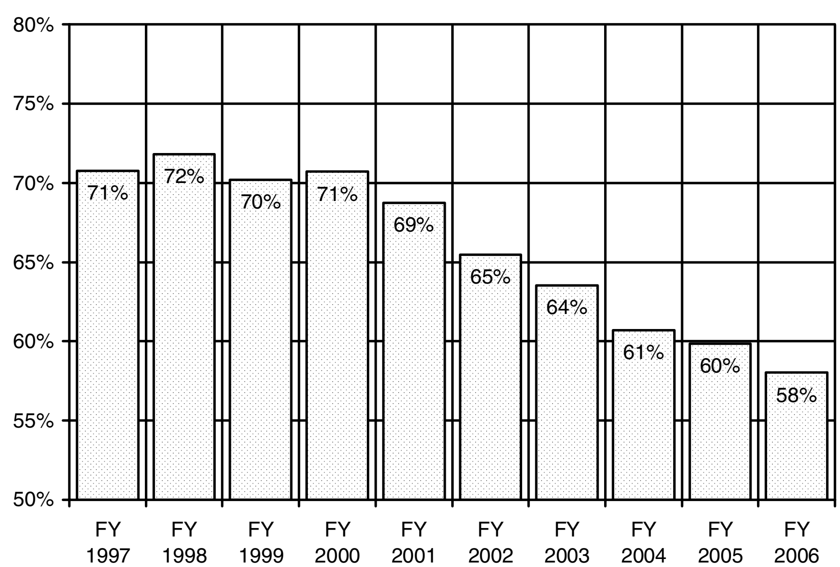
Principles of MIT Undergraduate Financial Aid

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 continues to assume an increasingly higher percentage of net undergraduate tuition and fees, which reduces the cost to the student, as exhibited by the chart below.

Net Undergraduate Tuition and Fees as Percentage of Total Tuition and Fees*



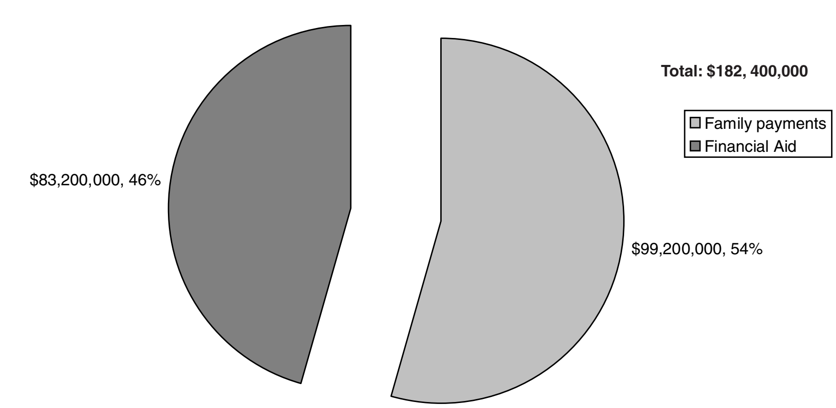
*Net tuition and fees calculated as gross undergraduate tuition and fees received, minus MIT undergraduate scholarships.

Who Pays for an MIT Undergraduate Education

MIT considers that parents and students have primary responsibility, to the extent that they are able, for paying the costs of an undergraduate education. Although the Institute is the largest source of financial aid to its undergraduates, other providers – especially the federal government – are critical to MIT's mission of ensuring economic access.

In the 2005-2006 academic year, the annual charge for an MIT education totaled $44,600 per student, a sum that comprises $32,300 for tuition and fees, $9,500 for room and board, and an estimated $2,800 for books, supplies, and personal expenses. With 4,053 students enrolled, the total cost for all undergraduates was $182.4 million. Of this amount, families paid $99.2 million, or 54 percent. Financial aid covered the remaining 46 percent, $83.2 million. In that year, 94.5 percent of students received some form of financial aid.

Financing an MIT Undergraduate Education: 2005-2006

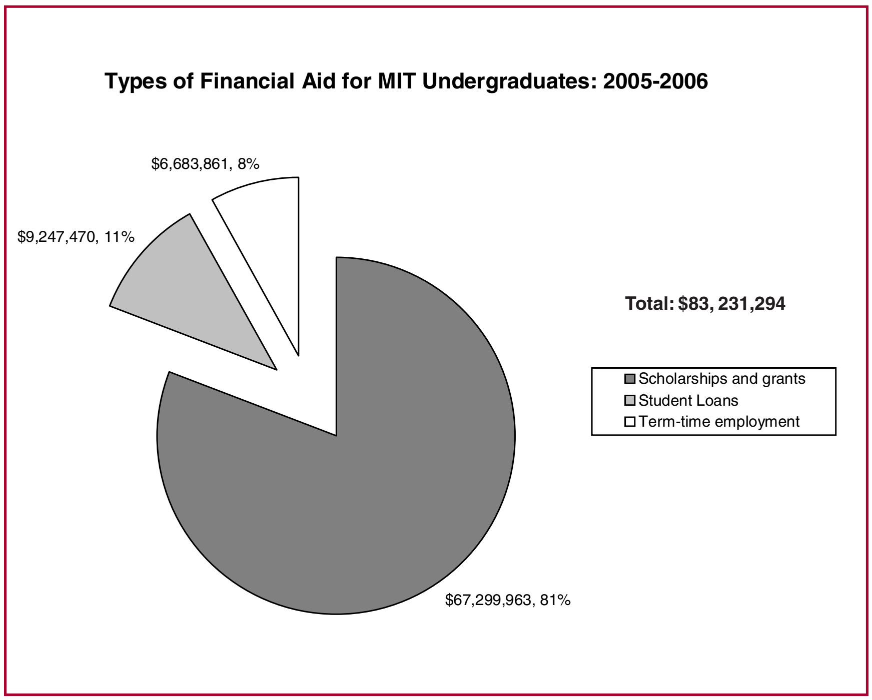


Forms of Undergraduate Financial Aid

In 2005-2006, grants (a term used interchangeably with scholarships) comprised 81 percent of financial aid to undergraduates; loans provided 11 percent; and term-time employment 8 percent. Grant support from all sources totaled $67,299,963, with approximately 73 percent of MIT undergraduates receiving this form of aid. The average grant was $22,821.

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 the national trend toward student loans as the primary form of undergraduate financial aid.

That year, approximately 43 percent of undergraduates borrowed $9,247,470 in student loans from all sources. The average loan was $5,299. Student employment from on-campus jobs and Federal Work-Study Program positions (which include both on- and off-campus work) totaled $6,683,861, with 66 percent of undergraduates working and earning an average of $2,486 each.



Sources of Undergraduate Financial Aid

In 2005-2006, MIT provided 72 percent of undergraduate financial aid. The federal government provided 16 percent, and the remaining 12 percent came from state and private resources. MIT also differs here from the national trend of relying on the federal government as the largest source of financial aid.

MIT Financial Aid

Ninety percent of the financial aid that MIT provides comes in the form of grants. In 2005-2006, approximately 58 percent of MIT undergraduates received an MIT grant, averaging $23,283 each. These grants come primarily from MIT's endowed funds, gifts from alumni and friends, and general Institute funds.

Federal Financial Aid

The US Department of Education is the second-largest source of financial aid to MIT undergraduates. MIT participates in the Federal Pell Grant and the Federal Supplemental Educational Opportunity Grant Programs, both of which provide need-based aid. Approximately 14 percent of MIT undergraduates receive Pell Grants. Acknowledging the decline in federal funding for student financial aid, MIT now matches Federal Pell Grants for all eligible students attending the Institute starting in September 2006, effectively doubling Pell Grant funds for eligible students.

MIT undergraduates also receive Robert C. Byrd Scholarships, the federally funded, state-administered grants which recognize exceptionally able high school seniors.

Fifty-two percent of the federal aid that MIT undergraduates receive is in the form of loans. In 2005-2006, approximately 39 percent of MIT undergraduates received a federal loan, which averaged $4,284 each.

MIT is a lender under the Federal Perkins Loan Program, which provides subsidized student loans; and takes part in the Federal Direct Loan Program, which offers both subsidized and unsubsidized loans. It also participates in the Federal Work-Study Program, which provides student jobs, including paid community service positions. Nationally, the Institute has one of the highest Federal Work-Study Community Service participation rates. All of these programs are partnerships between the government and participating institutions, where institutions match the federal contributions with their own funds. 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. This aid is not based on need.

Private and State Financial Aid

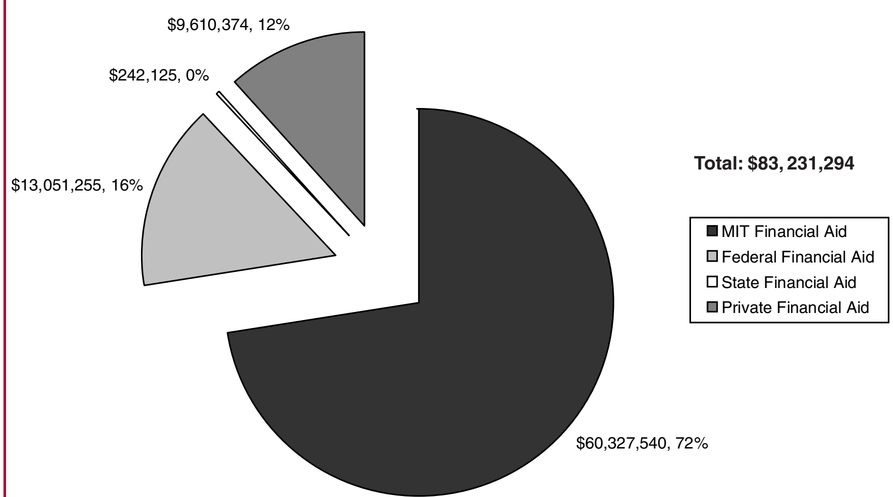
Private sources of financial aid – including charitable and civic organizations, corporations, foundations, banks, and other financial institutions – are the third-largest source of financial aid to MIT undergraduates. This aid includes private grants and alternative student loans (so-called to distinguish them from federal loans).

Students receive private scholarships in recognition of their academic accomplishments, athletic or musical skills, career interests, and many other criteria. Alternative loans ordinarily are unsubsidized and are based on the cost of education, less other financial awards, without any additional consideration for financial need.

Several states, in addition to Massachusetts, allow their residents to receive a state grant while attending MIT. These states include Connecticut, Delaware, Maine, New Hampshire, Pennsylvania, Rhode Island and Vermont. Most state grants are need-based. No state loan or employment programs are available to MIT undergraduates.

In 2005-2006, 81 percent of the private and state aid was in the form of grants.

Sources of Financial Aid for MIT Undergraduates: 2005-2006



The following chart summarizes the sources and types of financial aid MIT undergraduates received in 2004-2005.

	Scholarships/Grants		Loans		Employment		Total	
Source	Amount	Students	Amount	Students	Amount	Students	Amount	Students
Institutional	$54,273,183	2,331	$627,555	194	$5,426,802	2,081	$60,327,540	3,203
Federal	$5,046,766	9569	$6,747,430	1,575	$1,257,059	607	$13,051,255	2,237
State	$242,125	147	$0	0	$0	0	$242,125	147
Private	$7,737,889	1,367	$1,872,485	127	$0	0	$9,610,374	1,449
Overall	**$67,299,963**	**2,949**	**$9,247,470**	**1,745**	**$6,683,861**	**2,688**	**$83,231,294**	**3,827***

***Overall students are the unduplicated number of students.**

Service to Local, National, and World Communities

6

Service to Local, National, 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. Members of the MIT community helped build the Boston Public Library in the late 19th century and dam the Charles River early in the 20th. Research and development during World War II included radar systems; submarine and aircraft detection systems; a long-range navigation scheme based on radar principles; the SCR-584 radar for directing anti-aircraft fire; the Ground-Controlled Approach system for landing aircraft in low visibility; and the Draper Gun Sight which positions a gun at the proper lead angle to fire at moving targets.

In 1985, Eric Chivian, a physician in MIT's medical department and a founder of the International Physicians for the Prevention of Nuclear War, shared a Nobel Peace Prize for the group's service to mankind. More recently, Amy Smith, an MIT alumna and mechanical engineering instructor in MIT's Edgerton Center, won a MacArthur "genius grant" for her commitment to inventing simple technologies to solve problems in the world's poorest places, such as low cost water-purification systems or a simple and efficient technology for grinding grain. A recent *Washington Monthly* article ranking the public service commitment of the nation's colleges and universities named MIT No. 1 in the country.

While MIT faculty, students, and staff regularly engage in conventional projects that range from raising money for hurricane victims, renovating elderly housing, or restoring local nature reserves, MIT's scientific and technological orientation gives its public service outreach a particular emphasis. Many of its public service programs are specifically devoted, therefore, to inventing new technologies and applying new knowledge that will advance social wellbeing.

Key Programs

OpenCourseWare

Launched in 2002, OpenCourseWare (OCW) makes materials for MIT's courses freely available on the web. More than 1250 MIT courses – lecture notes, multimedia simulations, problem sets and solutions, past exams, reading lists, and selections of video lectures –now are posted on the OCW website. (The goal is to publish all 2000 courses by 2008.) OCW records an average of 11,000 visits a day, with nearly a quarter-million unique visitors every month. About 45 percent of these visitors are from the United States and Canada. Outside North America, the top countries are China, the United Kingdom, Germany, India, Brazil, and Japan. Among those using OCW are an educational technology instructor in Bangalore, India, a home-schooling parent in rural Kentucky, a professor in Lagos, Nigeria, and a student at the University of Mississippi.

About 52 percent of OCW's visitors identify themselves as self-learners, 31 percent as students enrolled in an academic program, and 13 percent as educators who use the material to develop curriculum, enhance their understanding, advise students, and support their research. MIT is pursuing two missions with OCW – sharing its educational materials freely and openly and, by creating a model other universities can follow and advance, promoting a universally available storehouse for human knowledge.

Service Learning

In 2001, MIT's Public Service Center and Edgerton Center began working with faculty to design service-learning courses that enable students to contribute to society as they learn. At the program's beginning, MIT offered three such courses, with 35 students enrolled. Five years later, the Institute was offering 19 courses to more than 200 students. Students have used these classes to develop a voice-activated toy that helps speech therapists working with children, a technology for converting sawdust – a common waste product in some developing countries – into cooking fuel, and a tree mover that eases the job of public service forestry volunteers who plant trees in urban areas.

International Development Initiative

With a focus on invention, wide-spread dissemination, and technology transfer, MIT's International Development Initiative works with impoverished communities around the world to help them develop and deploy appropriate solutions that enable them to improve their ability to provide for their basic needs and develop their economies. Its programs let MIT students travel developing countries, work with partner organizations to identify needs and the challenges in meeting them, and develop solutions. They include:

D-Lab

A year-long series of classes and field trips, D-Lab enables students to learn about the technical, social, and cultural aspects of development work in selected countries, and then provides them the opportunity for field work and implementation. Among D-Lab's achievements are a low-cost, low-maintenance device that allows health care workers in Uganda, who lack access to conventional – and expensive – electrically-powered equipment, to test for microorganisms in local water supplies and determine which chemicals will kill them; a technology developed for Haiti that makes cooking fuel out of sugar cane waste, and thus helps the island nation preserve its forests and prevent health problems caused by inhaling wood smoke (D-Lab students are now adapting this technology for paddy straw to use in India); and an automated flash-flood warning system developed with engineers in Honduras.

IDEAS Competition

The IDEAS Competition encourages teams of students to develop innovative solutions that address community needs. With a grant that covers the cost of materials and mentoring from faculty, staff, and industry professionals, competing teams of students work through a needs analysis, the product development process, and group organization. Winners receive cash grants that provide seed money for launching their projects.

International Fellowships

These fellowships provide stipends that enable students to work full-time on capacity-building community projects all over the world. Projects can be initiated by students or by community organizations or donors.

International Development Grants

These grants support international development projects that involve MIT students. Faculty, students, and other MIT community members can use them to cover materials, travel, and other expenses in projects that serve communities in developing regions.

MIT Poverty Action Lab

Founded in 2003 with funds from the Department of Economics and the School of Humanities, Arts, and Social Sciences, the Poverty Action Lab is the only research center in the world devoted to combating global poverty by rigorously testing the effectiveness of poverty programs. Working on issues as diverse as boosting girls' attendance at school, improving the output of farmers in sub-Saharan Africa, or overcoming racial bias in employment in the US, the lab's objective is to provide policy makers with clear scientific results that will enable them to improve the effectiveness of programs designed to combat poverty.

Selected Recent Projects

Post-Katrina Environmental Issues
Members of the Department of Urban Studies and Planning (DUSP) participated in a variety of projects in response to the devastation of New Orleans by Hurricane Katrina. Included among them was the spring 2006 "The Katrina Practicum" taught in New Orleans by DUSP faculty members. The class researched affordable housing, community development, and post-disaster environmental issues on behalf of two community development corporations in New Orleans. The MIT practicum group focused on the historic Treme neighborhood, sometimes identified as the oldest African-American neighborhood in the United States.

Lake Pontchartrain Ecosystem
The Department of Civil and Environmental Engineering (CEE) has participated in several Katrina-related projects. Instructors and students from the Aquatic Chemistry and Biology Lab traveled to New Orleans to focus on the impacts of dewatering operations on the Lake Pontchartrain ecosystem. The project also saw collaboration with professors from Louisiana State University (LSU) who were examining the occurrence and distribution of pathogens in the sediments.

Inexpensive Glasses: Sight for the Poor
As many as 1.4 billion people around the world need corrective lenses but can't afford them. Not only is their quality of life significantly reduced, but their productivity also slows, they are more prone to accidents and, in some cases, they simply can't function. As an alternative to far more expensive glass molding machines currently in use, MIT Media Lab graduate student Saul Griffith invented a portable machine with a programmable mold that, in about 10 minutes, forms a low-cost acrylic lens in the exact shape required. Griffith also has a patent pending for a low-cost prescription testing device that will make vision evaluation much more accessible.

Clean Water for Developing Countries
According to UNICEF, some 1.7 billion people lack access to clean drinking water. Waterborne diseases are a major cause of illness and death across much of the developing world. In Nepal alone, some 44,000 children under the age of five die annually from such diseases. In 1999, Susan Murcott, a research engineer in the Department of Civil and Environmental Engineering, launched the Nepal Water Project, a Master's program whose goal is to develop quick, cheap, and relatively simple systems that Nepal's rural poor can use to clean their water. In collaboration with the Environment & Public Health Organization in Katmandu and the Rural Water Supply & Sanitation Support Programme in Butwal, Tommy Ngai, one of Murcott's students, developed an arsenic-biosand filter (ABF) constructed of a round plastic bin, layers of sand, brick chips, gravel, and iron nails. The system removes both arsenic and pathogens that can lead to dehydration, malnutrition, stunted growth in children, and sometimes death. In 2004, with an award from the World Bank, Ngai, his MIT team and their Nepali partners, installed ABFs in 25 Nepalese villages and established a center to forward research and provide villagers with training in the ABF technology.

Water-chemistry variation among countries makes it difficult to find one technology that will suit all areas, so Murcott and her students have been developing a collection of water-treatment systems that are low-cost, easy to maintain, and match the targeted country's needs and resources. The program has now expanded to include water and wastewater research in Bolivia, Brazil, Haiti, and Nicaragua.

Gasoline Storage Tank Leak Detection

Developed by Andrew Heafitz, a graduate student in mechanical engineering, and Carl Dietrich, a graduate student in aeronautics and astronautics, this new low-cost technology enables owners of gasoline tanks in developing countries to continually test the water in the tanks' monitor wells, thus reducing the risks of environmental and health damage caused when the tanks leak. If the system detects gasoline in the well, a window in the well cover changes from green to red; and because they no longer have to unbolt the cover, tank owners can check wells for contamination much more frequently. The new system replaces the need for both unaffordable electronic detection equipment and the tedious processes of testing water manually. A simple, practical, and inherently safe mechanical system, the technology is particularly useful for a very cost-sensitive industry.

Passive Incubator for Premature Infants

Every year, four million infants die within the first 28 days of life. Of this number, 3.9 million belong to the developing world. Twenty-four percent of these deaths are caused by the complications of prematurity – most often, from heat loss and dehydration. Electrically- powered incubators can minimize this problem, but in the developing world, the lack of electricity in most rural regions and the frequent loss of power in urban areas render this technology worthless. Using phase-change material that, once heated (for example, by wood- or coal-fire) maintains its temperature for 24 hours, and devising ways to use indigenous raw materials for an outer shell, a team of MIT students are designing a low-cost incubator that will run without electricity. The design will have broad applicability in war-torn regions of the world or in areas where portability, cost, and energy are primary concerns. The students now are reviewing their design with Doctors without Borders in Sri Lanka, and once they have built a working model, they will meet with Sri Lankans to implement field tests.

iMath – Keeping Kids Interested in School

Invented by MIT undergraduate John Velasco while visiting his own middle school in San Diego as a volunteer to work with students, iMath is an interactive Internet-based curriculum that, with its mentoring component, helps eighth graders understand and apply math concepts and expand their technical skills, while motivating and inspiring them to pursue their education. When he returned to MIT, Velasco implemented his new program in the Cambridge public schools. iMath now involves 70 eighth graders and 30 MIT undergraduates, graduate students, and alumni – with teachers and parents reporting a dramatic change in students' attitudes about math and learning in general. In 2005, Velasco received the prestigious national Howard R. Swearer Student Humanitarian Award, presented annually to five students across the country for outstanding commitment to community service.

Understanding How to Serve the Homeless

Lack of data is one of the major barriers to combating the root causes of homelessness. Because groups undertaking research on such questions as the links between homelessness and poor health or education have little hard data, their results and proposed solutions are often questioned. Furthermore, with no good way to collect data, organizations that serve the homeless have no way to evaluate their clients needs and monitor the effectiveness of their services. The Salvation Army of Cambridge, Massachusetts, came to a group of MIT students on MIT Graduate Student Volunteer Day and asked if they could help with this problem. The students designed a system that, instead of asking clients who came to the shelter for services to sign in with paper and pencil, enabled them to register with a bar-coded card. Able to collect data accurately and reliably, the shelter now can study how it can best use its resources to meet its clients' needs. To encourage its clients to use the card, the Salvation Army worked with community partners to provide benefits such as meal discounts and free use of public transportation. The students also designed the system to ensure clients' privacy. The Cambridge Salvation Army has been using the system since 2003.

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