2 Campus Research

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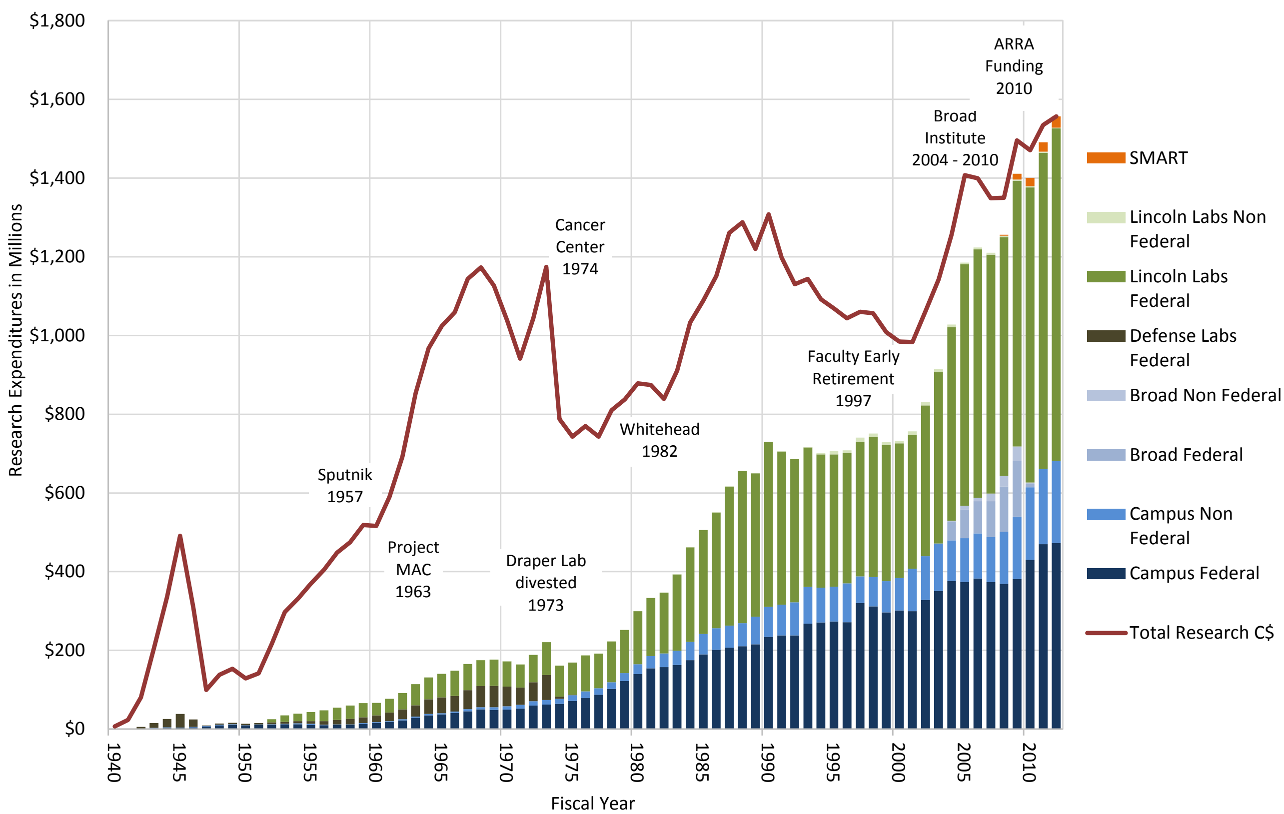
Research Support

MIT has historically viewed teaching and research as inseparable parts of its academic mission. Therefore, the Institute recognizes its obligation to encourage faculty to pursue research activities that hold the greatest promise for intellectual advancement. MIT maintains one of the most vigorous programs of research of any university and conducts basic and applied research principally at two Massachusetts locations, the MIT campus in Cambridge and MIT Lincoln Laboratory, a federally funded research and development center (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 fulfill its original mission 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 FY2012, there were 2,540 active awards and 460 members of research consortiums.

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

MIT Research Expenditures
1940–2012



The red line represents an adjustment for inflation, using the Consumer Price Index for all Urban Consumers (CPI-U) as the deflator with fiscal year 2012 as the base.

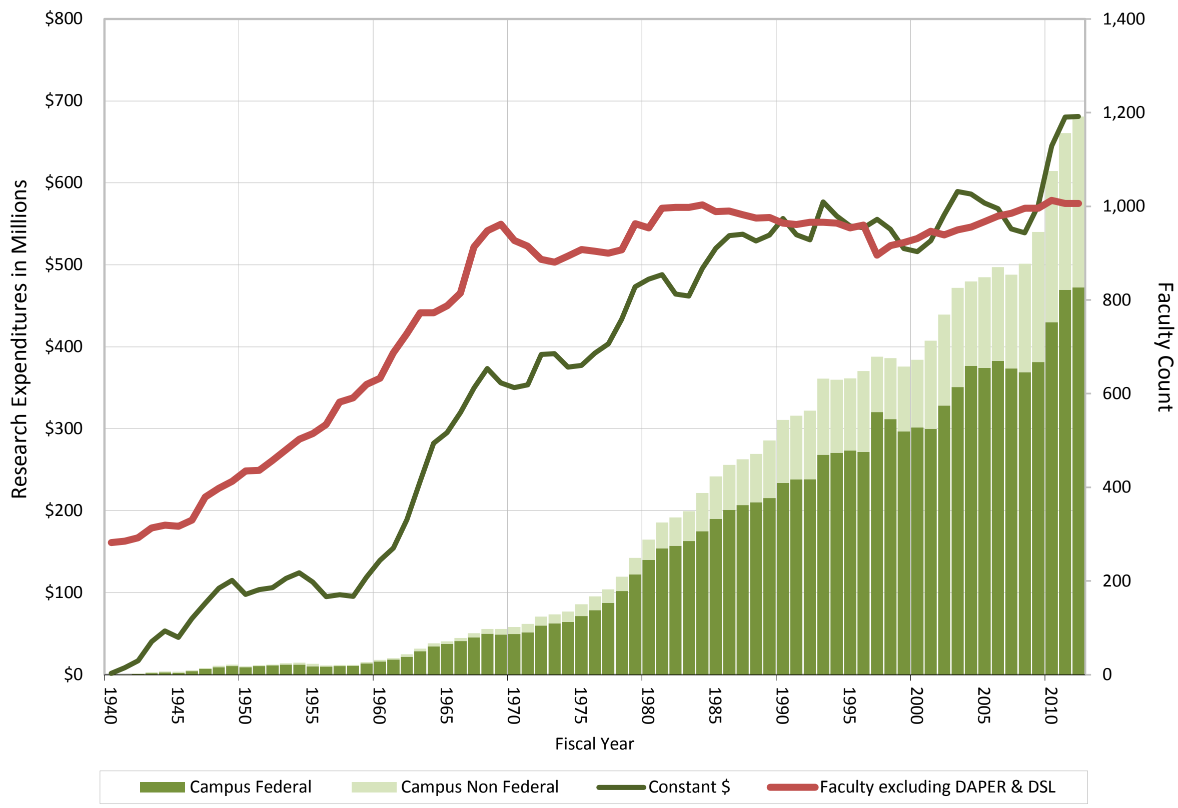
SMART: Singapore-MIT Alliance for Research and Technology

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

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

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

Campus Research Expenditures and Faculty
Excluding Broad and Defense Labs
1940–2012



DAPER: Department of Athletics, Physical Education and Recreation
DSL: Division of Student Life

Broad Institute of Harvard and MIT

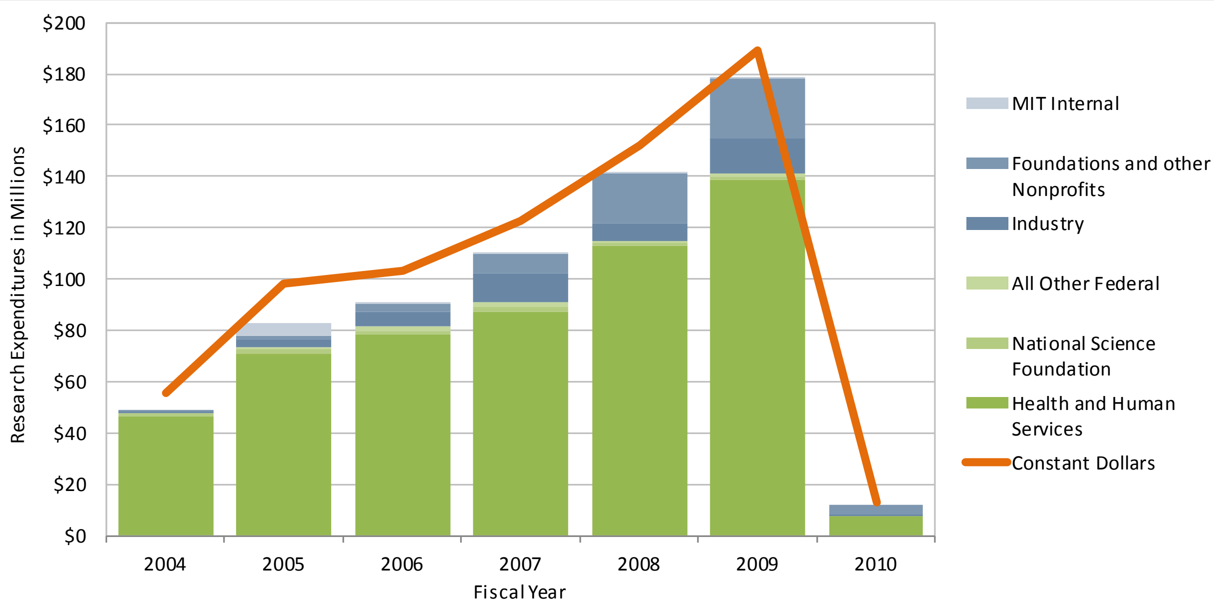
The Broad Institute is founded on two principles—that this generation has a historic opportunity and responsibility to transform medicine, and that to fulfill this mission, we need new kinds of research institutions with a deeply collaborative spirit across disciplines and organizations. Operating under these principles, the Broad Institute is committed to meeting the most critical challenges in biology and medicine.

Broad scientists pursue a wide variety of projects that cut across scientific disciplines and institutions. Collectively, these projects aim to: assemble a complete picture of the molecular components of life; define the biological circuits that underlie cellular responses; uncover the molecular basis of major inherited diseases; unearth all the mutations that underlie different cancer types; discover the molecular basis of major infectious diseases; and transform the process of therapeutic discovery and development.

MIT administered Broad Institute research expenditures during FY2004–FY2010. The Broad Institute separated from MIT on July 1, 2009. The chart below displays Broad Institute research expenditures funded through MIT. Five MIT faculty members are currently core members of the Broad Institute. Their research expenditures are not reflected in the campus research expenditures totals found in the rest of this section.

Broad Institute Research Expenditures by Sponsor (in U.S. dollars)*
Fiscal Years 2004–2010

	2004	2005	2006	2007	2008	2009	2010
Health and Human Services	46,344,769	71,220,070	78,238,123	87,315,284	112,958,244	138,935,579	7,637,672
National Science Foundation	1,304,105	1,809,782	1,416,267	2,107,756	1,022,548	990,917	(772)
All other federal	33,683	464,691	1,912,009	1,377,190	919,377	1,113,471	79,716
Industry	514,186	3,200,233	5,944,244	11,242,651	6,935,104	13,656,981	680,132
Nonprofit organizations	425,355	1,432,595	2,694,886	7,683,458	19,370,397	23,376,207	3,792,875
MIT internal	(3,317,186)	4,516,525	143,822	549,160	341,683	74,792	0
Total	**45,304,913**	**82,643,895**	**90,349,350**	**110,275,500**	**141,547,351**	**178,147,946**	**12,189,623**
Constant dollars†	55,401,735	98,109,832	103,322,554	122,930,748	152,153,320	188,859,674	12,798,706



*The Broad Institute separated from MIT on July 1, 2009 and no longer receives funding through MIT.
† Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

MIT and the American Recovery and Reinvestment Act

The 2009 economic stimulus package, the American Recovery and Reinvestment Act (ARRA) provided support for science funding at a time when universities nationwide were facing funding cutbacks and financial concerns due to the recession. Overall, ARRA provided $22 billion in one-time research and development (R&D) funding for fiscal years 2009 and 2010, in addition to regularly appropriated funds. This funding was included in the legislation to help fulfill its purpose of "reinvestment"; since R&D support is directly related to the nation's innovation capacity and therefore its longer term economic strength, the Congress allocated approximately two percent of the total funding in the legislation to R&D.

In most cases, ARRA R&D funding was applied toward existing research proposals that had received high ratings within agencies but had not been awarded due to funding limitations. In some cases, however, ARRA funding was applied toward new initiatives. For example at the Department of Energy, ARRA included the initial funding ($400 million) for the new Advanced Research Projects Agency-Energy (ARPA-E) and full five-year funding for additional Energy Frontier Research Centers (EFRCs). MIT has received several ARPA-E awards, and houses two EFRCs, one of which is funded through ARRA.

ARRA awards at MIT

Original source of funding	Number of awards	Obligated amount (in U.S. dollars)
Department of Energy	23	53,534,812
Health and Human Services/ National Institutes of Health	91	63,054,451
National Science Foundation	62	30,824,929
NASA	3	885,212
All other agencies	7	2,644,100

MIT's total ARRA expenditures through fiscal year ending June 30, 2012 total $117,810,486.

For the quarter April 1, 2012–June 30, 2012, MIT reported that 275.74 jobs were created or retained with ARRA funding.

The following are a selection of some of the various research projects at MIT supported by ARRA:

ARPA-E: Energy Storage for the Nation's Energy Grid

With a nearly $7 million five-year grant from the newly formed ARPA-E (Advanced Research Projects Agency-Energy), a group led by Donald Sadoway is developing an innovative solution to the problem of storing huge amounts of energy as part of the nation's energy grid—a liquid metal battery. The first of its kind, the all-liquid battery is designed to use low-cost, abundant molten metals. ARPA-E predicts the liquid battery technology "could revolutionize the way electricity is used and produced on the grid, enabling round-the-clock power from America's wind and solar power resources, increasing the stability of the grid, and making blackouts a thing of the past."

Neutrino Physics at MIT

New findings from physicists at MIT may force scientists to rethink the Standard Model, the theory that serves as the foundation of particle physics. Scientists led by Janet Conrad at MIT's Neutrino and Dark Matter Group have observed unexpected behavior in neutrinos, tiny particles generated by nuclear reactions in the sun. These unexpected behaviors suggest there are more types of neutrinos than the three specified in the Standard Model. To investigate these observations, the group is designing a state-of-the-art 100-ton liquid argon chamber detection device in collaboration with the Fermi National Acceleration Laboratory. The detector is scheduled to begin operating in 2013.

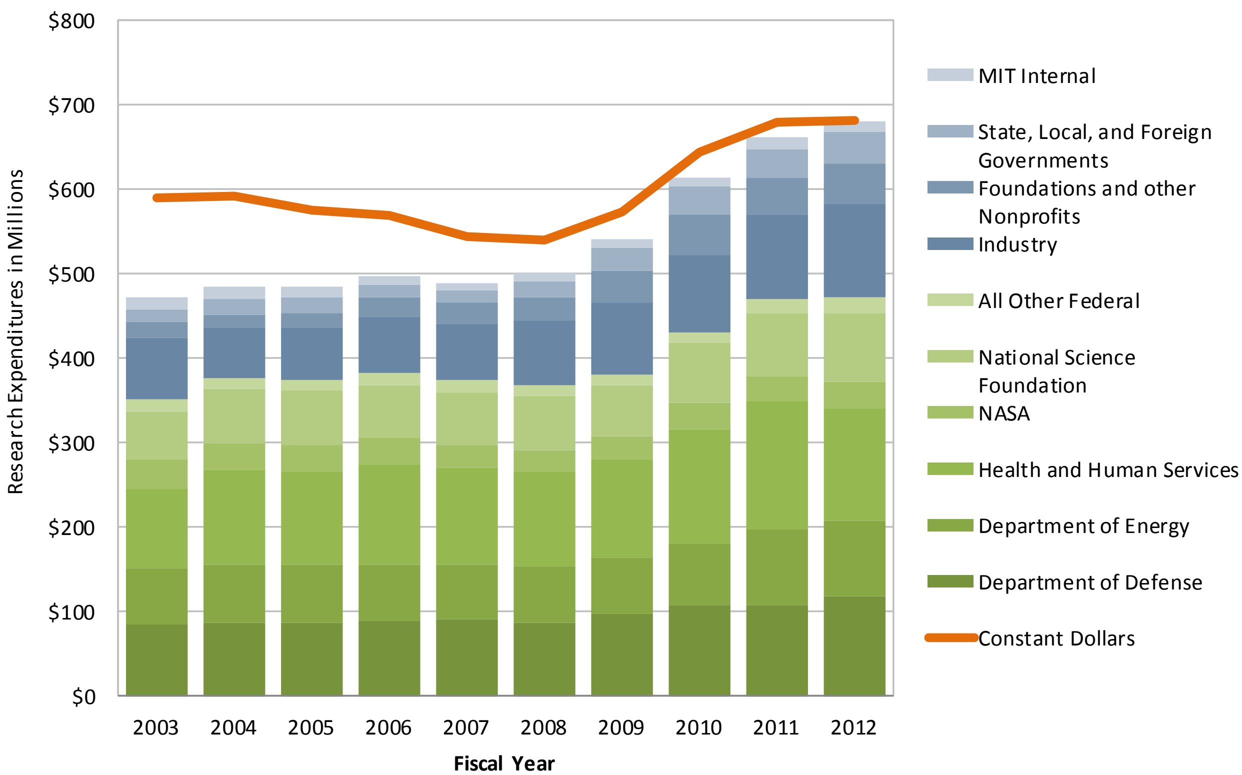
Campus Research Sponsors

The tables and charts for campus research expenditures below, and on the following pages, show the amount MIT expended by fiscal year (July 1–June 30). These figures do not include expenditures for MIT Lincoln Laboratory. Information for Lincoln Laboratory begins on page 55. Expenditures funded by industrial sponsors are shown on page 73 in the MIT and Industry section. Federal research expenditures include all primary contracts and grants, including sub-awards from other organizations where the federal government is the original funding source.

Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2003–2012

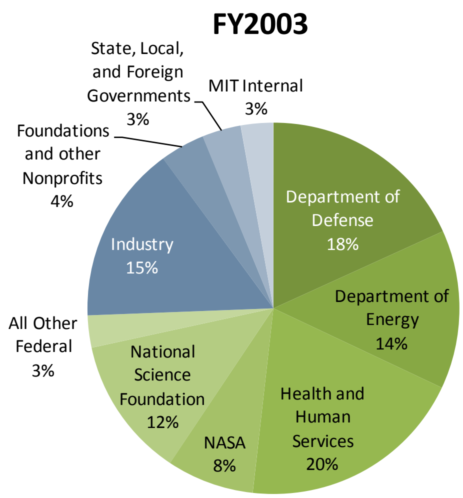
	2003	2004	2005	2006	2007
Federal	350,897,272	376,476,261	374,103,793	382,784,774	373,603,371
Non-federal	120,857,180	107,672,988	110,675,892	114,361,780	114,389,201
Total	**471,754,452**	**484,149,249**	**484,779,685**	**497,146,554**	**487,992,571**
Constant dollars*	589,510,002	592,048,558	575,501,115	568,531,503	543,994,740

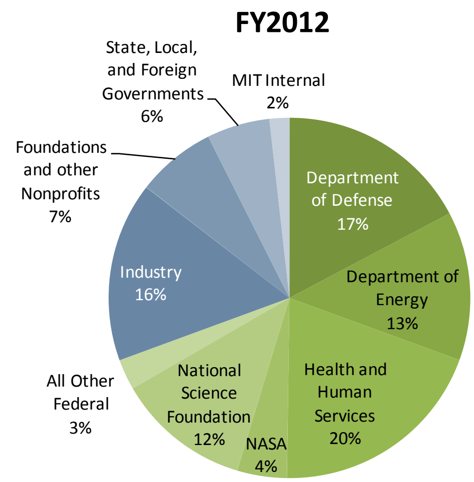
	2008	2009	2010	2011	2012
Federal	369,008,780	381,459,466	430,154,479	469,520,579	472,582,743
Non-federal	132,487,316	158,595,887	184,216,417	191,304,692	208,496,567
Total	**501,496,096**	**540,055,353**	**614,370,896**	**660,825,271**	**681,079,310**
Constant dollars*	539,072,583	572,527,950	645,069,350	680,186,642	681,079,310



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

Campus Research Expenditures by Primary Sponsor





Campus Research Expenditures by Primary Sponsor

Primary Sponsor	2012 (in U.S. Dollars)	Percentage of Total
Department of Defense	117,457,789	17%
Department of Energy	90,940,035	13%
Health and Human Services	133,687,332	20%
NASA	30,203,575	4%
National Science Foundation	81,487,208	12%
All other federal	18,806,804	3%
Total Federal	**472,582,743**	**69%**
Industry	109,744,829	16%
Foundations and other nonprofits	48,373,460	7%
State, local, and foreign governments	38,272,515	6%
MIT internal	12,105,763	2%
Total Non-Federal	**208,496,567**	**31%**
Grand Total	**681,079,310**	

Department of Defense

Selected Current Projects

The Angstrom Project

Computer chips' clocks have stopped getting faster, making it difficult to maintain the regular doubling of computer power that we now take for granted. To keep up, chip makers have been giving chips more "cores," or processing units; but distributing computations across these multiple cores is a complex problem.

In August 2010, the Department of Defense's Defense Advanced Research Projects Agency announced that it was dividing almost $80 million among four research teams as part of a "ubiquitous high-performance computing" initiative. Three of those teams are led by commercial chip manufacturers. The fourth is led by MIT's Computer Science and Artificial Intelligence Laboratory, and will concentrate on the development of multicore systems.

The MIT-led Angstrom team will rethink computing and create a fundamentally new computing architecture to meet the challenges of extreme-scale computing. One component of this goal is to create more efficient channels of communication among the multiple cores. A personal computer today may have between 4 and 8 cores. Angstrom researchers hope to enable communication between hundreds or even thousands of cores. They are also working to develop a self-aware operating system that would communicate with this complex network of cores. The multicore operating system would constantly monitor each of the cores, and would judge how to best distribute tasks among them.

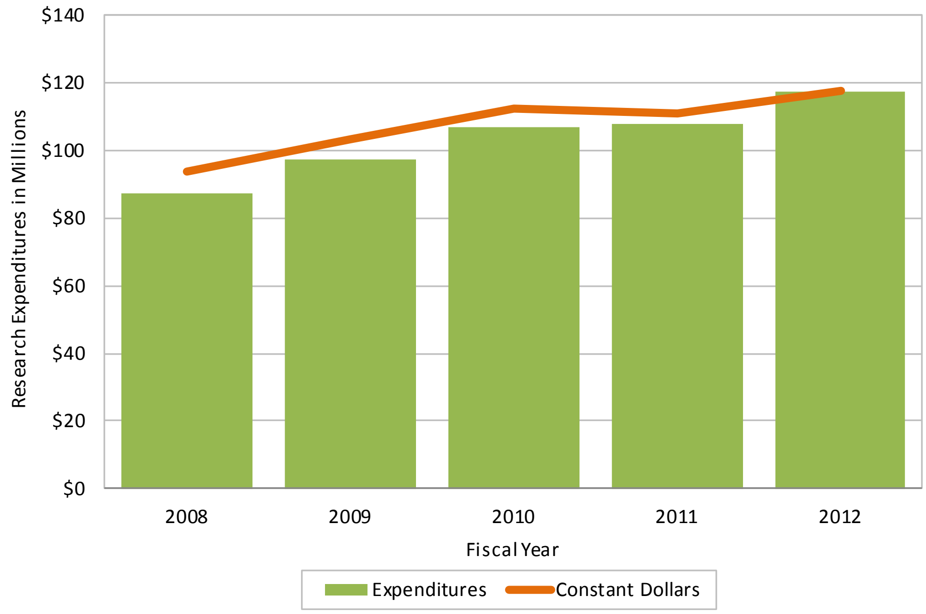
Nanoparticle Vaccine Delivery

One of the barriers to developing vaccines for diseases like HIV, malaria, and hepatitis B, where vaccines containing the virus would be too dangerous or difficult to make, is how to provoke a strong immune response. Current vaccines that do not use a killed or altered virus do this by delivering synthetic versions of proteins produced by the virus. These vaccines, while safer, do not provoke a strong immune response. A nanoparticle developed by Darrell Irvine, may solve this problem. The particle is a series of concentric fatty droplets called liposomes. Irvine hopes that encasing the proteins in this virus-like packaging could promote a stronger immune response. Existing liposome packagings have failed because liposomes have poor stability in blood and bodily fluids. Irvine's concentric spheres approach creates a particle that is less likely to break down too quickly following injection. However, once the nanoparticles are absorbed by the cell, they degrade quickly, releasing the vaccine and provoking an immune response.

Irvine is now collaborating with scientists at the Walter Reed Army Institute of Research to test the nanoparticles' ability to deliver an experimental malaria vaccine in mice. His work is sponsored by the Department of Defense, as well as the National Institutes of Health, and the Gates Foundation.

Department of Defense Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2008–2012

	2008	2009	2010	2011	2012
Campus research	87,369,845	97,528,094	106,890,338	107,753,196	117,457,789
Constant dollars*	93,916,360	103,392,290	112,231,360	110,910,233	117,457,789



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2012
(shown in descending order of expenditures)

Research Laboratory of Electronics
Computer Science and Artificial Intelligence Laboratory
Institute for Soldier Nanotechnologies
Microsystems Technology Laboratories
Mechanical Engineering
Aeronautics and Astronautics
Plasma Science and Fusion Center
Laboratory for Information and Decision Systems
Media Laboratory
McGovern Institute for Brain Research

In fall 2011, the Department of Defense funded the primary appointments of graduate students with 343 research assistantships and 72 fellowships.

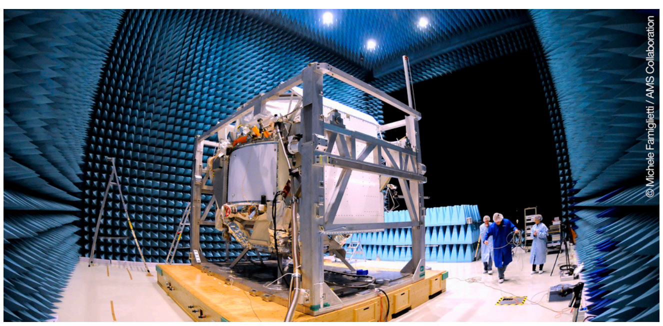
Twenty-six current faculty and staff have received the Office of Naval Research Young Investigator Program Award.

Department of Energy

Selected Current Projects

Detecting Cosmic Rays

Although physicists understand a lot about the composition of conventional atomic matter, these familiar materials represent only a small part of the universe's total mass and energy, about four percent. The composition of the other 96 percent is a mystery. Now a team of researchers from 56 institutions is working to solve this mystery with an instrument that measures cosmic rays, charged particles in space, before they react with the Earth's atmosphere. On its final mission, the Space Shuttle Endeavor delivered the instrument, the Alpha Magnetic Spectrometer (AMS) to the International Space Station—transforming the station into a high-energy physics laboratory with access to the most powerful accelerator in the universe, the universe itself. The AMS will search for primordial antimatter, the identity of dark matter, and the origin of cosmic rays. The principal investigator of the AMS experiment is Nobel Laureate and Samuel C. C. Ting, who led the design, construction, and commissioning of AMS with his Electromagnetic Interactions Group at the MIT Laboratory for Nuclear Science.



The AMS at a test facility
Photo Credit: Michele Famiglietti AMS-02 Collaboration

The original agreement to develop the AMS experiment for the International Space Station was signed by the Department of Energy and NASA. The AMS is expected to operate for the lifetime of the International Space Station.

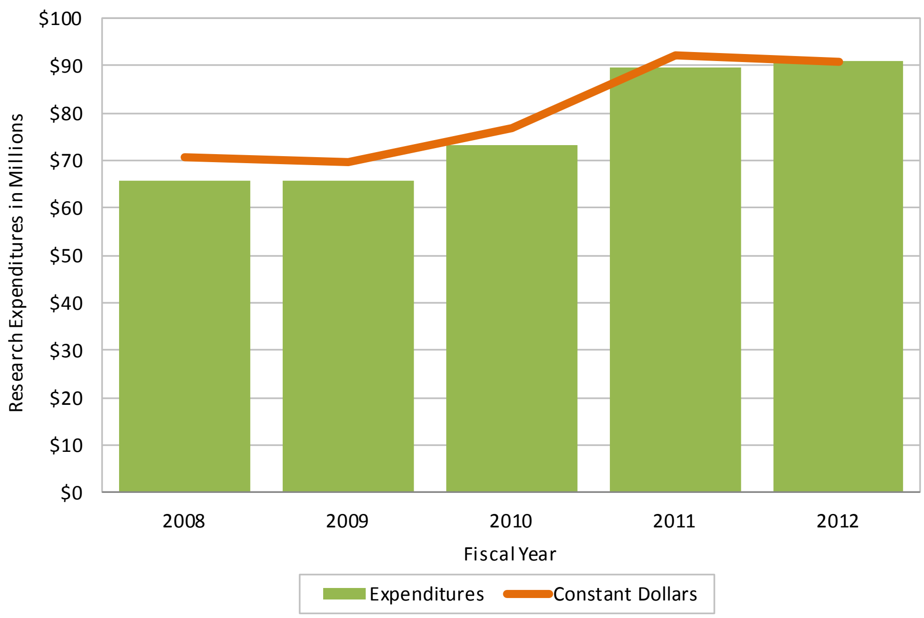
Improved Nuclear Energy

MIT is committed to making nuclear power safer and more efficient. MIT is a partner in the Department of Energy funded Nuclear Energy Innovation Hub known as the Consortium for Advanced Simulation of Light Water Reactors (CASL). The Hub is led by Oak Ridge National Laboratory, and in addition to MIT, includes partners from universities, industry, and other national labs. It is a rare collaboration among veteran researchers and technology application groups to achieve improved energy sources, in this case putting the power of modern computing into a multi-scale representation of nuclear plants.

CASL aims to provide state-of-the-art simulation models of the important physics that govern the behavior of nuclear power reactors. In particular, CASL aims to improve the reliability of nuclear plant operation by enabling better prediction of materials failures limits and safety margins in the plants. The simulation tools will enable plants to avoid some of the limiting factors in the operation of plants. This includes materials phenomena, such as corrosion in the radiation environment, and thermal hydraulic phenomena, such as deposition of crud on fuel elements, thereby limiting heat transfer conditions from the fuel to the coolant under realistic conditions of plant chemistry. Such improved models will aid the design of future reactors with enhanced safety and economics.

Department of Energy Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2008–2012

	2008	2009	2010	2011	2012
Campus research	65,610,631	65,773,294	73,273,733	89,562,126	90,940,035
Constant dollars*	70,526,755	69,728,128	76,935,023	92,186,186	90,940,035



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2012
(shown in descending order of expenditures)

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

In fall 2011, the Department of Energy funded the primary appointments of graduate students with 215 research assistantships and 18 fellowships.

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

Department of Health and Human Services

Selected Current Projects

Convergence: A New Era of Cancer Research

On October 9, 2007, MIT announced the launch of a major new initiative in cancer research, supported by a $100 million gift from MIT alumnus David H. Koch. The David H. Koch Institute for Integrative Cancer Research, which opened in March 2011, addressed one of the most pressing challenges to human health: the ultimate eradication of cancer, starting with real improvements in detection, treatment, and prevention.

The Koch Institute strives to foster a new era of cancer research based on convergence, which is the principle of merging distinct technologies, devices, and disciplines into a unified whole that creates a host of new pathways and opportunities. The promise of the convergence approach is outlined in an MIT White Paper released in January 2011 by 12 members of the MIT faculty. "The Third Revolution: The Convergence of Life Science, Physical Science, and Engineering" outlines this new approach to life sciences that will enable advances in translational medicine and the future of personalized medicine.

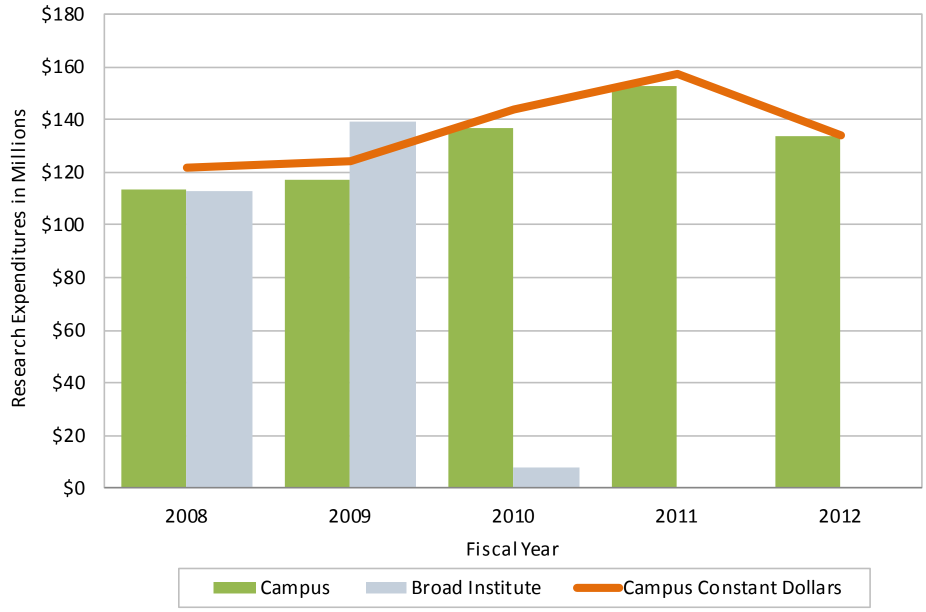
The Koch Institute brings together more than 40 laboratories and more than 650 researchers from the fields of engineering, physical, and life sciences, including cancer biologists, genome scientists, chemists, engineers, and computer scientists. These scientists will press the front line of cancer research. Areas of research include developing nanotechnology-based cancer drugs; improving detection and monitoring; exploring the molecular and cellular basis of metastasis; advancing personalized medicine through analysis of cancer pathway and drug resistance; and engineering the immune system to fight cancer.

Invisibility Cloaking Devices

Researchers at the Singapore-MIT Alliance for Research and Technology (SMART) Centre have created a device that can render an object the size of a peppercorn invisible. The team's "cloaking" device, which hides an object from view in ordinary visible light, is unique among previous attempts at invisibility. Other existing cloaking devices hide only microscopic objects, do not affect light from the full visible spectrum, or use rare or difficult to manufacture materials. The "shields" used in this experiment were made from calcite crystal, a component of which, calcite, occurs naturally in sea shells. The team placed a metal wedge 2 mm in height on a mirror covered in a layer of calcite crystal. Shields of calcite crystal with opposite crystal orientations were glued together and suspended over the wedge. When viewed from a certain angle, the wedge "disappears," and is undetectable. The research team was led by George Barbastathis, postdoctoral fellows Baile Zhang and Yuan Luo, and researcher Xiaogang Liu, and the research was funded by the National Institutes of Health and Singapore's National Research Foundation.

Health and Human Services (HHS) Campus and Broad Institute Research Expenditures (in U.S. Dollars)*
Fiscal Years 2008–2012

	2008	2009	2010	2011	2012
Campus research	113,348,419	116,960,155	136,923,238	152,664,013	133,687,332
Broad Institute research	112,958,244	138,935,579	7,637,672	0	0
Total HHS	**226,306,663**	**255,895,734**	**144,560,910**	**152,664,013**	**133,687,332**
Constant dollars†	243,263,543	271,282,303	151,784,228	157,136,882	133,687,332



*The Broad Institute separated from MIT on July 1, 2009 and no longer receives funding through MIT. The chart above displays both campus research expenditures and Broad Institute research expenditures funded through MIT.
†Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2012
(shown in descending order of expenditures)

Koch Institute for Integrative Cancer Research
Biology
Chemistry
Biological Engineering
Harvard/MIT Division of Health Sciences and Technology
Center for Environmental Health Sciences
Picower Institute for Learning and Memory
McGovern Institute for Brain Research
Computer Science and Artificial Intelligence Laboratory
Research Laboratory of Electronics

In fall 2011, the Department of Health and Human Services, including the National Institutes of Health (NIH), funded the primary appointments of graduate students with 173 research assistantships and 137 fellowships.

Seven current faculty have received the NIH Director's Pioneer Award. The recipients are Emery Brown, Arup Chakraborty, Aviv Regev, Leona Samson, Alice Ting, Alexander van Oudenaarden, and Mehmet Fatih Yanik.

NASA

Selected Current Projects

Detecting Ancient Radio Waves

Astronomers at MIT's Haystack Observatory are building a radio array telescope in the Australian Outback that is orders of magnitudes more sensitive than any other existing instrument. The telescope, the Murchison Widefield Array (MWA), should help to answer questions about a poorly understood period of the universe's formation called the Epoch of Reionization (EOR). After the Big Bang, but before the formation of stars, there was no light in the universe. During this time, gravity caused hydrogen and helium particles to form clouds. The energy from this condensation ignited the clouds, creating the first stars, and with them, light. It is nearly impossible to detect this early light, so astronomers hope to learn more about the birth of the stars by detecting ancient radio waves.

The MWA is unique in its construction. It will consist of 8,000 antennas spread across 1.5 km of a radio-silent area of the Australian Outback. The telescope will have no moving parts. Instead, it will use sophisticated computation to transform the huge amount of data it collects into images of the sky. This digital approach gives the MWA an expansive field of view, and allows astronomers to focus on a particular area in the sky without having to physically point the telescope.

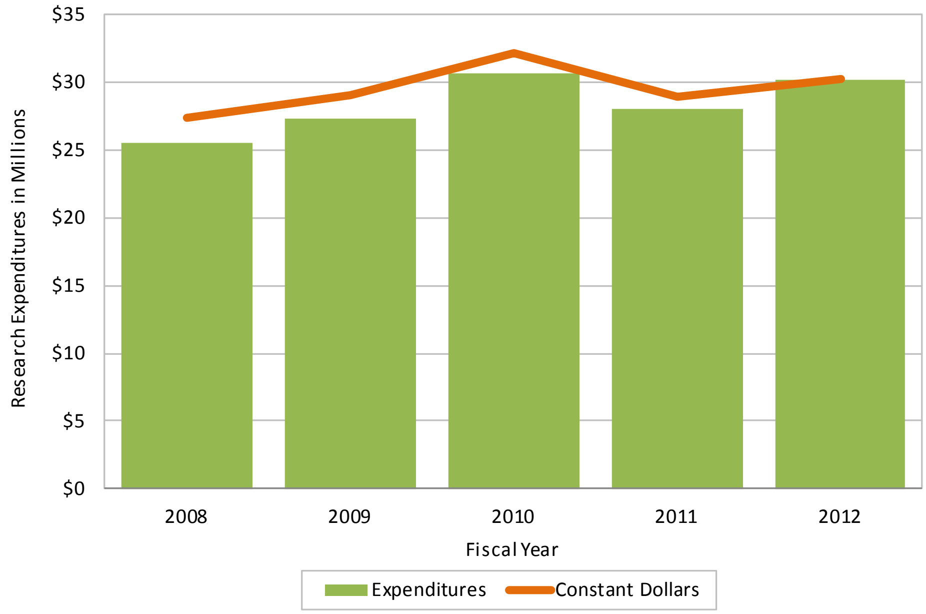
In addition to studying ancient remnants of the EOR, the MWA will also study our sun and the surrounding heliosphere to improve our understanding of how space weather affects the earth. The MWA is an international collaboration led by MIT Haystack Observatory. It is supported by NASA, as well as other federal sources and institutional partners within the U.S., Australia, and India.

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 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 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, Massachusetts.

NASA Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2008–2012

	2008	2009	2010	2011	2012
Campus research	25,479,571	27,358,036	30,629,006	28,079,693	30,203,575
Constant dollars*	27,388,724	29,003,028	32,159,455	28,902,394	30,203,575



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2012
(shown in descending order of expenditures)

Kavli Institute for Astrophysics and Space Research
Earth, Atmospheric, and Planetary Sciences
Aeronautics and Astronautics
Earth System Initiative
Haystack Observatory
Center for Global Change Science
Research Laboratory of Electronics
Harvard/MIT Division of Health Sciences and Technology
Mechanical Engineering
Institute for Soldier Nanotechnologies

In fall 2011, NASA funded the primary appointments of graduate students with 67 research assistantships and 10 fellowships.

National Science Foundation

Selected Current Projects

Solar-Power Breakthrough

Researchers led by Daniel Nocera have created what they call an "artificial leaf"—a device that can turn energy from the sun into a storable fuel source. The artificial leaf takes the form of a wireless solar cell that splits water molecules into hydrogen and oxygen gases, which can then be stored for later use. The cell is made of a silicon solar cell with a different catalytic material bonded to each side. When it is placed in water and exposed to sunlight, one side generates H_2 bubbles, and the other side generates O_2 bubbles.

The artificial leaf is unique among existing solar-powered water-splitting systems, which use corrosive or rare materials. The device is made entirely of inexpensive, abundant materials such as silicon, cobalt, and nickel. It needs only sunlight and water at room temperature to operate. Nocera hopes that these properties will lead to an energy system that is safe and cheap enough to be widely adopted in homes around the world, including in areas without reliable access to electricity.

The team is currently working on the next step in creating a commercially viable device—collecting and storing the gases produced by the catalysts.

Mind-Machine Interface

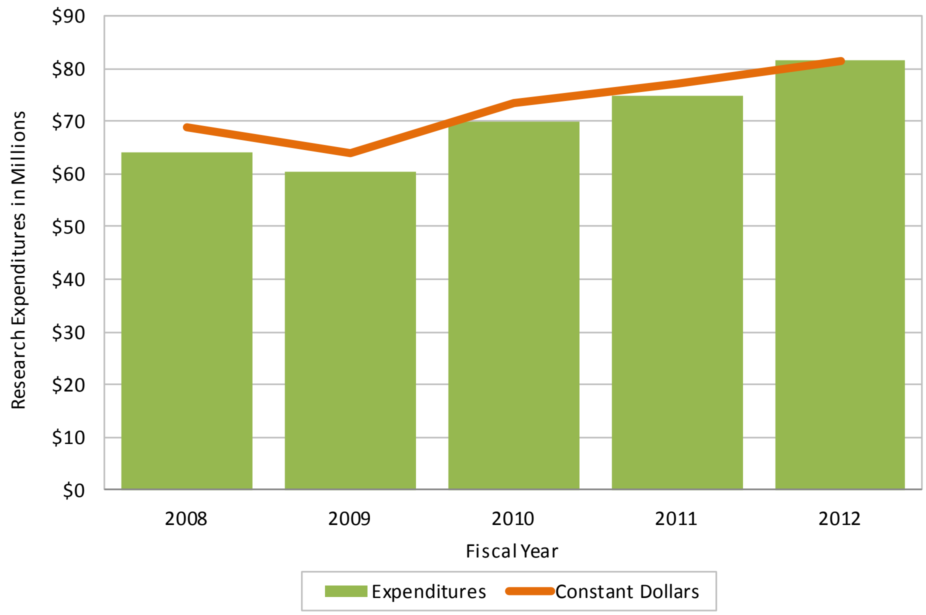
MIT researchers at a new multi-institution research center hope to make robotic systems that are truly integrated with the body's nervous system. The National Science Foundation Engineering Research Center for Sensorimotor Neural Engineering was launched with an $18.5 million grant from the National Science Foundation. Its mission is to "develop innovative ways to connect a deep mathematical understanding of how biological systems acquire and process information with the design of effective devices that interact seamlessly with human beings." Researchers from MIT and the University of Washington, among others, will develop new technologies for amputees, and people with spinal cord injuries, cerebral palsy, stroke, Parkinson's disease, and age-related neurological disorders. Scientists at MIT and partner institutions will work to perform mathematical analysis of the body's neural signals; design and test implanted and wearable prosthetic devices; and build new robotic systems.

Printable Solar Cells

In conventional solar cells, the costs of the inactive components—the substrate (usually glass) that supports the active photovoltaic material, the structures to support that substrate, and the installation costs—are typically greater than the cost of the active components of the cells themselves, sometimes twice as much. Researchers have come up with a method of printing solar cells directly onto paper—a method that may greatly decrease the cost and increase the versatility of solar power. The technique represents a major departure from the systems used to create most solar cells, which require exposing the substrates to potentially damaging conditions, either in the form of liquids or high temperatures. The new printing process uses vapors, not liquids, and temperatures less than 120 degrees Celsius. These conditions make it possible to use ordinary untreated paper, cloth, or plastic as the substrate on which the solar cells can be printed. The resilient solar cells still function even when folded into a paper airplane. Researchers also printed a solar cell on a sheet of PET plastic (a thinner version of the material used for soda bottles) and then folded and unfolded it 1,000 times, with no significant loss of performance. By contrast, a commercially produced solar cell on the same material failed after a single folding. The work was supported by the National Science Foundation and the Eni-MIT Alliance Solar Frontiers Program.

National Science Foundation Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2008–2012

	2008	2009	2010	2011	2012
Campus research	63,950,370	60,394,853	69,801,369	74,859,339	81,487,208
Constant dollars*	68,742,093	64,026,291	73,289,155	77,052,626	81,487,208



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2012
(shown in descending order of expenditures)

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

In fall 2011, the National Science Foundation funded the primary appointments of graduate students with 289 research assistantships and 279 fellowships.

The National Science Foundation has awarded Faculty Early Career Development (CAREER) Awards to 133 current faculty and staff members.

Other Federal Agencies

Selected Current Project

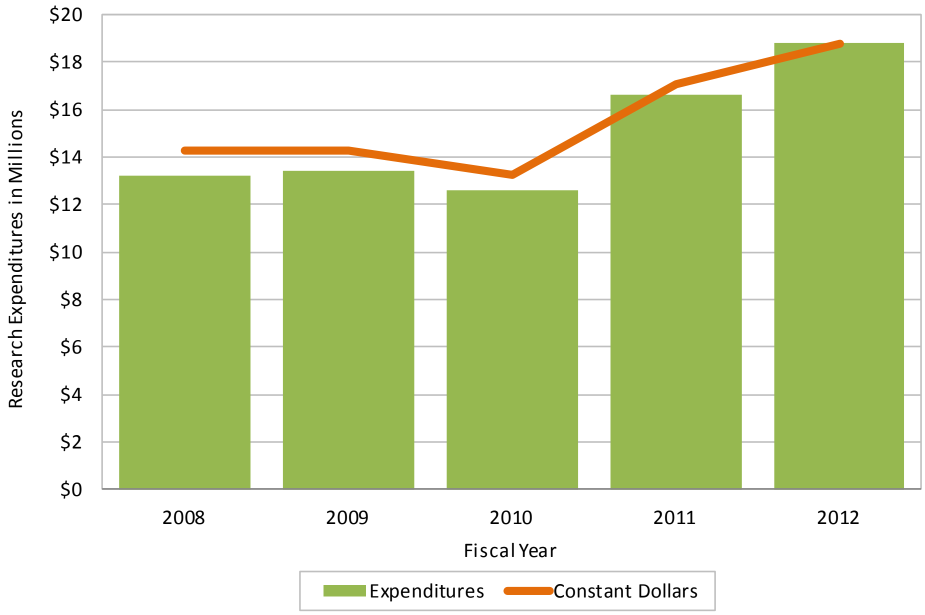
Safer Skies

In the last 10 years alone, over 110 small planes have been involved in midair collisions, and thousands more have reported close calls. In an effort to reduce the number of collisions, the Federal Aviation Administration (FAA) has mandated that by 2020, all commercial aircraft—and small aircraft flying near most airports—must be equipped with a new tracking system that broadcasts GPS data. In anticipation of the deadline, the FAA has charged MIT with leading an investigation of the system's limits and capacities. In October 2011, at the 30th Digital Avionics Systems Conference in Seattle, MIT researchers presented an early result of that investigation, a new algorithm that uses data from the tracking system to predict and prevent collisions between small aircraft.

The main challenge in designing a collision-detection algorithm is limiting false alarms. If a warning system using the algorithm goes off too easily, then pilots may ignore it, or turn the system off. At the same time, it needs to have room for error. While GPS is more accurate than radar tracking, it's not perfect; nor are the communications channels that planes would use to exchange location information. Moreover, any prediction of a plane's future position can be thrown off by unexpected changes of trajectory. Much of the work on the new algorithm thus involves optimizing the trade-off between error tolerance and false alarms. Researchers hope to begin live testing of the algorithm soon.

Other Federal Agencies Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2008–2012

	2008	2009	2010	2011	2012
Campus research	13,249,945	13,445,035	12,636,795	16,602,212	18,806,804
Constant dollars*	14,242,747	14,253,461	13,268,221	17,088,636	18,806,804



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

Some of the leading other federal agencies providing funding include: Federal Aviation Administration, Intelligence Advanced Research Projects Activity, Department of Transportation, Department of Commerce, Department of Homeland Security, and Environmental Protection Agency.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2012
(shown in descending order of expenditures)

Aeronautics and Astronautics
Center for Transportation and Logistics
Computer Science and Artificial Intelligence Laboratory
Sea Grant College Program
Center for Global Change Science
Earth, Atmospheric and Planetary Sciences
Civil and Environmental Engineering
Research Laboratory of Electronics
Sloan School of Management
Materials Processing Center

In fall 2011, other federal agencies funded the primary appointments of graduate students with 44 research assistantships and 8 fellowships.

Nonprofit Organizations

Selected Current Projects

Synthetic Vocal Cords

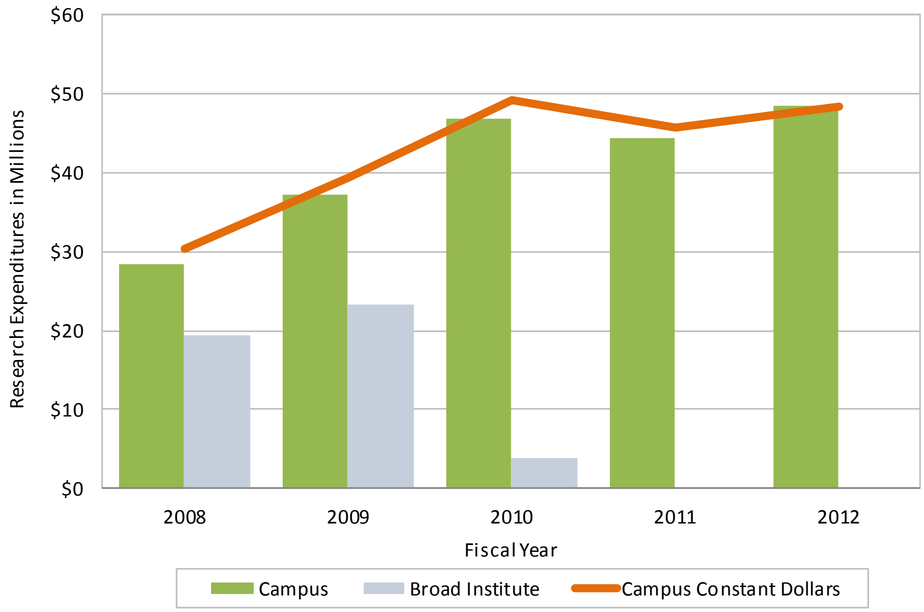
In 1997, the actress and singer Julie Andrews lost her singing voice following surgery to remove non-cancerous lesions from her vocal cords. She went to Steven Zeitels, a professor of laryngeal surgery at Harvard Medical School, for help. Zeitels was already starting to develop a new type of material that could be implanted into scarred vocal cords to restore their normal function. In 2002, he enlisted the help of MIT's Robert Langer, an expert in developing polymers for biomedical applications. The team led by Langer and Zeitels has now developed a polymer gel that they hope to start testing in a small clinical trial. The gel, which mimics key traits of human vocal cords, could help millions of people with voice disorders—not just singers such as Andrews and Steven Tyler, another patient of Zeitels'. The team hopes that the polymer will benefit those with voices strained from overuse, children whose cords are scarred from intubation during surgery, and victims of laryngeal cancer. The project is funded by the Institute of Laryngology and Voice Restoration, which consists of patients whose mission is to support and fund research and education in treating and restoring voice.

Protein linked to memory and learning may lead to novel Alzheimer's treatments

Findings from the Picower Institute for Learning and Memory may lead to new drugs for Alzheimer's disease and other debilitating neurological diseases. Sirtuin1, an enzyme associated with Resveratrol, a compound found in red wine, is known to slow the aging process. In the brain, it does this by shielding neurons from damage. A team of researchers lead by Li-Huei Tsai, found that it also increases synaptic plasticity, the ability to strengthen or weaken neural connections in response to new information. This means that, in addition to preventing damage, Sirtuin1 actually promotes new learning and memory. Researchers hope to use this finding to create Sirtuin1-based treatments for neurodegenerative diseases. The research is supported by the National Institutes of Health, as well as the Simons Foundation, the Swiss National Science Foundation, and the Howard Hughes Medical Institute.

Nonprofit Organizations (in U.S. Dollars)
Campus and Broad Institute Research Expenditures*
Fiscal Years 2008–2012

	2008	2009	2010	2011	2012
Campus research	28,324,003	37,161,950	46,846,106	44,436,470	48,373,460
Broad Institute research	19,370,397	23,376,207	3,792,875	0	0
Total Nonprofit	**47,694,400**	**60,538,156**	**50,638,981**	**44,436,470**	**48,373,460**
Constant dollars†	51,268,083	64,178,211	53,169,274	45,738,404	48,373,460



*The Broad Institute separated from MIT on July 1, 2009 and no longer receives funding through MIT. The chart above displays both campus research expenditures and Broad Institute research expenditures funded through MIT.
†Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2012 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2012
(shown in descending order of expenditures)

Masdar Institute of Science and Technology
Mechanical Engineering
Economics
McGovern Institute for Brain Research
Brain and Cognitive Sciences
MIT-Singapore University of Technology and Design Collaboration
Civil and Environmental Engineering
MIT Energy Initiative
Earth System Initiative
Koch Institute for Integrative Cancer Research