Section 3
Campus Research

Research Support

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

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

Research Expenditures (MIT FY2014)

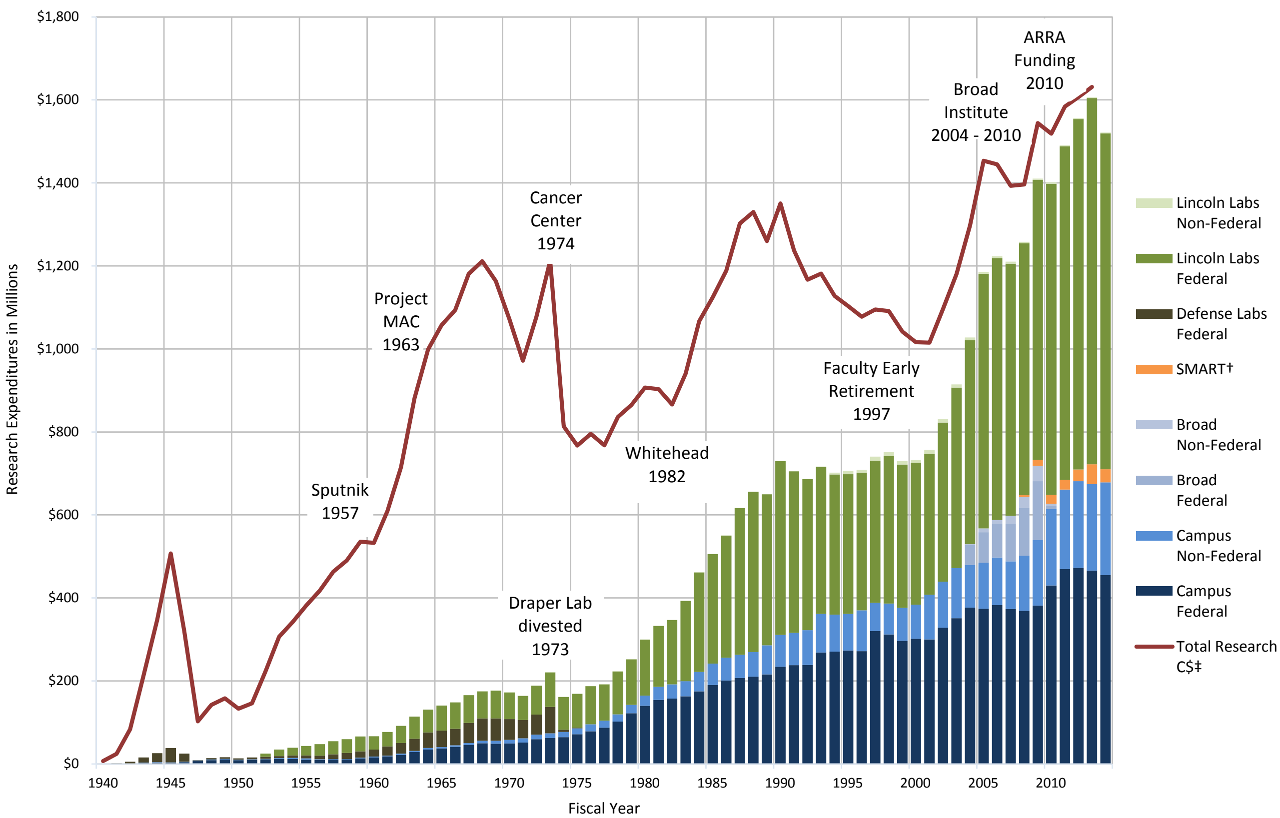
Cambridge campus	$678.4 million
Lincoln Laboratory*	$811.3 million
SMART*	$31.6 million
Total	**$1,521.3 million**

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

All federal research on campus is awarded competitively based on the scientific and technical merit of the proposals. In FY2014, there were 2,601 active awards and 389 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 1940–2014

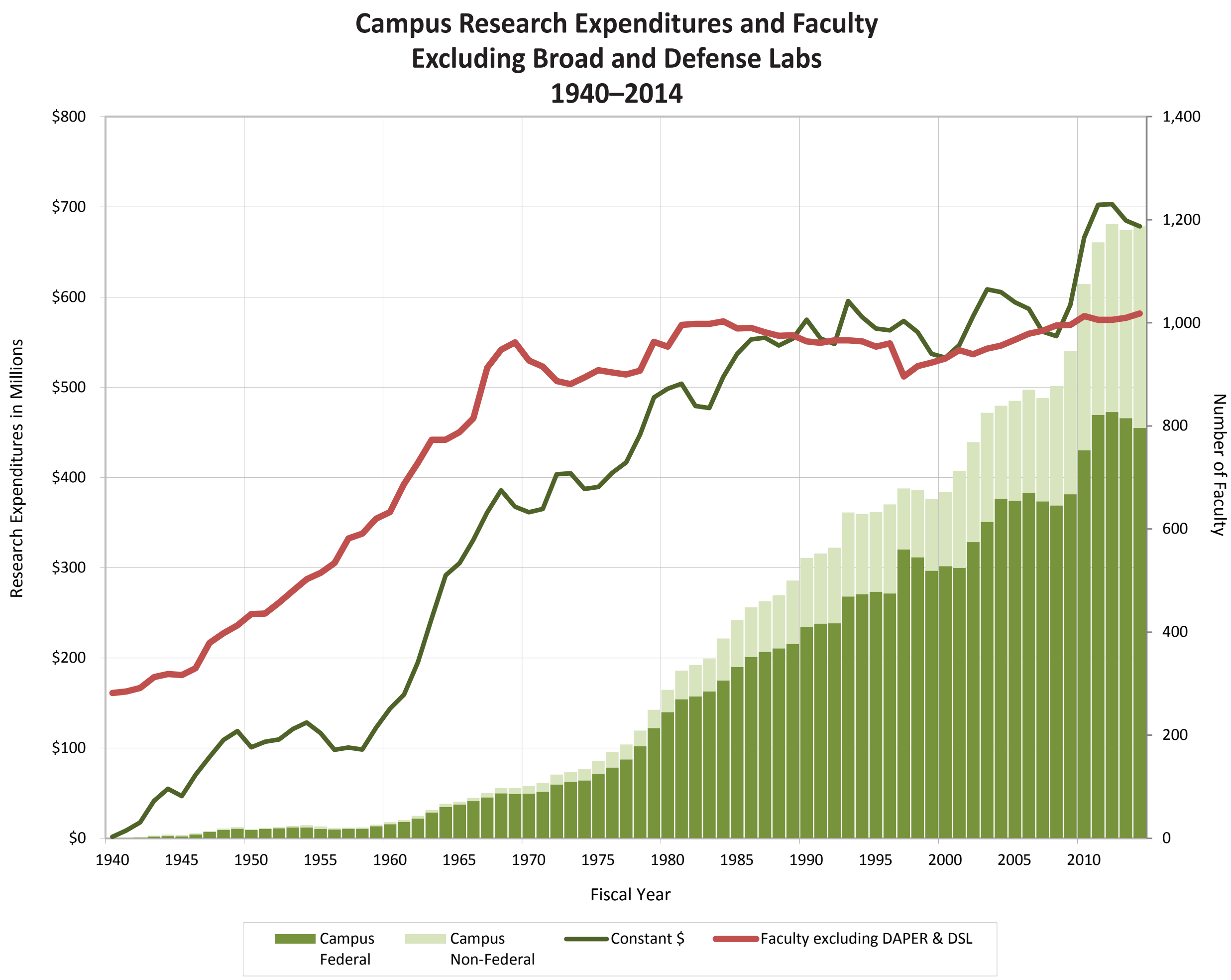


†SMART: Singapore-MIT Alliance for Research and Technology
‡Total Research constant dollars are calculated using the Consumer Price Index for all Urban Consumers weighted with fiscal year 2014 equaling 100.

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

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

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



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

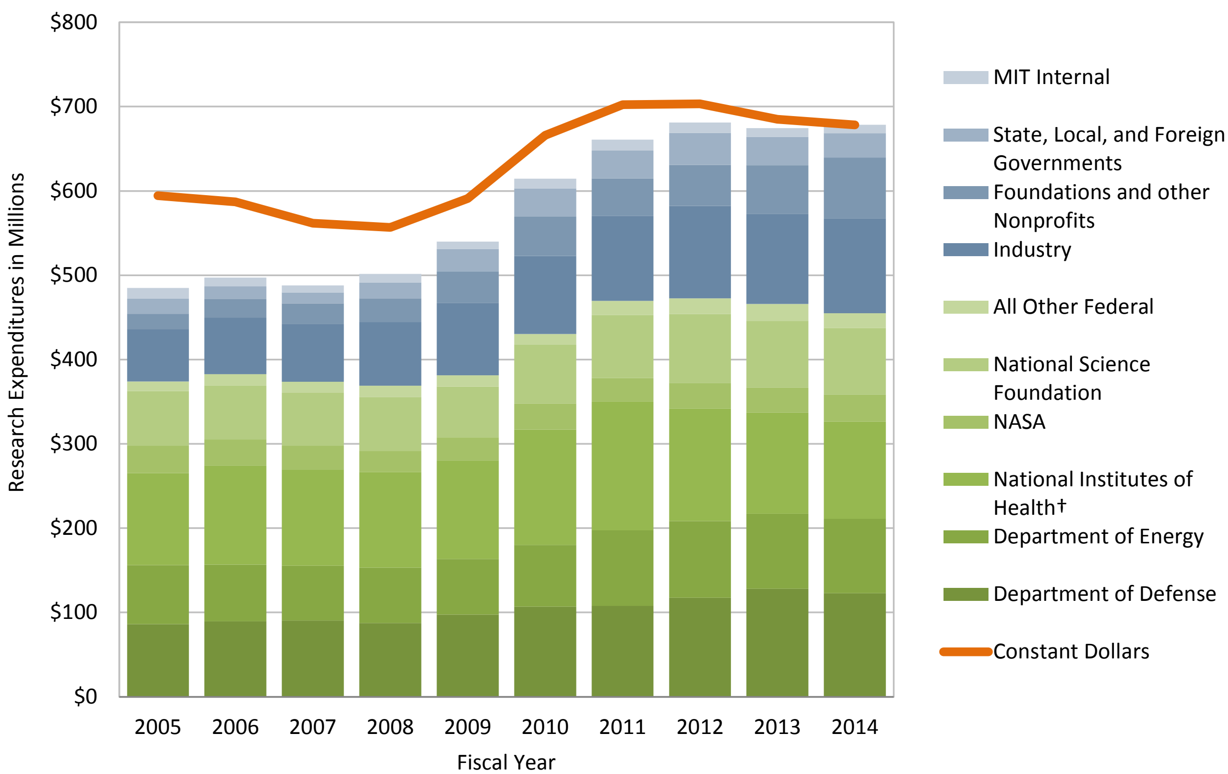
Campus Research Sponsors

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 69. Expenditures funded by industrial sponsors are shown on page 89 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 2005–2014

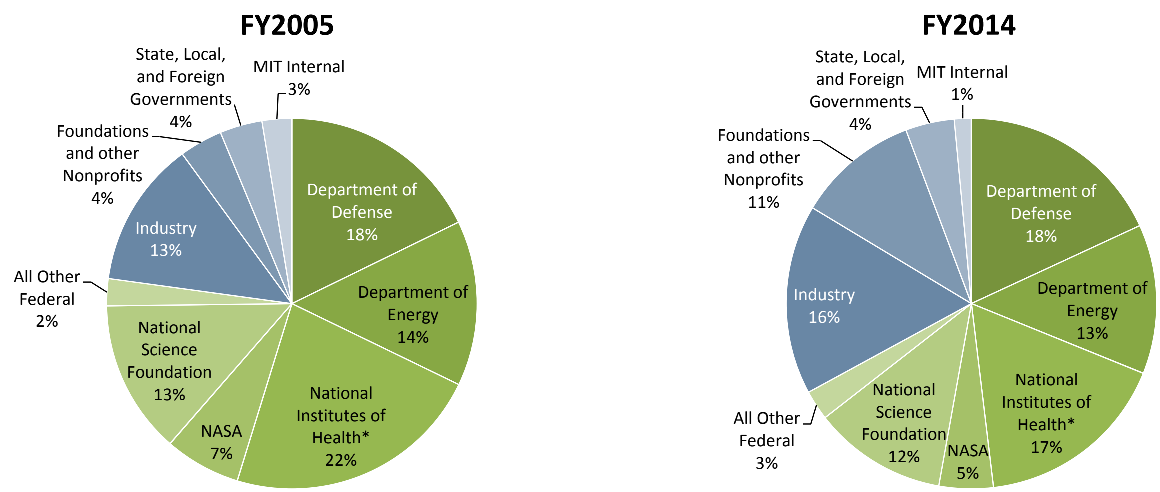
	2005	2006	2007	2008	2009
Federal	374,103,793	382,784,774	373,603,371	369,008,780	381,459,466
Non-federal	110,675,892	114,361,780	114,389,201	132,487,316	158,595,887
Total	**484,779,685**	**497,146,554**	**487,992,571**	**501,496,096**	**540,055,353**
Constant dollars*	594,218,336	587,022,048	561,687,268	556,605,026	591,148,473

	2010	2011	2012	2013	2014
Federal	430,154,479	469,520,579	472,582,743	465,946,679	454,938,599
Non-federal	184,216,417	191,304,692	208,496,567	208,401,668	223,473,071
Total	**614,370,896**	**660,825,271**	**681,079,310**	**674,348,348**	**678,411,670**
Constant dollars*	666,049,163	702,308,587	703,230,287	684,881,260	678,411,670



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2014 equaling 100.
†National Institutes of Health data includes expenditures from other Department of Health and Human Services agencies which account for less than 1% of expenditures per year.

Campus Research Expenditures by Primary Sponsor



Campus Research Expenditures by Primary Sponsor

Primary Sponsor	FY2014 (in U.S. Dollars)	Percent of Campus Total†
Department of Defense	122,761,059	18
Department of Energy	88,450,656	13
National Institutes of Health*	115,074,564	17
NASA	32,062,601	5
National Science Foundation	78,978,705	12
All other federal	17,611,014	3
Total Federal	**454,938,599**	**67**
Industry	112,379,455	17
Foundations and other nonprofits	72,117,488	11
State, local, and foreign governments	28,966,678	4
MIT internal	10,009,449	1
Total Non-Federal	**223,473,071**	**33**
Campus Total	**678,411,670**	**100**

*National Institutes of Health data includes expenditures from other Department of Health and Human Services agencies which account for less than 1% of expenditures per year.
†Percentages may not total due to rounding.

Department of Defense
Selected Projects

An easier way to control genes
MIT researchers have shown that they can turn genes on or off inside yeast and human cells by controlling when DNA is copied into messenger RNA—an advance that could allow scientists to better understand the function of those genes.

The technique could also make it easier to engineer cells that can monitor their environment, produce a drug or detect disease, says Timothy Lu, the senior author of a paper describing the new approach in the journal *ACS Synthetic Biology*. Lead author of the paper is Fahim Farzadfard, a graduate student in biology. Samuel Perli, a graduate student in electrical engineering and computer science, is also an author.

http://newsoffice.mit.edu/2013/
an-easier-way-to-control-genes-0903

Decoding the structure of bone
The bones that support our bodies are made of remarkably complex arrangements of materials—so much so that decoding the precise structure responsible for their great strength and resilience has eluded scientists' best efforts for decades. Researchers, led by Markus Buehler, have finally unraveled the structure of bone with almost atom-by-atom precision, after many years of analysis by some of the world's most powerful computers and comparison with laboratory experiments to confirm the computed results.

Buehler says the riddle was to find how two different materials—a soft, flexible biomolecule called collagen and a hard, brittle form of the mineral apatite—combine to form something that is simultaneously hard, tough and slightly flexible. One key they found, is that the hydroxyapatite grains are tiny, thin platelets deeply embedded in the collagen matrix. The two constituents are bound together by electrostatic interactions, which allow them to slip somewhat against each other without breaking. Ultimately, this work could lead to the synthesis of new bone-like materials, either as biomedical materials to substitute for bone or as new structural materials for engineering uses.

Postdoc Arun Nair was the first author of the paper, with graduate student Shu-Wei Chang, postdoc Alfonso Gautieri, and Markus Buehler.

The work was supported by the Office of Naval Research, the Army Research Office, the National Science Foundation, and the MIT-Italy Program. The research used high-performance computing resources from NSF's XSEDE program, the CILEA Consortium, the LISA Initiative, and the ISCRA Initiative

http://newsoffice.mit.edu/2013/
decoding-the-structure-of-bone-0416

Bound for robotic glory
Speed and agility are hallmarks of the cheetah: The big predator is the fastest land animal on Earth, able to accelerate to 60 mph in just a few seconds. As it ramps up to top speed, a cheetah pumps its legs in tandem, bounding until it reaches a full gallop.

MIT researchers, including Sangbae Kim, research scientist Hae-Won Park and graduate student Meng Yee Chuah, have developed an algorithm for bounding that they've successfully implemented in a robotic cheetah—a sleek, four-legged assemblage of gears, batteries, and electric motors that weighs about as much as its feline counterpart. The team recently took the robot for a test run on MIT's Killian Court, where it bounded across the grass at a steady clip.

In experiments on an indoor track, the robot sprinted up to 10 mph, even continuing to run after clearing a hurdle. The MIT researchers estimate that the current version of the robot may eventually reach speeds of up to 30 mph.

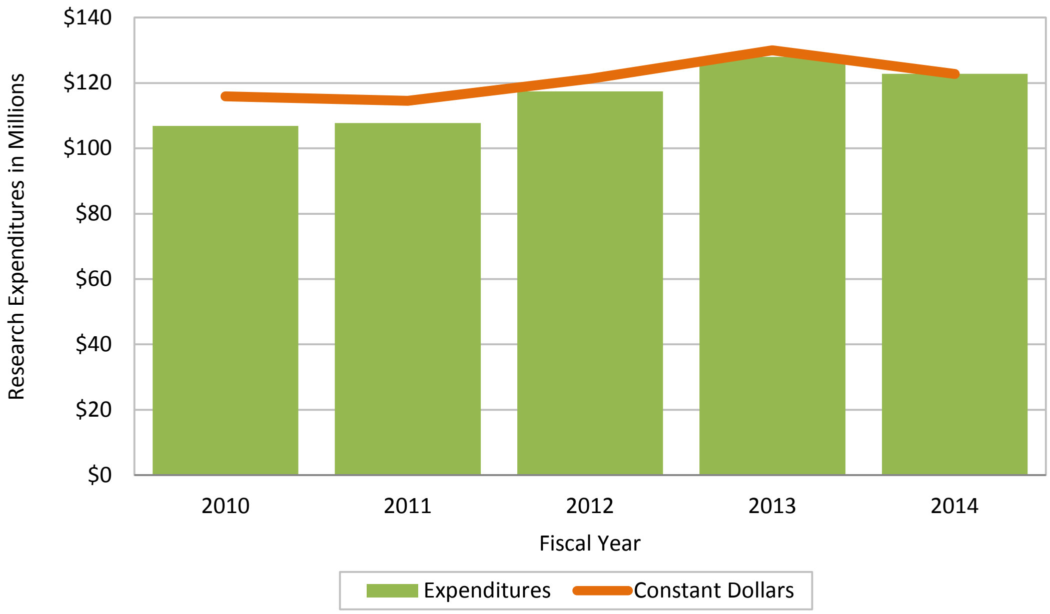
The key to the bounding algorithm is in programming each of the robot's legs to exert a certain amount of force in the split second during which it hits the ground, in order to maintain a given speed: In general, the faster the desired speed, the more force must be applied to propel the robot forward. Kim hypothesizes that this force-control approach to robotic running is similar, in principle, to the way world-class sprinters race.

This work was supported by the Defense Advanced Research Projects Agency.

http://newsoffice.mit.edu/2014/
mit-cheetah-robot-runs-jumps-0915

Department of Defense Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2010–2014

	2010	2011	2012	2013	2014
Campus research	106,890,338	107,753,196	117,457,789	127,966,747	122,761,059
Constant dollars*	115,881,499	114,517,405	121,277,909	129,965,510	122,761,059



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2014 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2014
(shown in descending order of expenditures)

Research Laboratory of Electronics
Computer Science and Artificial Intelligence Laboratory
Biological Engineering
Institute for Soldier Nanotechnologies
Mechanical Engineering
Sociotechnical Systems Research Center
Microsystems Technology Laboratories
Lab for Information & Decision Systems
Aeronautics and Astronautics
Media Laboratory

In fall 2013, the Department of Defense funded the primary appointments of graduate students with 310 research assistantships and 89 fellowships.

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

Department of Energy

Selected Projects

Engineering earth-abundant catalysts that mimic platinum in renewable energy technologies

When one considers nonrenewable resources, the first to come to mind are fossil fuels. The rapid depletion of these unsustainable resources has sparked global research on renewable-energy technologies, such as fuel cells, electrolyzers, and lithium-air batteries.

Unfortunately there is a common unsustainable thread that links these burgeoning technologies: a dependence on platinum-group metals (PGMs). These elements—platinum, palladium, rhodium, iridium, ruthenium, and osmium—are the six least-abundant in the Earth's lithosphere, yet are the most stable and active catalysts. Even with efficient recycling, numerous studies have indicated that the Earth simply does not contain enough PGMs to support a global renewable-energy economy. Thus, PGMs can be considered unsustainable resources that are currently needed to enable renewable energy technologies.

Graduate student Sean Hunt, postdoc Tarit Nimmandwudipong, and Yuriy Román, have an idea for how to replace PGMs with metals that are more plentiful. In a paper published recently in the journal *Angewandte Chemie*, the team explained its process of synthesizing these alternative catalysts. In the simplest sense, one can imagine that tungsten can be electronically modified to mimic platinum by reacting it with carbon to give the ceramic material tungsten carbide (WC). Studies have shown that WC is indeed platinumlike, and able to catalyze important thermo- and electrocatalytic reactions that tungsten metal cannot. Importantly, tungsten is more than three orders of magnitude more abundant than platinum in the Earth's crust, making it a viable material for a global renewable-energy economy.

http://newsoffice.mit.edu/2014/engineering-earth-abundant-catalysts-mimic-platinum-renewable-energy-technologies

One order of steel; hold the greenhouse gases

Anyone who has seen pictures of the giant, red-hot cauldrons in which steel is made—fed by vast amounts of carbon, and belching flame and smoke—would not be surprised to learn that steelmaking is one of the world's leading industrial sources of greenhouse gases. But remarkably, a new process developed by MIT researchers could change all that.

The new process even carries a couple of nice side benefits: The resulting steel should be of higher purity, and eventually, once the process is scaled up, cheaper. Donald Sadoway, senior author of a new paper describing the process, says this could be a significant "win, win, win" proposition. The paper, co-authored by Antoine Allanore, and former postdoc Lan Yin, has been published in the journal *Nature*.

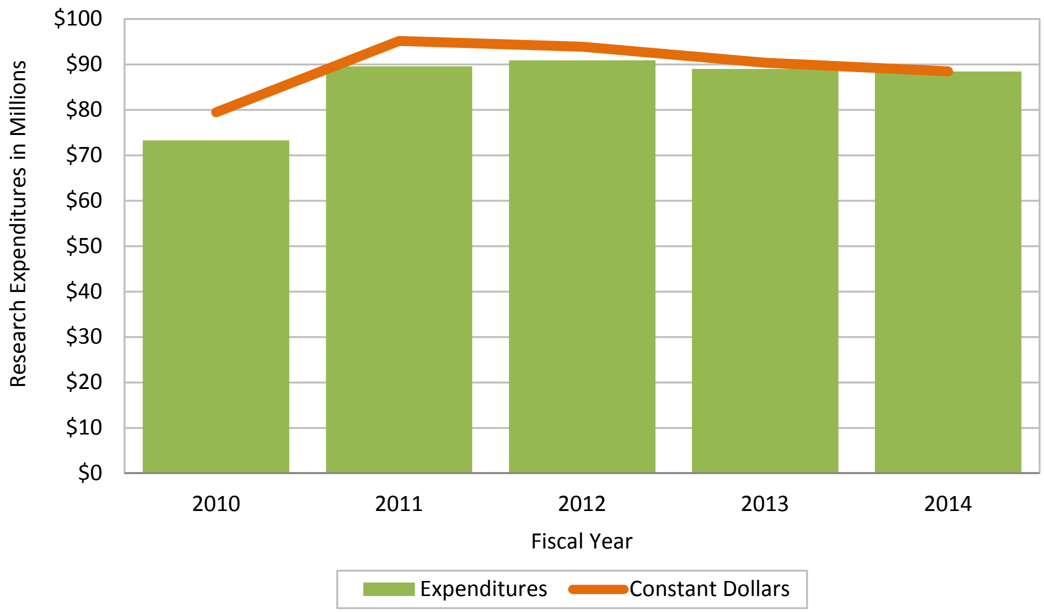
The idea for the new method, Sadoway says, arose when he received a grant from NASA to look for ways of producing oxygen on the moon—a key step toward future lunar bases. Sadoway found that a process called molten oxide electrolysis could use iron oxide from the lunar soil to make oxygen in abundance, with no special chemistry. He tested the process using lunar-like soil from Meteor Crater in Arizona finding that it produced steel as a by-product.

The research was supported by the American Iron and Steel Institute and the U.S. Department of Energy.

http://newsoffice.mit.edu/2013/steel-without-greenhouse-gas-emissions-0508

**Department of Energy Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2010–2014**

	2010	2011	2012	2013	2014
Campus research	73,273,733	89,562,126	90,940,035	88,987,983	88,450,656
Constant dollars*	79,437,208	95,184,389	93,897,709	90,377,922	88,450,656



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2014 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2014
(shown in descending order of expenditures)

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

In fall 2013, the Department of Energy funded the primary appointments of graduate students with 196 research assistantships, 2 teaching assistantships, and 20 fellowships.

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

National Institutes of Health

Selected Projects

A paper diagnostic for cancer

Cancer rates in developing nations have climbed sharply in recent years, and now account for 70 percent of cancer mortality worldwide. Early detection has been proven to improve outcomes, but screening approaches such as mammograms and colonoscopy, used in the developed world, are too costly to be implemented in settings with little medical infrastructure.

To address this gap, MIT engineers have developed a simple, cheap, paper test that could improve diagnosis rates and help people get treated earlier. The diagnostic, which works much like a pregnancy test, could reveal within minutes, based on a urine sample, whether a person has cancer. This approach has helped detect infectious diseases, and the new technology allows noncommunicable diseases to be detected using the same strategy.

The technology, developed by MIT professor and Howard Hughes Medical Institute investigator Sangeeta Bhatia, relies on nanoparticles that interact with tumor proteins called proteases, each of which can trigger release of hundreds of biomarkers that are then easily detectable in a patient's urine.

http://newsoffice.mit.edu/2014/a-paper-diagnostic-for-cancer-0224

Rett syndrome drug shows promise in clinical trial

Rett syndrome, a rare genetic disorder that causes intellectual disabilities, autism, and physical deformities, has no cure. However, a small clinical trial has found that a growth factor known as IGF1 can help treat some symptoms of the disease.

Children who received the drug for four weeks showed improvements in mood and anxiety, as well as easier breathing, in a trial led by researchers at Boston Children's Hospital. MIT scientists first identified IGF1 as a possible treatment for Rett syndrome in 2009.

"This trial shows that IGF1 is safe in the cohort of 12 kids, and at least on certain measures, it provides some effectiveness," says Mriganka Sur, an author of the paper, which appeared recently in the *Proceedings of the National Academy of Sciences*.

The research was funded by the National Eye Institute, the National Institutes of Health, the Simons Foundation, and the National Science Foundation.

http://newsoffice.mit.edu/2014/rett-syndrome-drug-shows-promise-clinical-trial-0623

Noninvasive brain control

Optogenetics, a technology that allows scientists to control brain activity by shining light on neurons, relies on light-sensitive proteins that can suppress or stimulate electrical signals within cells. This technique requires a light source to be implanted in the brain, where it can reach the cells to be controlled.

MIT engineers have now developed the first light-sensitive molecule that enables neurons to be silenced noninvasively, using a light source outside the skull. This makes it possible to do long-term studies without an implanted light source. The protein, known as Jaws, also allows a larger volume of tissue to be influenced at once.

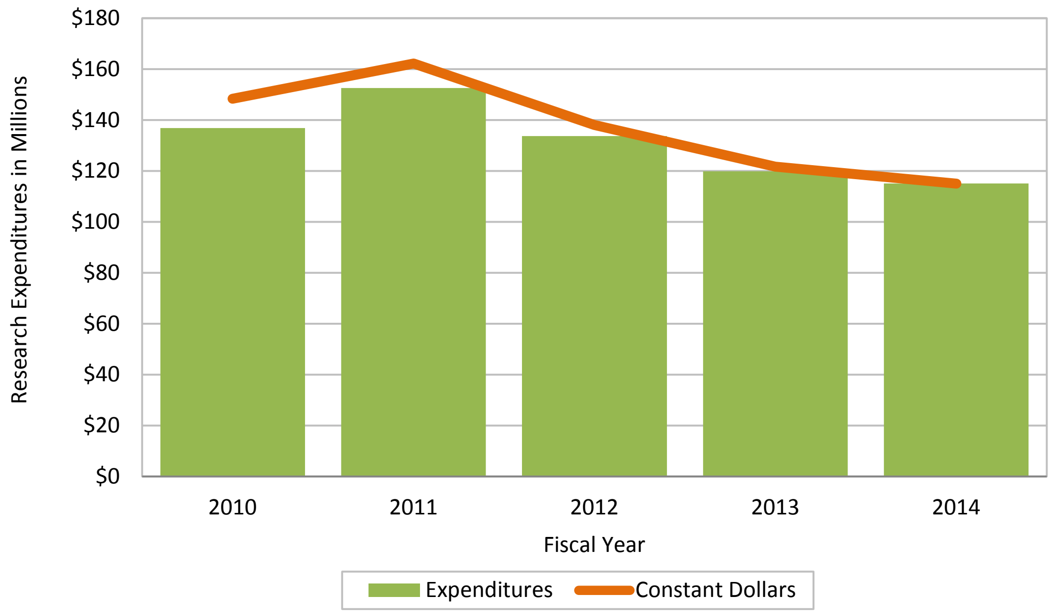
This noninvasive approach could pave the way to using optogenetics in human patients to treat epilepsy and other neurological disorders, the researchers say, although much more testing and development is needed. Led by Ed Boyden, the researchers described the protein in *Nature Neuroscience*.

The research at MIT was funded by Jerry and Marge Burnett, the Defense Advanced Research Projects Agency, the Human Frontiers Science Program, the IET A. F. Harvey Prize, the Janet and Sheldon Razin '59 Fellowship of the MIT McGovern Institute, the New York Stem Cell Foundation-Robertson Investigator Award, the National Institutes of Health, the National Science Foundation, and the Wallace H. Coulter Foundation.

http://newsoffice.mit.edu/2014/noninvasive-brain-control-0629

National Institutes of Health Campus Research Expenditures (in U.S. Dollars)*
Fiscal Years 2010–2014

	2010	2011	2012	2013	2014
Campus research	136,923,238	152,664,013	133,687,332	119,908,451	115,074,564
Constant dollars†	148,440,638	162,247,499	138,035,291	121,781,348	115,074,564



*National Institutes of Health data includes expenditures from other Department of Health and Human Services agencies which account for less than 1% of expenditures per year.
†Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2014 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2014
(shown in descending order of expenditures)

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

In fall 2013, the National Institutes of Health and other Department of Health and Human Services programs funded the primary appointments of graduate students with 155 research assistantships and 35 fellowships.

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

NASA

Selected Projects

Scientists discover water ice on Mercury

Mercury, the smallest and innermost planet in our solar system, revolves around the sun in a mere 88 days, making a tight orbit that keeps the planet incredibly toasty. Surface temperatures on Mercury can reach a blistering 800 degrees Fahrenheit—hot enough to liquefy lead. Researchers from NASA, MIT, the University of California at Los Angeles and elsewhere have discovered evidence that the scorching planet may harbor pockets of water ice, along with organic material, in several permanently shadowed craters near Mercury's north pole.

"We thought the most exciting finding could be that this really was water ice," says Maria Zuber, a member of the research team. "But the identification of darker, insulating material that may indicate complex organics makes the story even more thrilling."

To get a clearer picture of Mercury's polar regions, Zuber and her colleagues analyzed observations taken by NASA's MESSENGER (MErcury Surface, Space ENvironment, GEochemistry and Ranging) mission, a probe that has been orbiting the planet and mapping its topography since April 2011. MESSENGER will continue to orbit Mercury, and Zuber says future data may reveal information beyond the planet's surface. "There are still some really good questions to answer about the interior," Zuber says. "I'll tell you, we're not done."

http://newsoffice.mit.edu/2012/scientists-discover-water-ice-on-mercury-1129

GRAIL reveals a battered lunar history

Beneath its heavily pockmarked surface, the moon's interior bears remnants of the very early solar system. Unlike Earth, where plate tectonics has essentially erased any trace of the planet's earliest composition, the moon's interior has remained relatively undisturbed over billions of years, preserving a record in its rocks of processes that occurred in the solar system's earliest days.

Scientists at MIT, NASA, the Jet Propulsion Laboratory and elsewhere have found evidence that, beneath its surface, the moon's crust is almost completely pulverized. The finding suggests that, in its first billion years, the moon—and probably other planets like Earth—may have endured much more fracturing from massive impacts than previously thought.

The startling observations come from data collected by NASA's Gravity Recovery and Interior Laboratory (GRAIL) mission. From GRAIL's measurements, planetary scientists have now stitched together a high-resolution map of the moon's gravity—a force created by surface structures such as mountains and craters, as well as deeper structures below the surface. The resulting map reveals an interior gravitational field consistent with an incredibly fractured lunar crust. Maria Zuber leads the GRAIL mission.

http://newsoffice.mit.edu/2012/grail-reveals-a-battered-lunar-history-1205

NASA selects MIT-led TESS project for 2017 mission

Following a three-year competition, NASA has selected the Transiting Exoplanet Survey Satellite (TESS) project at MIT for a planned launch in 2017. The space agency announced the mission—to be funded by a $200 million grant to the MIT-led team—in April 2013.

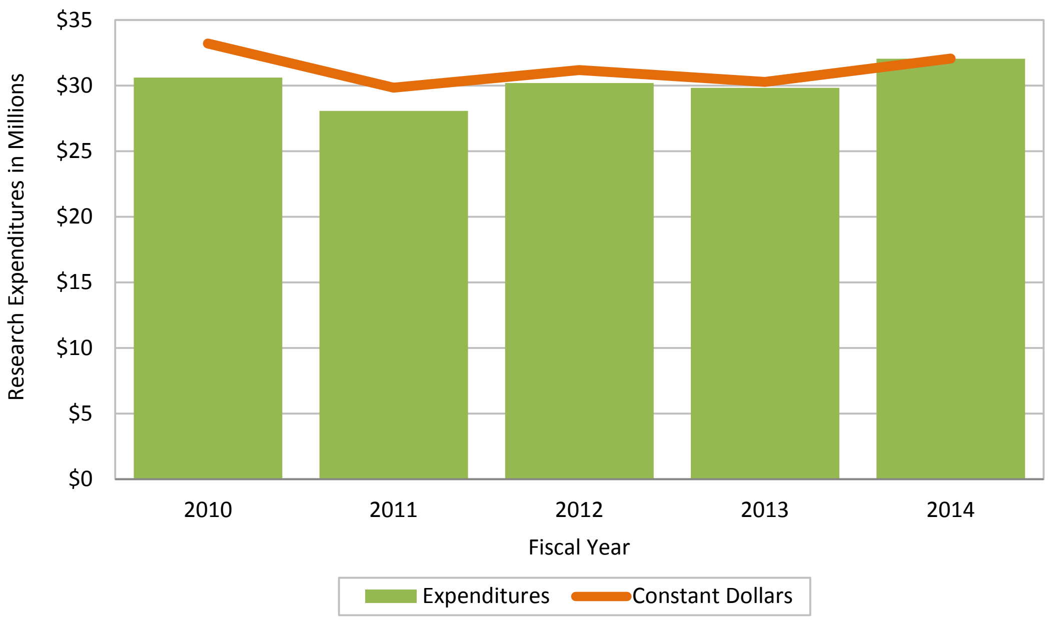
TESS team partners include the MIT Kavli Institute for Astrophysics and Space Research (MKI) and MIT Lincoln Laboratory; NASA's Goddard Spaceflight Center; Orbital Sciences Corporation; NASA's Ames Research Center; the Harvard-Smithsonian Center for Astrophysics; The Aerospace Corporation; and the Space Telescope Science Institute.

The project, led by principal investigator George Ricker, a senior research scientist at MKI, will use an array of wide-field cameras to perform an all-sky survey to discover transiting exoplanets, ranging from Earth-sized planets to gas giants, in orbit around the brightest stars in the sun's neighborhood.

http://newsoffice.mit.edu/2013/nasa-selects-tess-for-mission-0405

NASA Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2010–2014

	2010	2011	2012	2013	2014
Campus research	30,629,006	28,079,693	30,203,575	29,834,713	32,062,601
Constant dollars*	33,205,388	29,842,396	31,185,897	30,300,713	32,062,601



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2014 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2014
(shown in descending order of expenditures)

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

In fall 2013, NASA funded the primary appointments of graduate students with 51 research assistantships and 18 fellowships.

National Science Foundation

Selected Projects

Morphable surfaces could cut air resistance

There is a story about how the modern golf ball, with its dimpled surface, came to be: In the mid-1800s, it is said, new golf balls were smooth, but became dimpled over time as impacts left permanent dents. Smooth new balls were typically used for tournament play, but in one match, a player ran short, had to use an old, dented one, and realized that he could drive this dimpled ball much further than a smooth one.

Whether that story is true or not, testing over the years has proved that a golf ball's irregular surface really does dramatically increase the distance it travels, because it can cut the drag caused by air resistance in half. Now researchers at MIT are aiming to harness that same effect to reduce drag on a variety of surfaces—including domes that sometimes crumple in high winds, or perhaps even vehicles.

Detailed studies of aerodynamics have shown that while a ball with a dimpled surface has half the drag of a smooth one at lower speeds, at higher speeds that advantage reverses. So the ideal would be a surface whose smoothness can be altered, literally, on the fly—and that's what the MIT team has developed.

The new work is described in a paper in the journal *Advanced Materials* by Pedro Reis and former postdocs Denis Terwagne and Miha Brojan.

The research was supported by the National Science Foundation, MIT's Charles E. Reed Faculty Initiatives Fund, the Wallonie-Bruxelles International, the Belgian American Education Foundation, and the Fulbright Foundation.

http://newsoffice.mit.edu/2014/
morphable-surfaces-could-cut-air-resistance-0624

Improving a new breed of solar cells

Solar-cell technology has advanced rapidly, as hundreds of groups around the world pursue more than two dozen approaches using different materials, technologies, and approaches to improve efficiency and reduce costs. Now a team at MIT has set a new record for the most efficient quantum-dot cells—a type of solar cell that is seen as especially promising because of its inherently low cost, versatility, and light weight.

While the overall efficiency of this cell is still low compared to other types the rate of improvement of this technology is one of the most rapid seen for a solar technology. The development is described in a paper published in the journal *Nature Materials*, by Moungi Bawendi and Vladimir Bulović and graduate students Chia-Hao Chuang and Patrick Brown.

The work was supported by the Samsung Advanced Institute of Technology, the Fannie and John Hertz Foundation, and the National Science Foundation.

http://newsoffice.mit.edu/2014/
improving-new-breed-solar-cells-0527

From gold, a new way to control blood clotting

Using gold nanoparticles, MIT researchers have devised a new way to turn blood clotting on and off. The particles could help doctors control blood clotting in patients undergoing surgery, or promote wound healing. Currently, the only way doctors can manage blood clotting is by administering blood thinners such as heparin. This reduces clotting, but there is no way to counteract the effects of heparin and other blood thinners.

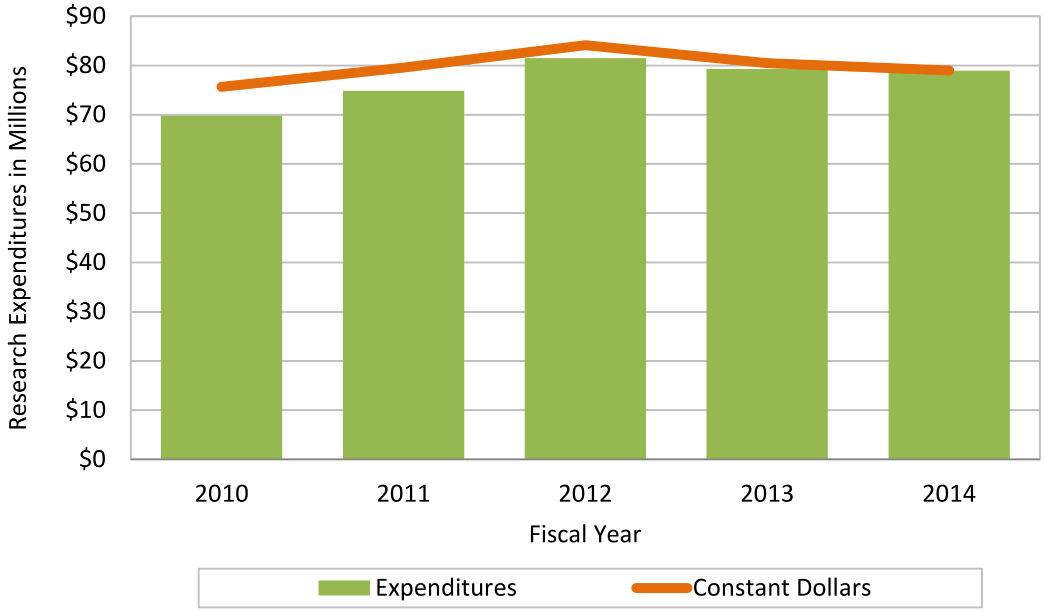
"It's like you have a light bulb, and you can turn it on with the switch just fine, but you can't turn it off. You have to wait for it to burn out," says Kimberly Hamad-Schifferli, a technical staff member at MIT Lincoln Laboratory and senior author of a paper describing the new particles, which can turn blood clotting off and then restore it when necessary.

Lead author of the paper, published in the journal *PLoS One*, is Helena de Puig, a graduate student in mechanical engineering. Other authors are Anna Cifuentes Rius, a visiting student from Ramon Llull University in Spain, and MIT senior Dorma Flemister.

http://newsoffice.mit.edu/2013/
from-gold-a-new-way-to-control-blood-clotting-0724

National Science Foundation Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2010–2014

	2010	2011	2012	2013	2014
Campus research	69,801,369	74,859,339	81,487,208	79,255,278	78,978,705
Constant dollars*	75,672,764	79,558,635	84,137,445	80,493,197	78,978,705



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2014 equaling 100.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2014
(shown in descending order of expenditures)

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

In fall 2013, the National Science Foundation funded the primary appointments of graduate students with 280 research assistantships and 317 fellowships.

The National Science Foundation has awarded Faculty Early Career Development (CAREER) Awards to 132 current faculty and staff members.

Other Federal Agencies
Selected Projects

More efficient ways to power our flights

As countries try to protect their domestic air carriers from a European Union proposal that would put a price on the emissions they release over European airspace, the global aviation industry is working to curb those emissions. Industry-wide, air carriers set a goal to be carbon neutral by 2020 and to cut their emissions in half by 2050. One way they'll meet this goal is through the use of biofuels.

"Biofuels release significantly fewer emissions than conventional fuel, and could reduce fuel price volatility for airlines," says Niven Winchester, the lead author of a study looking at the costs and efficiency of making the switch.

To meet the global targets, the U.S. Federal Aviation Administration (FAA) has set its own goal to use one billion gallons of renewable biofuels each year starting in 2018. Because the goal includes U.S. Air Force and Navy carriers, which consume the vast majority of fuel, commercial airlines are responsible for just 35 percent of the target (350 million gallons). In studying this target, Winchester and his co-authors find that while a carbon tax or cap-and-trade system—as the Europeans have employed—would be the most efficient way to reduce emissions, there are ways to cut the costs of using biofuels. The study was published in the December issue of *Transportation Research*. The researchers found that growing biofuel crops in rotation with food crops, as research from the U.S. Department of Agriculture suggests, can reduce the cost of biofuels.

The study was funded by the FAA.

http://newsoffice.mit.edu/2013/more-efficient-ways-to-power-our-flights-1202

MIT receives grant to develop new methods for detecting shielded nuclear materials

A research collaboration led by MIT has received a five-year $5 million grant from the National Science Foundation and the Domestic Nuclear Detection Office of the Department of Homeland Security to study new approaches to the detection of shielded nuclear material.

The approach proposed by MIT involves a new method for producing monoenergetic gamma rays which can penetrate materials and can clearly differentiate between ordinary materials and special nuclear materials (SNM) such as uranium, while reducing the radiation dose by a factor of 20 relative to previous approaches. The new system will combine a unique radiation source with new concepts in detectors and new approaches to inference and data analysis algorithms that can clearly delineate between potential threats and benign materials using both statistical inferences and physics-based simulations.

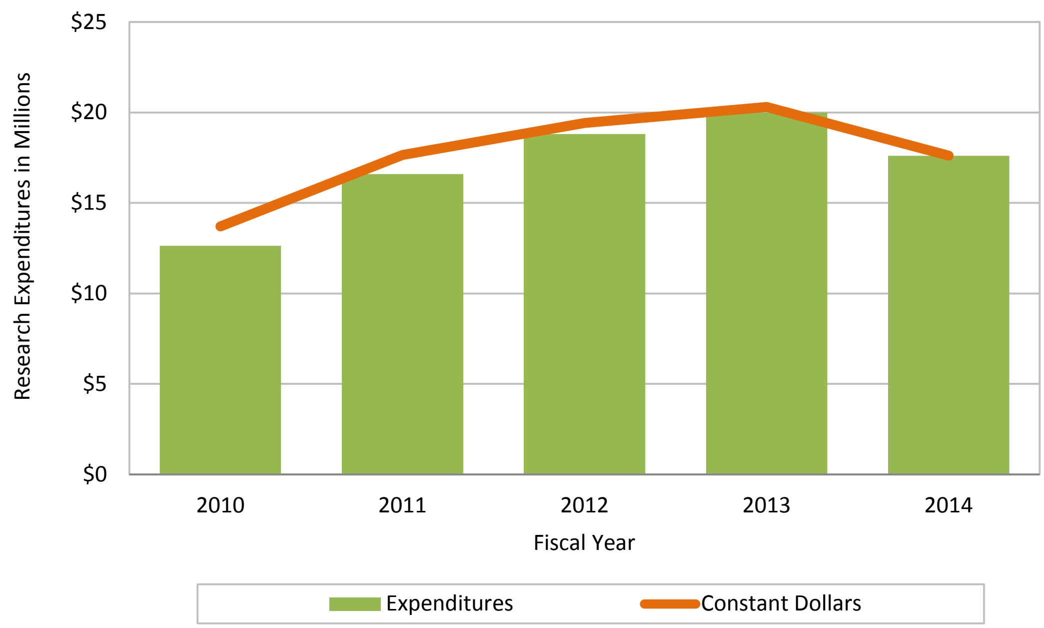
The overarching goal of the project is to develop a novel approach to the active detection of shielded nuclear materials while in transit with an easily relocatable low-dose system. The system approach will be such that a fast screen can be made to rapidly clear the vast majority of objects which pose no threat and, if a potential threat is detected, to use the same system to positively identify the presence of nuclear materials.

The MIT team includes scientists from NSE (Richard Lanza, overall project PI) and CSAIL (John Fisher), as well as collaborators from Penn State (Igor Jovanovic, Zoubeida Ounaies) and Georgia Tech (Anna Erickson).

http://newsoffice.mit.edu/2013/mit-receives-5m-to-develop-new-methods-for-detecting-shielded-nuclear-materials

Other Federal Agencies Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2010–2014

	2010	2011	2012	2013	2014
Campus research	12,636,795	16,602,212	18,806,804	19,993,508	17,611,014
Constant dollars*	13,699,748	17,644,416	19,418,464	20,305,794	17,611,014



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2014 equaling 100.

A few of the leading other federal agencies providing funding are: the Department of Commerce, the Department of Transportation, the Federal Aviation Administration, the Intelligence Advanced Research Projects Activity, and the Environmental Protection Agency.

Leading Departments, Laboratories, and Centers Receiving Support in Fiscal Year 2014
(shown in descending order of expenditures)

Computer Science and Artificial Intelligence Laboratory
Center for Transportation and Logistics
Aeronautics and Astronautics
Sea Grant College Program
Mechanical Engineering
Urban Studies and Planning
Earth System Initiative
Center for Global Change Science
Media Laboratory
Research Laboratory of Electronics

In fall 2013, Other Federal Agencies funded the primary appointments of graduate students with 44 research assistantships and 4 fellowships.

Nonprofit Organizations

Selected Projects

Editing the genome with high precision

Researchers at MIT, the Broad Institute, and Rockefeller University have developed a new technique for precisely altering the genomes of living cells by adding or deleting genes. The researchers say the technology could offer an easy-to-use, less-expensive way to engineer organisms that produce biofuels; to design animal models to study human disease; and to develop new therapies, among other potential applications.

To create their new genome-editing technique, the researchers modified a set of bacterial proteins that normally defend against viral invaders. Using this system, scientists can alter several genome sites simultaneously and can achieve much greater control over where new genes are inserted, says Feng Zhang, leader of the research team.

The research was funded by the National Institute of Mental Health; the W.M. Keck Foundation; the McKnight Foundation; the Bill & Melinda Gates Foundation; the Damon Runyon Cancer Research Foundation; the Searle Scholars Program; and philanthropic support from MIT alumni Mike Boylan and Bob Metcalfe, as well as the newscaster Jane Pauley.

http://newsoffice.mit.edu/2013/editing-the-genome-with-high-precision-0103

Exploring a breakdown in communication

One of the defining characteristics of autism is difficulty communicating with others. However, it is unclear whether those struggles arise only from the poor social skills commonly associated with autism, or whether autistic children suffer from more specific linguistic impairments. In a study appearing in the journal *Language Acquisition*, Kenneth Wexler reports that some autistic children do have a specific linguistic deficit: They are unable to understand a specific type of grammatical construction involving reflexive pronouns. This finding suggests that there may be a biological basis for the language impairments seen in autism, and paves the way for genetic studies that could reveal new targets for treating the disease, Wexler says.

Lead author of the paper is former postdoc Alexandra Perovic, now at University College London. Former graduate student and postdoc Nadezhda Modyanova is also an author of the paper.

The research was funded by the Anne and Paul Marcus Family Foundation and the Simons Initiative on Autism and the Brain.

http://newsoffice.mit.edu/2013/autism-language-acquisition-0419

Stacking 2-D materials produces surprising results

Graphene has dazzled scientists, ever since its discovery more than a decade ago, with its unequalled electronic properties, its strength and its light weight. But one long-sought goal has proved elusive: how to engineer into graphene a property called a band gap, which would be necessary to use the material to make transistors and other electronic devices.

New findings by researchers at MIT are a major step toward making graphene with this coveted property. The work could also lead to revisions in some theoretical predictions in graphene physics. The new technique involves placing a sheet of graphene—a carbon-based material whose structure is just one atom thick—on top of hexagonal boron nitride, another one-atom-thick material with similar properties. The resulting material shares graphene's amazing ability to conduct electrons, while adding the band gap necessary to form transistors and other semiconductor devices.

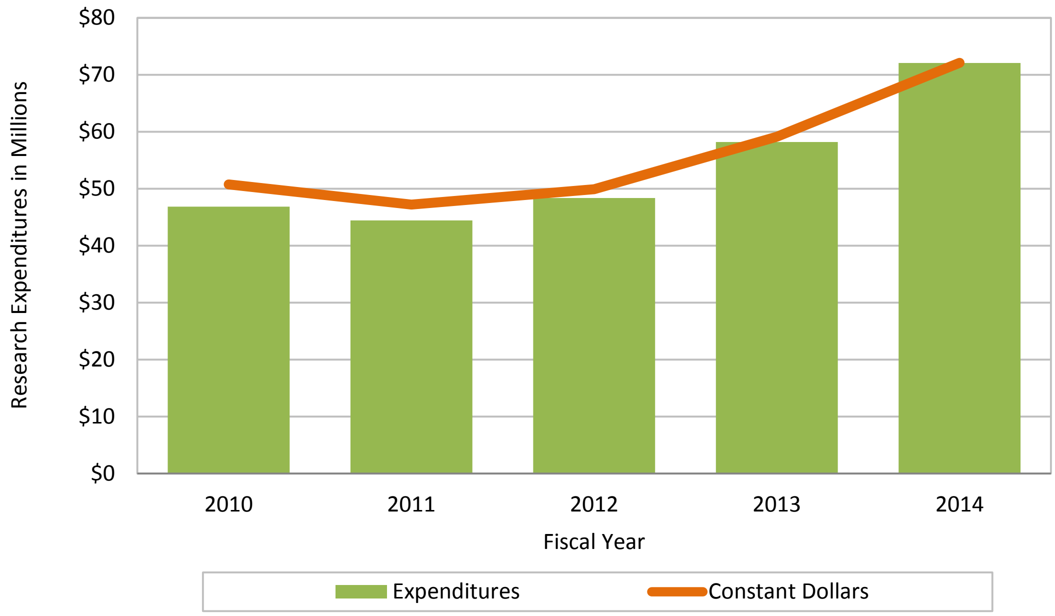
The work is described in a paper in the journal *Science* co-authored by Pablo Jarillo-Herrero, Ray Ashoori, and ten others. The research included postdocs Ben Hunt and Andrea Young, and graduate student Javier Sanchez-Yamagishi, as well as six other researchers from the University of Arizona, the National Institute for Materials Science in Tsukuba, Japan, and Tohoku University in Japan.

The work was funded by the U.S. Department of Energy, the Gordon and Betty Moore Foundation and the National Science Foundation.

http://newsoffice.mit.edu/2013/layered-stacks-could-unleash-graphenes-electronic-potential-0516

**Nonprofit Organizations Campus Research Expenditures (in U.S. Dollars)
Fiscal Years 2010–2014**

	2010	2011	2012	2013	2014
Campus research	46,846,106	44,436,470	48,373,460	58,226,616	72,117,488
Constant dollars*	50,786,601	47,225,970	49,946,727	59,136,081	72,117,488



*Constant dollars are calculated using the Consumer Price Index for All Urban Consumers weighted with the fiscal year 2014 equaling 100.

**Leading Departments, Laboratories, and Centers
Receiving Support in Fiscal Year 2014**
(shown in descending order of expenditures)

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