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TechTalk
SERVING THE MIT COMMUNITY

Superhero comics offer super physics lessons

Deborah Halber
News Office Correspondent

The public persona of the Atom is mild-mannered physics professor Ray Palmer, who fashioned a lens that enabled him to shrink any object to any degree he wished. The lens's secret ingredient is a chunk of a white dwarf star, and a 1960s version of the Atom comic book shows the professor in a grassy field, huffing and puffing as he carries a grapefruit-sized piece of the star (which has miraculously fallen to Earth) to his car.

Palmer seems undaunted by the fact that a sphere of white dwarf star that size would weigh 500,000 tons.

Jim Kakalios, a real-life physics professor from the University of Minnesota who spoke April 5 on "The Uncanny Physics of Superhero Comic Books" as part of the MIT Physics Colloquium Series, said that although a plethora of scientific bloopers could be found on the pages of comic books, Palmer carrying the star was completely believable. "We physics professors are just that strong," he wisecracked.

Kakalios's receptive audience couldn't get enough of his brand of one-liners: Supervillain Electro's pointy yellow lightning bolt mask would not be Kakalios's choice of attire if he was transformed into a living electrical capacitor; each superhero has a "one-time exemption from the laws of nature" for his or her powers; and when Superman says he got permission to carry two skyscrapers over his shoulders the way a waiter might carry trays, Kakalios exclaimed, "Who would you ask?"

Kakalios, who studies disordered systems as a condensed matter experimentalist in his day job, achieved fame if not fortune in May 2002, when "Spider-Man" opened in theaters. Kakalios, who uses examples from comic books to keep his students engaged, thought it might be nice to get "a little physics into the newspaper." The University of Minnesota put out a news release. The next thing Kakalios knew, a picture of him holding plastic action figures was zooming around the world faster than a speeding bullet.

Kakalios finds that students in his introductory physics classes are much more willing to learn about Newton's laws when they are calculating the force needed to leap over tall buildings in a single bound (Superman would need 140 mph of liftoff velocity and his legs would have to exert 6,000 pounds of force, in case you were wondering). From how air bags save lives to how cell phones work, Kakalios covers serious physics with the "silly premises" found in comic books. Comic books "actually get their science right more often than you think," said Kakalios, who wrote a book, "The Physics of Superheroes," in 2005.

In one comic book, an evil character proposes finding the location of the Bat Cave by burying sticks of dynamite and detecting the differences in the resulting sound waves. It's true that the waves would travel at different speeds depending on the material they encountered. Superman, carrying a terrified bad guy over

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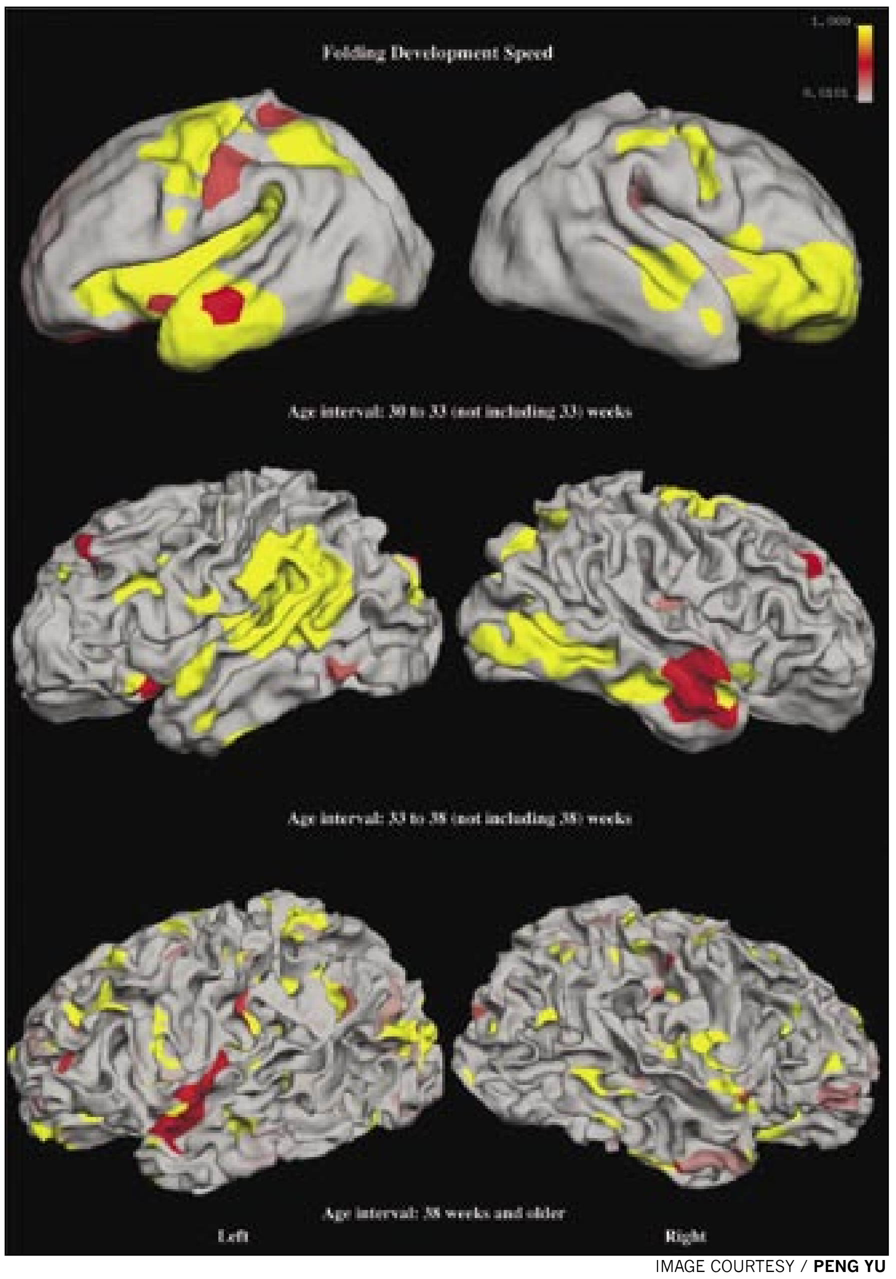
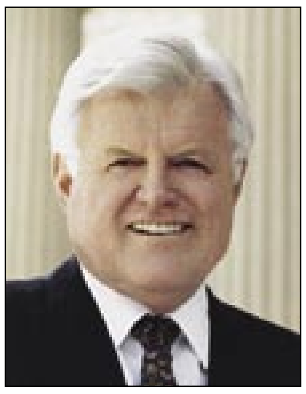


IMAGE COURTESY / **PENG YU**

Brain trust

New imaging tools show researchers how folds develop in the cerebral cortex. Larger-scale folds develop the fastest in premature infants born more than seven weeks early; medium-scale folds develop the fastest in infants born between seven and two weeks early. In older infants and children, fine folds develop the most quickly across the brain surface. See story on page 4.

Kennedy will deliver 2007 Compton Lecture



Edward M. Kennedy

Sen. Edward M. Kennedy, D-Mass., will deliver the 2007 Compton lecture April 13 at 2:30 p.m. in the Stata Center's Kirsch Auditorium.

Kennedy has represented Massachusetts in the U.S. Senate for 45 years. He was elected in 1962 to finish the final two years of the Senate term of his brother, Sen. John F. Kennedy, who was elected president in 1960. Since then, Kennedy has been re-elected to seven full terms and is now

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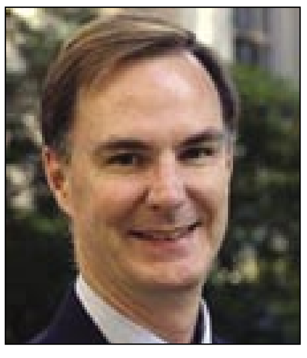
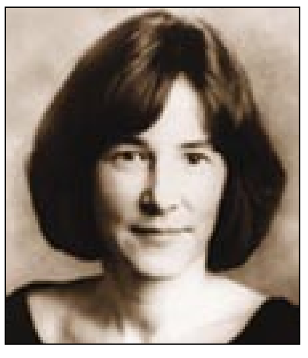
Five from MIT are Guggenheim Fellows

Five members of the MIT faculty have been awarded Guggenheim Fellowships for 2007. They are Edmund Bertschinger, astrophysics division head and professor of physics; Erica Funkhouser, poet and lecturer in the Program in Writing and Humanistic Studies; Michel X. Goemans, professor of applied mathematics; Erika Naginski, associate professor of the history of art; and Anne Whiston Spirn, professor of landscape architecture and planning.

Winners of the annual competition are selected on the basis of their "distinguished achievement in the past and exceptional promise for future accomplishment," from an applicant base of nearly 2,800 scientists, scholars and artists in fields ranging from the natural sciences to the creative arts.



Edmund Bertschinger



Erica Funkhouser

Bertschinger, a theoretical astrophysicist whose research interests focus on cosmology and relativistic astrophysics, uses "analytic methods and computer simulations to improve our understanding of the formation of cosmic structure after the big bang, the evolution of dark matter in galaxies and larger structures, and time variability in accretion disks around black holes and neutron stars," according to Guggenheim materials.

Funkhouser is the author of four collections of poetry, including "Pursuit" (Houghton Mifflin, 2002) and "Sure Shot and Other Poems" (1992). Her poems have been pub-

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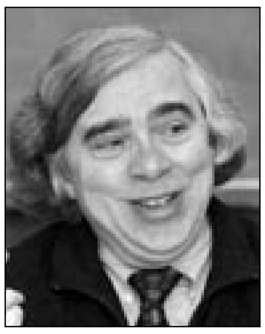
MIT-Cyprus program will focus on energy, environment, water

Deborah Halber
News Office Correspondent

Energy, environment and water are the focus of a new joint program between MIT and the Mediterranean island nation of Cyprus. The initiative will promote a high level of scientific research and education at a new university on Cyprus, which for millennia has been a crossroad of commerce, civilizations and cultures.



Ernest J. Moniz

The Cyprus Institute Program for Energy, Environment and Water Resources (CEEW) is a new research and education program established at MIT's Laboratory for Energy and the Environment (LFEE).

Its counterpart in Cyprus will be the Energy, Environment and Water Research Center (EEWRC) at the newly established Cyprus Institute (CyI), a university focused on undergraduate and graduate education and research in science, technology, arts and social sciences.

"The government of Cyprus is committed to turning the Cypriot economy into a knowledge-based economy and to rendering our island into a regional center of excellence for educational services," said Tassos Papadopoulos, president of the Republic of Cyprus, in a speech at the presidential palace Feb. 10. "The government's target is to make available government funds for research, reaching the EU level of 1 percent of GDP by 2010, of course with a corresponding contribution of the private sector."

Cyprus has been a member state of the European Union since 2004.

CyI is working on architectural plans for renovating a technical institute that is transitioning to a new location and building a new laboratory for EEWRC, the first of several centers to be housed at the new campus in Nicosia. "Through shared postdoctoral researchers, joint research projects and a graduate fellows program at LFEE, the CEEW program will build collaborative research and educational opportunities for both institutes," said Ernest J. Moniz, co-director of LFEE and director of the MIT Energy Initiative.

Joint efforts will include an annual international conference in Cyprus and Cyprus Fellows, a newly established fellowship program at LFEE for graduate students pursuing doctoral studies on energy science and technology, water resources and environmental issues.

The CEEW program will undertake research and education on issues of energy, environment and water from multiple technical and policy perspectives, concentrating on issues of relevance to Cyprus and the eastern Mediterranean. MIT's LFEE and the Alliance for Global Sustainability (AGS) are collaborating on the initial phase of the program.

The initiatives are the work of the recently created Cyprus Research and Educational Foundation (CREF) and the Cyprus Research Promotion Foundation.

In 2005 and 2006, AGS partnered with CREF to host international workshops on the implications of climate change for the eastern Mediterranean and on urban pollution.

Op-ed: Voters win with 'winner take all'

Deborah Halber
News Office Correspondent

If we want individuals and small groups to have the democratic power to elect the president fairly, we must score presidential elections by winner-take-all states—not in a single giant national district too large for small numbers to turn, said Alan Natapoff, a research scientist at MIT who has studied the mathematics of voting power and has testified before Congress concerning the Electoral College.

In an op-ed, "Stop plan to diminish Marylanders' voting power," that appeared April 5 in the Baltimore Sun, Natapoff urged Maryland Gov. Martin O'Malley not to sign a bill that, if passed by enough states, would bypass the Electoral College and elect the president by raw popular vote. Natapoff contends that the proposed legislation is unconstitutional and that the change would destroy the individual voter's national voting power.

"Small numbers of votes will never turn a national raw-vote election in our lifetime, yet a mere 537 votes in Florida turned the election of 2000," Natapoff wrote in the op-ed. "When close states vote on a winner-take-all basis, their individual voters have large national leverage. Without that leverage, we would all be equally impotent—an irony that would give equality a bad name."

Natapoff would count popular votes cast for any candidate vote-for-vote for the state's winner: If Florida casts six million votes for all the candidates, its winner should receive precisely six million electoral votes plus the popular-vote equivalent of two senatorial electoral votes—a quarter of the popular vote in the average state, or about half a million votes now.

"This system would empower voters in poorly contested states, who could withhold their vote from the state's winner by casting a blank ballot," Natapoff wrote. "The dominant candidate would need (acceptance from his opposition) or risk losing 40 percent of the state's electoral votes." It would give 80 million impotent voters in those states an immediate impact on presidential elections. It is the only basic change we need or dare make, he says.

Small states cancel each other in a close election. The greater coherence of large states under winner-take-all, Natapoff claims, gives them much greater national power per vote—in proportion to the square root of their size—than the same number of electoral votes in small states. That, he believes, is why senatorial electoral votes have worked for two centuries and are still needed.

In 2000, he says, California cast half as many popular votes, but had the same net electoral vote impact, as the 29 smallest states combined—even counting their 58 senatorial electoral votes. Without senatorial electoral votes, Natapoff says, small states will not have their fair share of voting power per vote. What is worse, he believes, eliminating senatorial votes without a Constitutional amendment breaks the promise of the Constitution (Article V) that no state will be deprived of them without its consent.

Jacobs receives Levitan Prize in the Humanities

Deborah K. Fitzgerald, the Kenan Sahin Dean of the School of Humanities, Arts, and Social Sciences, has announced that the 2007 James A. and Ruth Levitan Prize in the Humanities has been awarded to Associate Professor Meg Jacobs of the history faculty.

Meg Jacobs

Jacobs received her Ph.D. in history from the University of Virginia in 1998 and joined the MIT faculty as an assistant professor in 1999.

Jacobs will complete research for her book, "Panic at the Pump: How Conservatives Used the Energy Crisis to Start a Revolution." In "Panic," Jacobs will explain "how and why conservative reformers, from the young Dick Cheney and Donald Rumsfeld to Milton Friedman, Alan Greenspan, Irving Kristol and others used the energy crisis of the 1970s to launch a deliberate campaign to discredit the power of the federal government to regulate and revitalize the American economic life," she said.

Jacobs' 2005 book, "Pocketbook Politics: Economic Citizenship in Twentieth-Century America," analyzed how "reformers organized social movements to build the New Deal order. 'Panic at the Pump' will explore another age, when reformers, once again, mobilized citizens, but this time to dismantle the liberal state," she said.

The $25,000 Levitan prize was established through a gift from the late James A. Levitan, a 1945 MIT graduate in chemistry, who was also a member of the MIT Corporation and of-counsel at the law firm of Skadden, Arps, Slate, Meagher and Flom of New York City. The prize, first awarded in 1990, supports innovative and creative scholarship in the humanities by faculty members in the School of Humanities, Arts, and Social Sciences.

Navy's nuclear director will discuss national security

Adm. Kirkland Donald, the fourth highest-ranking U.S. Navy officer and director of the Navy's nuclear program, will talk about "Technical Education and National Security" at MIT on Wednesday, April 11.

Donald will address the MIT community at a one-hour seminar at 3 p.m. in NW14-1112. At 4 p.m., he will answer questions from Navy ROTC midshipmen.

Donald, director of naval nuclear propulsion, said that recent statistics reflect an erosion of America's scientific and technical base. "We lack the number of students in science and engineering disciplines to replenish our retiring and diminishing workforce," he said. "In 2004, China graduated over 600,000 engineers; India, 350,000; and America, about 70,000." Donald said that tens of thousands of construction and plant operation jobs will result from the resurgence of the commercial nuclear industry driven by global and domestic energy demands, but the United States may not be graduating enough engineers to fulfill the need.

The event is sponsored by the MIT section of the American Nuclear Society.

—Deborah Halber

OBITUARIES

Margaret Otto, former associate director of the MIT Libraries, died Dec. 10 of complications from colon cancer at her home in Hanover, N.H. She was 69.

Otto worked at the MIT Libraries from 1964 to 1979 and later became the first woman to head the Dartmouth College libraries. At MIT, she was assistant science librarian before becoming associate director.

Otto was born in Boston and graduated from Boston University in 1960 with a degree in English literature. She also earned two master's degrees from Simmons College, one in library science and one in English literature.

She is survived by two sons, Peter, of Salem, Ore., and Christopher, of Olympia, Wash.; a sister, Joan Sergi of Sudbury, Mass.; and two grandsons.

A memorial service was held in December at St. Thomas Episcopal Church in Hanover, N.H.

Richard E. Dean Sr. of Braintree, a retired employee of Lincoln Laboratory, died Dec. 6.

Dean was a member of the MIT Quarter Century Club and was a veteran of the Korean War.

The husband of the late Lorraine P. (Conway) Dean, he is survived by two sons, Richard Dean Jr. of Braintree and Stephen Dean of Weymouth; five daughters, Mary Patts, Janice Martini and Carol Ritz of Braintree, Lorraine Patts of Quincy and Nancy Burke of Pembroke; a sister, Marilyn English of Woburn; 13 grandchildren; three great-grandchildren and many nieces and nephews.

Donations may be made to the American Legion Child Welfare Foundation, P.O. Box 1055, Indianapolis, IN 46206.

KENNEDY

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the second most senior member of the Senate.

Kennedy, who was invited to MIT by President Susan Hockfield, will speak on "A Life in Public Service."

The Karl Taylor Compton Lecture Series was established in 1957 to honor the late Karl Taylor Compton, who served as president of MIT from 1930-48 and chair of the Corporation from 1948-54. The purpose of the lectureship is to give the MIT community direct contact with the important ideas of our times and with people who have contributed much to modern thought.

This event in the series is sponsored by the MIT Information Center and the Office of the President.

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MIT hosts events for Cambridge Science Festival

Selections from a computer graphics animation festival and a Charles River demonstration of an autonomous underwater vehicle are among the MIT-hosted events during the first-of-its-kind Cambridge Science Festival, April 21-29.

Presented by the MIT Museum, the festival features more than 150 events throughout the city geared toward highlighting the excitement of science. Events from April 21-23 include:

April 21, 9 a.m.-12 p.m.
Professional Development Workshop
A workshop for teachers on the latest genome research.

April 21, 10 a.m.-4 p.m.
MIT's Environmental Health and Safety Office Open House
Bring in water samples for lead testing.

April 21-22, 28-29, 12-6 p.m.
COLLISIONeleven
An experimental art show involving kinetic sculptures, light art, interactive videos, robots and more in the Stata Center.

April 21, 9:30 a.m.-12 p.m. and 1-3:30 p.m.
Augmented Reality
Adult-child teams will be assigned a role in a game simulating a mysterious environmental problem on the MIT campus.

April 22, 1 p.m.
Rocks from Mars! Rocks from the Moon!
Can we learn from Mars and moon rocks?

April 22, 6-8 p.m.
Cold Enough for You?
Find out how the Antarctic ice sheet has behaved for 10 million years and see a model for how it will behave in the future.

April 23, 10 a.m.-3 p.m.
Robots on the River
MIT Sea Grant program demonstrates autonomous underwater vehicles in the Charles River.

April 24, 6-9 p.m.
The Science of Wine
Find out what's behind the new findings about the anti-aging properties of red wine derivatives while sipping carefully chosen vintages.

For more information on the Cambridge Science Festival and a complete listing of events and locations, visit www.cambridgesciencefestival.com.

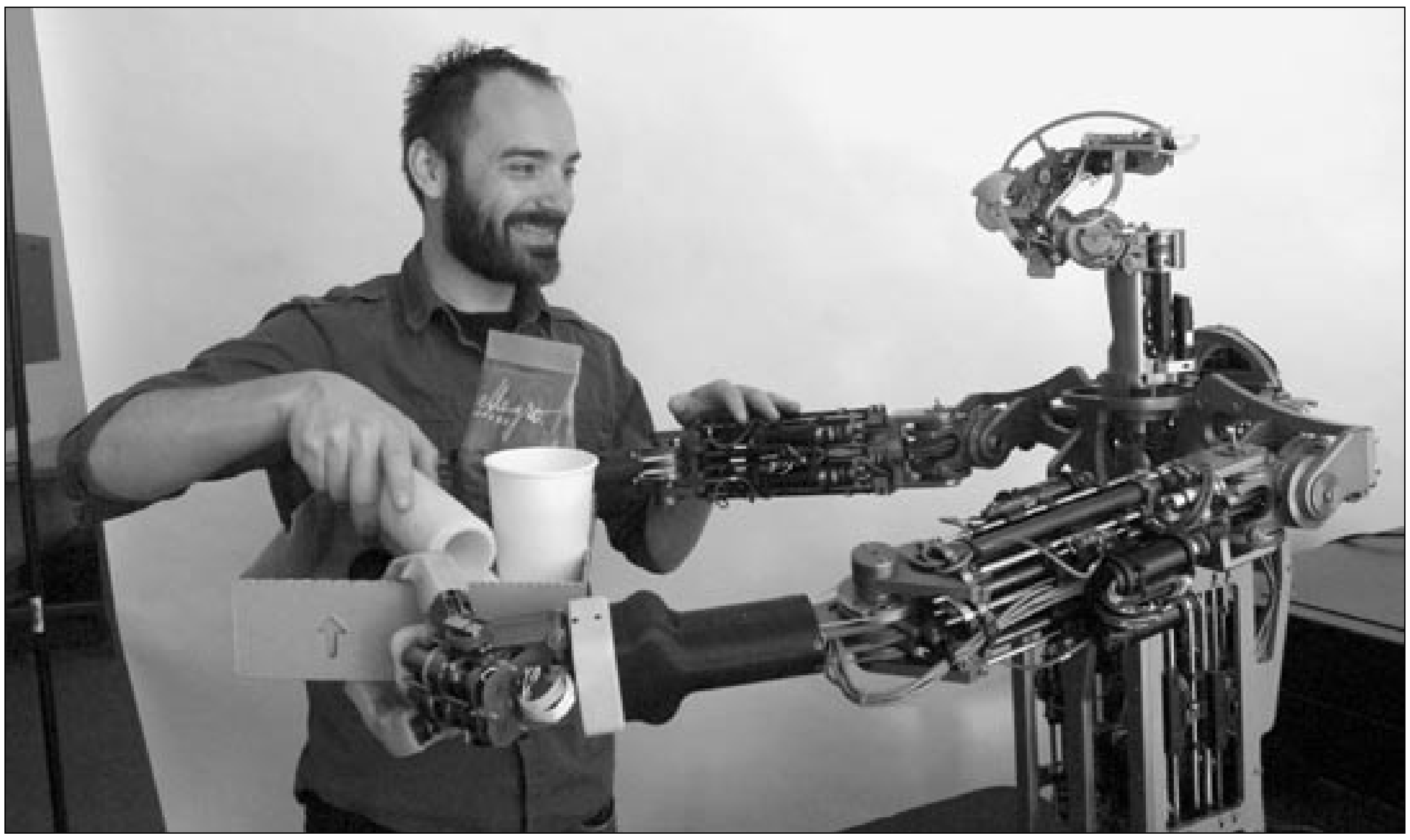

PHOTO / DONNA COVENEY

Postdoctoral associate Aaron Edsinger puts objects in a box held out to him by robot Domo, in his lab at CSAIL.

Assistive robot responds to faces, new places

Anne Trafton
News Office

In the futuristic cartoon series "The Jetsons," a robotic maid named Rosie whizzed around the Jetsons' home doing household chores—cleaning, cooking dinner and washing dishes.

Such a vision of robotic housekeeping is likely decades away from becoming reality. But at MIT, researchers are working on a very early version of such intelligent robotic helpers—a humanoid called Domo who can grasp objects and place them on shelves or counters.

A robot like Domo could help elderly or wheelchair-bound people with simple household tasks like putting away dishes. Other potential applications include agriculture, space travel and assisting workers on an assembly line, says Aaron Edsinger, an MIT postdoctoral associate who has been working on Domo for the last three years.

Edsinger describes Domo as the "next generation" of earlier robots built at MIT—Kismet, which was designed to interact with humans, and Cog, which could learn to manipulate unknown objects. Domo incorporates elements of both of those robots.

"The real potential of robots in the future is going to be realized when they can do many types of manual tasks," including those that require interaction with humans, Edsinger said.

> **Of human-robot bondage**
>
> As part of the Cambridge Science Festival, MIT professors Rodney Brooks and Sherry Turkle will discuss human-machine relations on a panel moderated by MIT artist-in-residence Pia Lindman at the MIT Museum on Tuesday, April 24 from 2 to 4 p.m.

There are now plenty of robots doing manual work on factory assembly lines, but those machines follow a script and can't learn to adapt to new situations, as Domo can, said Rodney Brooks, director of MIT's Computer Science and Artificial Intelligence Laboratory.

"Robots in an automobile factory manipulate objects, but they do the same thing, along the same path, every time," Brooks said. "If robots are ever going to be truly useful, they need to be able to manipulate the objects we manipulate."

Living in the real world

Edsinger's team, overseen by Brooks, decided to focus on making a robot that can function in a real human environment—in someone's kitchen, for example. Robots that are designed to help people in their homes will have to be able to ignore the clutter found in most environments and focus only on certain stimuli, says Edsinger.

"Typically robots are placed in very restricted worlds because then you can control the environment. If you put a robot in someone's home, that approach just doesn't extend to that," he said. "We want the robot to adapt to the world, not the world to adapt to the robot."

Perched on a table in Edsinger's workspace, Domo can "see" everything going

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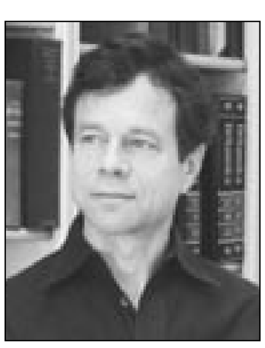
'Einstein's Dreams' opens at Broad Institute auditorium

The Catalyst Collaborative at MIT (CC@MIT), a collaboration of MIT and the Underground Railway Theater, will present its first fully staged production, "Einstein's Dreams," a dramatization of the 1992 novel by Alan Lightman, MIT physicist and adjunct professor of humanities. It was adapted for the stage by David Alford and Brian Niece.



Alan Lightman

The production is being presented as part of the MIT Museum's inaugural Cambridge Science Festival (April 21-29), a celebration of the impact of science and technology on our lives.

Performances of "Einstein's Dreams" begin Thursday, April 19, at MIT's Broad Institute auditorium, 7 Cambridge Center, and run through Sunday, April 29.

Directed by Wes Savick, the production will feature Boston actors Robert Najarian (Albert Einstein), Steven Barkhimer and Debra Wise.

Postperformance discussions will feature an array of prominent artists and scientists, including Alan Lightman; John Durant, director of the MIT Museum; Claude Canizares, professor of physics and vice president for research; Jerome Friedman, professor of physics and 1990 Nobel laureate; Alan Guth, the V.F. Weisskopf Professor of Physics; and Paula Apsell, executive producer, NOVA, and director of the WGBH science unit.

Tickets are $18 general admission or $12 for students and seniors and will be available starting March 26 at the Cambridge Science Festival. The show is recommended for ages 10 and older.

Student science policy initiative focuses on leadership, public service

The second annual MIT Science Policy Bootcamp—an outgrowth of a student-led initiative to get scientists, engineers and public policy-makers to talk to one another—will be held April 13-16. This class for undergraduates and graduate students, funded by the Office of the Dean for Student Life, will feature a panel discussion with congressional staffers.

Bill Bonvillian

At an event last spring for women graduate students, MIT graduate student Alicia Jackson spoke with MIT President Susan Hockfield about the need for young scientists to be involved in science policy at a national level. Their conversation led to the first-ever MIT Science Policy Bootcamp, an intensive five-day seminar for 25 MIT graduate students taught by MIT Washington Office Director Bill Bonvillian.

Bonvillian worked in the U.S. Senate for more than 15 years before coming to MIT. "Federal support for science and technology is not on autopilot," he said. "If this support is to continue and grow, the next generation of scientists and engineers will need to learn how to work in the public policy arena. MIT historically has provided leadership in this area, and this course is an attempt by President Hockfield to start to grow that effort."

The Science Policy Initiative has two thrusts: to educate participants on the science and innovation infrastructure, which includes the organizational framework between U.S. science agencies, the DARPA model and the drivers behind science and technology innovation systems theory; plus proactive training in Congressional advocacy. With support from the Department of Materials Science and Engineering and the MIT Public Service Center, MIT students attended Congressional Visits Day (CVD) in March. CVD is an annual event where scientists and engineers convene on Capitol Hill to discuss policy issues and participate in the legislative process. Twenty additional MIT students plan to travel to Washington May 1-2 for a second round of congressional visits.

Looking ahead, the group is collaborating with the leadership in public service speaker series sponsored by the dean of student life. Bringing notable persons to campus will allow students in the MIT community to actively engage with leaders in the public and government service arena, preparing students to be better citizens and public servants, Bonvillian said.

Supercooling may yield view of quantum effects

Anne Trafton
News Office

Using a laser-cooling technique that could one day allow scientists to observe quantum behavior in large objects, MIT researchers have cooled a coin-sized object to within one degree of absolute zero.

This study marks the coldest temperature ever reached by laser-cooling of an object of that size, and the technique holds promise that it will experimentally confirm, for the first time, that large objects obey the laws of quantum mechanics just as atoms do.

Although the research team has not yet achieved temperatures low enough to observe quantum effects, "the most important thing is that we have found a technique that could allow us to get (large objects) to ultimately show their quantum behavior for the first time," said MIT assistant professor of physics Nergis Mavalvala, leader of the team.

The MIT researchers and colleagues at Caltech and the Albert Einstein Institute in Germany will report their findings in an upcoming issue of Physical Review Letters.

Quantum theory was developed in the early 20th century to account for unexpected atomic behavior that could not be explained by classical mechanics. But at larger scales, objects' heat and motion blur out quantum effects, and interactions are ruled by classical mechanics, including gravitational forces and electromagnetism.

"You always learn in high school physics that large objects don't behave according to quantum mechanics because they're just too hot, and the thermal energy obscures their quantum behavior," said Thomas Corbitt, an MIT graduate student in physics and lead author of the paper. "Nobody's demonstrated quantum mechanics at that kind of (macroscopic) scale."

To see quantum effects in large objects, they must be cooled to near absolute zero. Such low temperatures can only be reached by keeping objects as motionless as possible. At absolute zero (0 degrees Kelvin, -273 degrees Celsius or -460 degrees Fahrenheit), atoms lose all thermal energy and have only their quantum motion.

In their upcoming paper, the researchers report that they lowered the temperature of a dime-sized mirror to 0.8 degrees Kelvin. At that temperature, the 1 gram mirror moves so slowly that it would take 13 billion years (the age of the universe) to circle the Earth, said Mavalvala, whose group is part of MIT's LIGO (Laser Interferometer Gravitational-wave Observatory) Laboratory.

The team continues to refine the technique and has subsequently achieved much lower temperatures. But in order to observe quantum behavior in an object of that size, the researchers need to attain a temperature that is still many orders of magnitude colder, Mavalvala said.

To reach such extreme temperatures, the researchers are combining two previously demonstrated techniques—optical trapping and optical damping. Two laser beams strike the suspended mirror, one to trap the mirror in place, as a spring would (by restoring the object to its equilibrium position when it moves), and one to slow (or damp) the object and take away its thermal energy.

Combined, the two lasers generate a powerful force—stronger than a diamond rod of the same shape and size as the laser beams—that reduces the motion of the object to near nothing.

Using light to hold the mirror in place avoids the problems raised by confining it with another object, such as a spring, Mavalvala said. Mechanical springs are made of atoms that have their own thermal energy and thus would interfere with cooling.

As the researchers get closer and closer to reaching the cold temperature they need to see quantum behavior, it will get more difficult to reach the final goal,

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PHOTO / DONNA COVENEY

Assistant Professor Nergis Mavalvala, left, and Ph.D. student Thomas Corbitt are part of an international team that has devised a way to cool large objects to near absolute zero.

Model helps researchers 'see' brain development

Work could facilitate early detection of autism

Elizabeth Dougherty
Harvard-MIT Division of
Health Sciences and Technology

Large mammals—humans, monkeys and even cats—have brains with a somewhat mysterious feature: The outermost layer has a folded surface. Understanding the functional significance of these folds is one of the big open questions in neuroscience.

Now a team led by MIT, Massachusetts General Hospital and Harvard Medical School researchers has developed a tool that could aid such studies by helping researchers "see" how those folds develop and decay in the cerebral cortex.

By applying computer graphics techniques to brain images collected using magnetic resonance (MR) imaging, they have created a set of tools for tracking and measuring these folds over time. Their resulting model of cortical development may serve as a biomarker, or biological indicator, for early diagnosis of neurological disorders such as autism.

The researchers describe their model and analysis in the April issue of IEEE Transactions on Medical Imaging.

Peng Yu, a graduate student in the Harvard-MIT Division of Health Sciences and Technology (HST), is first author on the paper. The work was led by coauthor Bruce Fischl, associate professor of radiology at Harvard Medical School, research affiliate with the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL) and HST, and director of the computational core at the HST Martinos Center for Biomedical Imaging at Massachusetts General Hospital (MGH).

The team started with a collection of MR images from 11 developing brains, provided by Ellen Grant, chief of pediatric radiology at MGH and the Martinos Center. Of the subjects scanned, eight were newborn, mostly premature babies ranging from about 30 to 40 weeks of gestational age, and three were from children aged two, three and seven years. Grant scanned these infants and children to assess possible brain injury and found no neural defects. Later, she also consulted with Fischl's team to ensure that their analyses made sense clinically.

"We can't open the brain and see by eye, but the cool thing we can do now is see through the MR machine," a technology that is much safer than earlier techniques such as X-ray imaging, said Yu.

The first step in analyzing these images is to align their common anatomical structures, such as the "central sulcus," a fold that separates the motor cortex from the somatosensory cortex. Yu applied a technique developed by Fischl to perform this alignment.

The second step involves modeling the folds of the brain mathematically in a way that allows the researchers to analyze their changes over time and space.

The original brain scan is then represented computationally with points. Charting each baby's brain requires about 130,000 points per hemisphere. Yu decomposed these points into a representation using just 42 points that shows only the coarsest folds. By adding more points, she created increasingly finer-grained domains

See BRAIN
Page 6

MIT Darwin Project will model ocean microbes

Matthew Gardner
Earth System Initiative

A new program to develop computational models of how marine microbes live and evolve in the global ocean has been launched with a $3.7 million gift from the Gordon and Betty Moore Foundation.

The program is important because it will help researchers understand and simulate the relationships between climate change, marine ecosystems and the ocean carbon cycle.

In the March 30 issue of Science, an MIT team describes the first of these models.

The MIT Darwin Project is developing novel computer models of marine microbial communities in which a diverse range of organisms are explicitly represented. In these models, ecosystem structure is an emergent property determined by the relative fitness of the simulated organisms in specific physical, chemical and predatory environments.

The modeled ecosystem self-organizes in an analogy of natural selection.

The MIT Darwin Project is a collaboration between affiliates of the Earth System Initiative (ESI) and the Computational and Systems Biology Initiative (CSBi). It is a new model for cross-disciplinary research at MIT, connecting systems biology, microbial ecology, global biogeochemical cycles and climate.

Principal investigator Michael Follows, a principal research scientist in the Department of Earth, Atmospheric and Planetary Sciences, was inspired to develop this approach after hearing Professor Penny Chisholm present her genomic studies of phytoplankton at an ESI retreat. Chisholm is the Lee and Geraldine Martin Professor of Environmental Studies in the

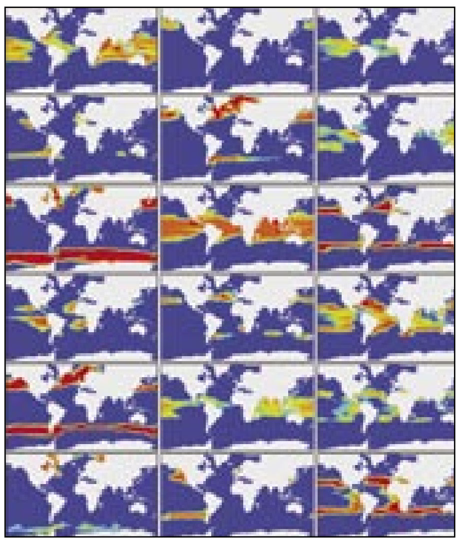


FIGURE / STEPHANIE DUTKIEWICZ

Image above shows the emergent ocean ecosystem community structure. The phytoplankton community is organized according to relative fitness in the physical, chemical and predatory environment.

Departments of Civil and Environmental Engineering and Biology.

Chisholm's group monitors the abundance and variations of phytoplankton prochlorococcus in the world's oceans. Her team has identified fine-scale genetic variants at the subspecies level that also have distinct oceanic distributions and physiological attributes.

"We face a significant challenge in trying to understand and simulate the relationships between climate change, marine ecosystems and the ocean carbon cycle. These new observations and models can

See DARWIN
Page 6

TechTV launches with 'video shootout'

Images of the 2.007 design contest, working on a housing redevelopment plan for New Orleans or building a nacho-cheese fountain in a dorm could all be winners among videos MIT students will enter in the Tech Video Shootout, a contest that will use a new offering at the Institute: MIT TechTV, a YouTube-like pilot web site currently under development.

Students should submit short videos about science and engineering that are fun, informative or inspiring. The first 100 contestants who submit a video will receive a $5 coupon to Anna's Taqueria or Dunkin' Donuts. Any enrolled MIT student may enter the contest by registering at the contest web site, mit.edu/techtv/contest/.

Dean of Engineering Thomas L. Magnanti will present "TechAdemy Awards" to the contest winners on April 30 at 5 p.m. Individuals and teams that submit the top-placing entries will receive prizes, along with others who will receive honorable mentions.

Magnanti stressed that the contest is more about fun than production values. "Students shouldn't be concerned with making their videos look polished—they can use their digital cameras and even their cell phones to shoot video. It's the quality of the content that is important."

Students shouldn't be concerned with making their videos look polished–they can use their digital cameras and even their cell phones to shoot video.

Thomas L. Magnanti
Dean of Engineering

Also under development is the first web "channel" on MIT TechTV. That channel will focus on generating interest in science and engineering among seventh- through ninth-graders nationwide, particularly girls and underrepresented minorities.

Sponsored by the School of Engineering, the contest began on April 10 with a kickoff event in the Mezzanine Lounge. Contestants will be able to upload their videos to the TechTV web site as soon as it goes into "soft launch" on April 20; the deadline for submissions is April 23 at 5 p.m. MIT TechTV will be an interactive web site for uploading and viewing multimedia by students, faculty, staff, alumni and other members of the MIT community—particularly videos about science, engineering and technology.

The MIT community is invited to go to the MIT TechTV web site to vote on the contest entries beginning April 24. These votes, along with those of a panel of judges, will determine the winners, who will be announced at the TechAdemy Awards ceremony.

The School of Engineering, in partnership with Academic Media Production Services, is sponsoring the Tech Video Shootout. For more information on the contest, go to mit.edu/techtv/contest/.

High-resolution images herald new era in Earth sciences

Deborah Halber
News Office Correspondent

High-resolution images that reveal unexpected details of the Earth's internal structure are among the results reported by MIT and Purdue scientists in the March 30 issue of Science.

The researchers adapted technology developed for near-surface exploration of reservoirs of oil and gas to image the core-mantle boundary some 2,900 kilometers, or 1,800 miles, beneath Central and North America.

"Rather than depth, it's the resolution and lateral scale that are unique in this work," said lead author Robert van der Hilst, professor of earth, atmospheric and planetary sciences (EAPS) and director of MIT's Earth Resources Laboratory. "This could lead to a new era in seismology and all the other deep Earth sciences. In addition, our new expertise may be able to improve how we look for oil in or beneath geologically complex structures such as the Gulf of Mexico salt domes," he said.

The technique—akin to medical imaging such as ultrasounds and CAT scans—led to detailed new images of the boundary between the Earth's core and mantle. These images, in turn, help researchers better understand how and where the Earth's internal heat is produced and how it is transported to the surface. They also provide insight into the Earth's giant heat engine—a constant cycle of heat production, heat transfer and cooling.

The Earth is made up of the outermost rocky crust, which is around 40 kilometers deep; iron and magnesium silicates of the upper and lower mantles; and the liquid outer core and solid inner core.

Scientists have long assumed that the lower mantle is relatively featureless. But more detailed views have indicated that there is more complexity than expected. "I expect that the Earth is full of such surprises, and with these new imaging technologies and data sets, we have only just begun to scratch the surface of possibilities afforded by modern data sets,"

See **MANTLE**
Page 6

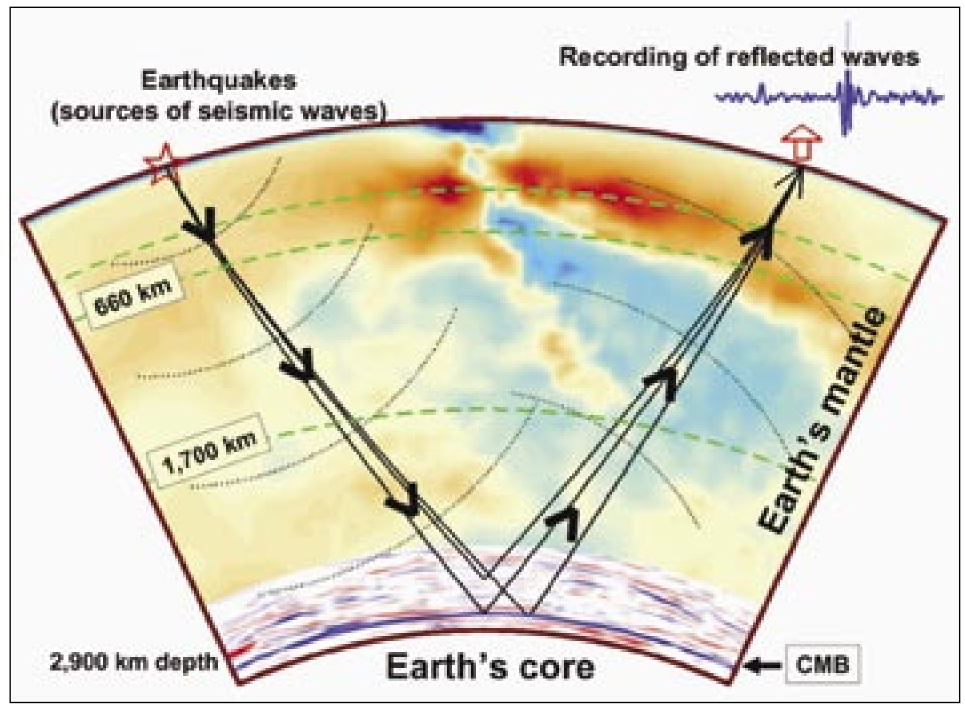


IMAGE COURTESY / **ROBERT VAN DER HILST, MIT**

Seismic waves from earthquakes penetrate the Earth's mantle and scatter back at the core-mantle boundary to detectors on the surface. Nearly 100,000 such recordings are used to illuminate the planet's deep internal structures.

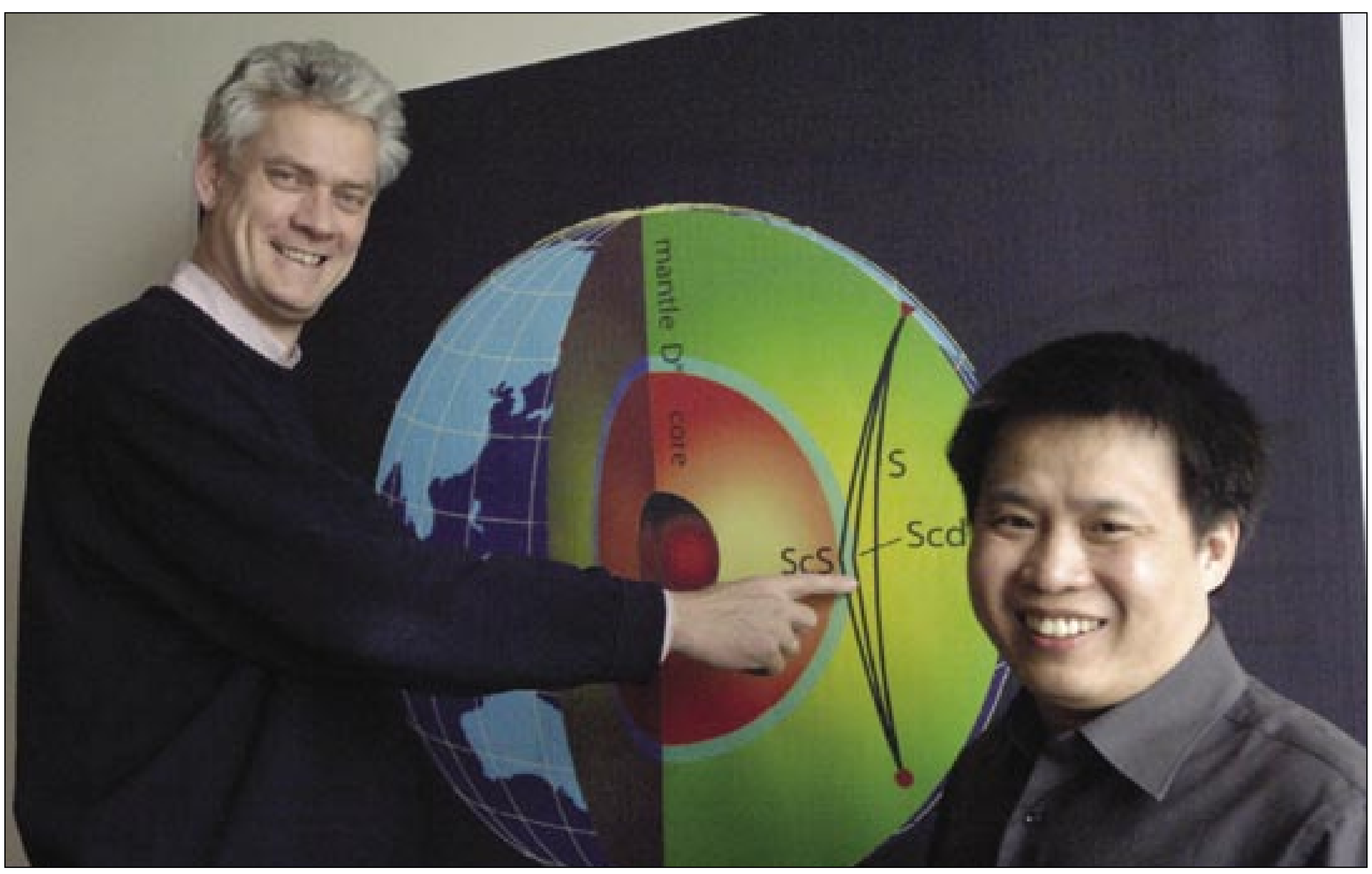


PHOTO / **DONNA COVENEY**

Professor Robert van der Hilst, left, and graduate student Ping Wang of the MIT Department of Earth, Atmospheric and Planetary Sciences, are adapting technology developed for near-surface exploration of hydrocarbon reservoirs to image the core-mantle boundary deep beneath Central and North America.

PHOTO / **DAVID HILL**

Three MIT students, senior Brian Jacokes, junior Eric Price and senior Hubert Hwang compete in the Association for Computing Machinery International Collegiate Programming Finals held in March. The team won fourth place overall out of 88 teams.

MIT programmers strike gold

A team of MIT programmers won a gold medal in the world finals of the 31st Association for Computing Machinery International Collegiate Programming Contest, held mid-March in Tokyo.

Overall, the MIT team placed fourth among the 88 teams from all over the world that qualified for the ACM-ICPC world finals, which are sponsored by IBM. The 88 teams were selected from more than 6,000 teams, representing 1,756 universities, that participated in the regional competitions last fall. MIT's team of Brian Jacokes, Hubert Hwang and Eric Price was one of only 20 U.S. teams that made it to the finals. The MIT team was coached by Professor Martin Rinard of electrical engineering and computer science and by student coaches Jelani Nelson, Daniel Dumitran and Ivo Riskov, and was supported by staff member Mary McDavitt.

Each team of three students was challenged to solve 10 complex, real-world computer programming problem—such as improving the efficiency of the baggage claim process at airports and decreasing the time it takes to load cargo ships traveling overseas—under intense deadline pressure. The teams were awarded medals based on the number of problems they solved in the shortest amount of time.

The world champion team came from Warsaw University, followed by Tsinghau University in second place and St. Petersburg University of IT, Mechanics and Optics in third place. In 2006, an MIT team won a silver medal (8th place) in the competition.

"These superstars will extend society's ability to address challenges, strengthening and improving the world of tomorrow," said Bill Poucher, ICPC executive director and Baylor University professor. "They are team players who will make a difference by enhancing the avenues we use to interact with each other."

—Stephanie Schorow

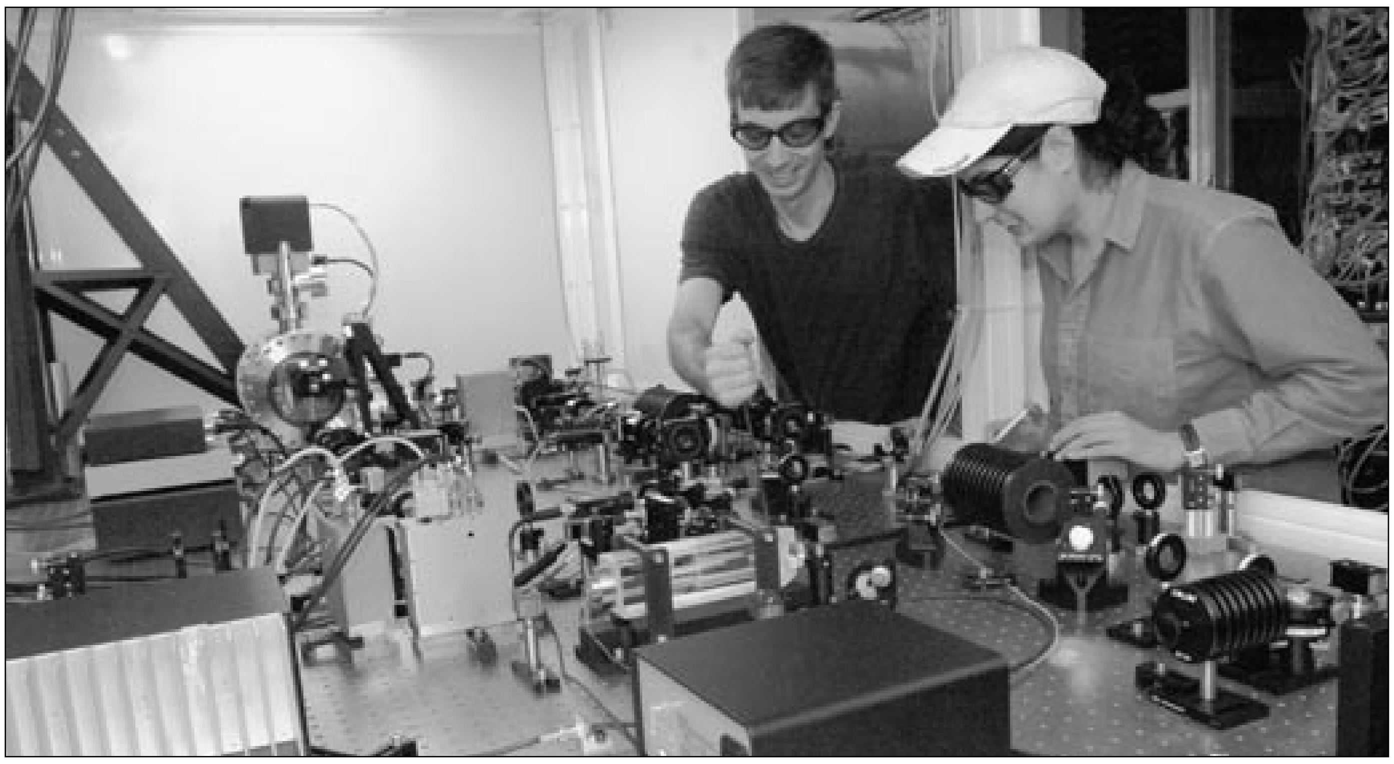


PHOTO / DONNA COVENEY

Assistant Professor Nergis Mavalvala, right, and Ph.D. student Thomas Corbitt look over the laser system they use to cool a coin-sized mirror to within one degree of absolute zero.

SUPERCOOL

Continued from Page 4

Mavalvala predicted. Several technical issues still stand in the way, such as interference from fluctuations in the laser frequency.

"That last factor of 100 will be heroic," she said.

Once the objects get cold enough, quantum effects such as squeezed state generation, quantum information storage and quantum entanglement between the light and the mirror should be observable, Mavalvala said.

Other authors on the paper are Christopher Wipf, MIT graduate student in physics; David Ottaway, research scientist at MIT LIGO; Edith Innerhofer (formerly a postdoctoral fellow at MIT); Yanbei Chen, leader of the Max Planck (Albert Einstein Institute) group; Helge Muller-Ebhardt and Henning Rehbein, graduate students at the Albert Einstein Institute; and research scientists Daniel Sigg of LIGO Hanford Observatory and Stanley Whitcomb of Caltech.

The research was funded by the National Science Foundation and the German Federal Ministry of Education and Research.

MANTLE

Continued from Page 5

van der Hilst said.

Deeply propagating waves generated by large earthquakes hit the core-mantle boundary and bounce back—as if from a mirror—to the Earth's surface.

Each time one of these waves hits an underground structure, it emits a weak signal. "With enough data, we can detect and interpret this signal," van der Hilst said. Using data from thousands of earthquakes recorded at more than 1,000 seismic observatories, an interdisciplinary team of earth scientists and mineral physicists led by van der Hilst pinpointed the details of deep earth structures. The cross-disciplinary study involved seismologists, mathematicians, statisticians and mineral physicists from the University of Illinois and Colorado School of Mines in addition to MIT and Purdue.

The imaging technique was introduced 20 years ago as a powerful tool for finding subsurface reservoirs of gas or oil. Meanwhile, over the past decades, large arrays of seismometers have been installed at many places in the world for research on earthquakes and the Earth's interior. "It is now possible to begin applying techniques developed by the oil industry to these large earthquake databases," van der Hilst said.

The idea for the research reported in Science was born over breakfast in a Cambridge, Mass., Au Bon Pain some five years ago, when Maarten de Hoop, an applied mathematician at Purdue University, and van der Hilst realized that they might be able to pair up the industry tools and the earthquake data to study the core-mantle boundary.

Years of work by Ping Wang, EAPS graduate student at MIT, led to the possibility for high-resolution imaging, and in collaboration with EAPS mineral physicist Dan Shim, the team produced maps of temperature and heat flow some 3,000 kilometers below the Earth's surface, using the data to provide a kind of "seismothermometer" of the Earth's temperature at extreme depths.

No one has ever seen the turbulently swirling liquid iron of the outer core meeting the silicate rock of the mantle—10 times as far below ground as the International Space Station is above—but the cross-disciplinary study led the researchers to estimate the temperature there is a white-hot 3,700 degrees Celsius.

They hope to apply the techniques to image an even more remote boundary of the inner core close to the center of the Earth.

This work was supported by the National Science Foundation.

SUPERHEROES

Continued from Page 1

electrical wires, says correctly that electrocution shouldn't be a problem unless they are grounded by the wooden pole. It would be difficult, but you could potentially make a locomotive into a giant electromagnet. A superhero capable of traveling at super speed catching a bullet in his hand is a "beautiful illustration of relativity," according to Kakalios.

Just the idea of learning math and science from a comic book is disarming enough to make even the most math-phobic willing to give it a try. And while not all Kakalios's students will become physicists, he pointed out that as future voters, they should have the background to make better decisions about funding for science and technology.

When the Green Goblin kidnapped Spiderman's girlfriend, Gwen Stacey, and pushed her from the George Washington Bridge to her death, the debate raged in comic book circles for years: Was it the fall that killed her or Spidey's attempt to save her by catching her in webbing mid-fall, causing her neck to snap?

If Gwen has a mass of 50 kilograms, falls 300 feet and acquires a velocity of 95 mph, there would be 10g of force on her body, which she could potentially survive. But stopping short against all that force in half a second would certainly break her neck, as the Green Goblin declared in a later issue after Kakalios was widely quoted making the same calculation. "If I can teach a homicidal maniac like the Green Goblin about forces and motion, I'm making a difference," he said.

BRAIN

Continued from Page 4

of smaller, higher-resolution folds.

Finally, Yu modeled biological growth using a technique recommended by Grant that allowed her to identify the age at which each type of fold, coarse or fine, developed, and how quickly.

She found that the coarse folds, equivalent to the largest folds in a crumpled piece of paper, develop earlier and more slowly than fine-grained folds.

In addition to providing insights into cortical development, the team is now comparing the images to those being collected from patients with autism. "We now have some idea of what normal development looks like. The next step is to see if we can detect abnormal development in diseases like autism by looking at folding differences," said Fischl. This tool may also be used to shed light on other neurological diseases such as schizophrenia and Alzheimer's disease.

> This tool may also be used to shed light on other neurological diseases.

In addition to Yu, Grant and Fischl, co-authors on the paper are postdoctoral associate Yuan Qi and Assistant Professor Polina Golland of CSAIL (Golland also holds an appointment in MIT's Department of Electrical Engineering and Computer Science); Xiao Han of CMS Inc.; Florent Segonne of Certis Laboratory; Rudolph Pienaar, Evelina Busa, Jenni Pacheco and Nikos Makris of the Martinos Center; and Randy L. Buckner of Harvard University and the Martinos Center.

The research was supported by the National Center for Research Resources, the National Institutes of Health, the Washington University Alzheimer's Disease Research Center, and the Mental Illness and Neuroscience Discovery (MIND) Institute. It is part of the National Alliance for Medical Image Computing, funded by the National Institutes of Health.

Long-term care enrollment ends April 27

MIT Benefits has announced a new enrollment period for long-term care insurance. Eligible, actively-at-work employees can enroll in long-term care insurance between March 26 and April 27, without having to answer any health questions.

This insurance can help provide protection against the high costs of long-term care that can result from the effects of aging, illness or a serious accident. All eligible employees and their eligible family members can apply for this insurance. Family members will need to establish proof of good health before being accepted into the program. Spouses or spousal equivalents have a simplified underwriting process during this period.

MIT employees will have the chance to learn more about this benefit by attending a presentation scheduled on campus, stopping by during a question and answer session, attending a live "webinar" or viewing a prerecorded webinar. For a presentation and webinar schedule, visit mit.jhancock.com/longtermcare/mit/meeting.html (username: mit; password: jhancock).

For more information please contact John Hancock at 1-888-453-2030 or gltc@jhancock.com. You can also visit the MIT long-term care web site at mit.jhancock.com (username: mit; password: jhancock).

DARWIN

Continued from Page 4

help to do so," said Follows.

Modeling the regulation of global elemental cycles by marine microbial communities requires a detailed understanding of the physical and chemical environment, the molecular and cellular scale processes that dictate the response of an individual cell to that environment, and the organization of communities of organisms within that environment.

"The Darwin Project is the place where all these things meet. The understanding of the biologist and the ecologist merges with the geochemist and the physical oceanographer and it is exciting to develop a framework in which that can happen," Follows said.

Said MIT Professor Bruce Tidor, "The Darwin Project integrates measurement, mechanism and understanding across a vast range of scales using models to connect underlying processes. It is as much a study in how to leverage new knowledge and understanding as it is a study of the relationships among marine microbes, ocean circulation and global biogeochemical cycles."

Tidor has appointments in the Department of Electrical Engineering and Computer Science and the Biological Engineering Division, and he is the co-director for education, outreach and community for CSBi.

Chisholm is equally excited about the project, noting that it represents the type of project that ESI was designed to foster. "It is extreme cross-scale, multidisciplinary research—from genomes to biomes—that would not be easily launched within traditional departmental boundaries," she says.

In addition to Follows and Tidor, the Darwin Project team also includes marine microbiologist Ed Delong from the Biological Engineering Division and the Department of Civil and Environmental Engineering, and oceanographers John Marshall, Chris Hill and Stephanie Dutkiewicz from the Department of Earth, Atmospheric and Planetary Sciences.

The Gordon and Betty Moore Foundation gift will fund new postdoctoral scientists and graduate students to help develop the models of microbes in the world's oceans. It will also fund new computing infrastructure to support these activities, including a new parallel processing computational cluster, a massive data storage system, a room-sized data visualization facility and a connection for MIT to the National Lambda Rail, a nationwide high-speed fiber optic data network.

'Last Mughal' author discusses Great Mutiny's toll

Robin H. Ray
News Office Correspondent

Despite the vacation-week lull, more than 125 students, faculty and visitors came to hear renowned travel writer and historian William Dalrymple discuss his latest book. "The Last Mughal: The Fall of a Dynasty, Delhi, 1857" (Knopf, $30) is a dynamic narrative of the final flowering and violent end of the last Mughal imperial court, that of Bahadur Shah Zafar II. The lecture, discussion and reception—complete with hot samosas—was co-sponsored by the Indo-American Arts Council and MIT's Program in Writing and Humanistic Studies.

Tuli Banerjee, lecturer in the foreign languages and literature section, introduced the speaker. "I've been teaching William in bits and pieces for years, sometimes essays, sometimes whole books," she said, including his popular "City of Djinns: A Year in Delhi." Dalrymple's other work includes a prize-winning first novel, "In Xanadu," and "White Mughals: Love and Betrayal in Eighteenth-Century England."


Bahadur Shah Zafar II

Dalrymple, who lives in Delhi with his family, pieced together the story of India's last emperor and the Great Mutiny that spelled his doom from a trove of 20,000 documents, called the Mutiny Papers, which have languished with little scholarly attention at the National Archives of India since the 1920s. He discovered in Zafar a man of discerning taste, a poet and calligrapher who attracted artists and intellectuals to his court, in an empire that had "contracted to the walls of the Red Fort of Delhi."

Zafar had the ill luck to rule at the confluence of two historical currents: a surge in British power that left it suddenly in control of all of India, and a wave of evangelism, in which English missionaries, with the connivance of the British East India Company (EIC), posed a rising threat to India's Muslims and Hindus, including the Sepoy soldiers of the EIC. When the conflict came to a head, over the use of cow and pig grease on the Enfield rifles issued to the Sepoy soldiers, the result was butchery on both sides.

Dalrymple finds resounding parallels with current events, where the United States finds itself the sole superpower after the collapse of the Soviet Union and is convinced that its gospel—democracy—will lead the benighted peoples of the Middle East out of their darkness.

"The Last Mughal" is a publishing sensation in India, where the appetite for narrative history and biography has apparently been underserved, said Dalrymple during Q and A after his talk. The book has sold 35,000 copies in just two months, "not counting the pirates selling them at every traffic light in Bombay," he joked.


PHOTO / **DONNA COVENEY**

Dance master

Instructor Jamie Rae Walker, a Paul Taylor dancer (second from right) leads (from left) junior Jessica Luttkus, Greg Pintilie G, Professor Thomas DeFrantz, and Paul Taylor dancer John Eirich in a master class.

MIT musicians participate in Jazz Week

Lynn Heinemann
Office of the Arts

MIT musicians will join the groove during Jazz Week, a celebration featuring more than 100 events in locations throughout the Boston area from April 21 to 29.

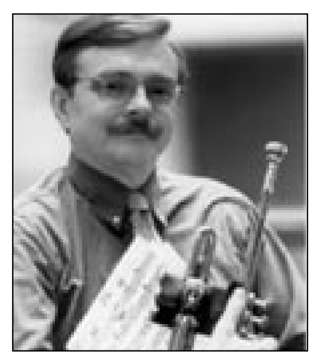
Boston's first jazz week in 25 years is coordinated and promoted by the nonprofit organization JazzBoston. Composer and trumpeter Mark Harvey, lecturer in the music and theater arts section and co-chair of 2007 Jazz Week, was one of the leaders of the original Boston Jazz Week in 1973.

"MIT has a strong jazz presence on campus and in the community," said Harvey. "It is only natural that faculty and students would be key participants in this venture."

The week kicks off with an "All-Star Jazz Blowout" that will include students and faculty from MIT and other area colleges—including the New England Conservatory, Harvard, Brandeis, Longy School of Music and Wellesley—all performing together. "To our knowledge, this is the first time this has ever taken place," said Harvey.

Trombonist Jay Keyser, professor emeritus and special assistant to the chancellor, and pianist Nathan Ball, graduate student in mechanical engineering and this year's winner of the $30,000 Lemelson-MIT Student Prize, will be among the participants in the Blowout. The concert is Saturday, April 21 at 8 p.m. at Berklee Performance Center, with part of the proceeds going to Habitat for Humanity Musicians' Village in New Orleans.


Frederick Harris


Mark Harvey

Keyser and Frederick Harris, director of MIT's wind ensembles, will present a lecture on big bands titled, "Tight Makes Right," on Monday, April 23, in Room 4-152 at 3:30 p.m.

On Tuesday, April 24, Harvey and Keyser will join other musicians for "A Moment in Chaos," a screening of animated films by Kate Matson accompanied by live musical improvisation. The event takes place at the Volpe Transportation Building in Kendall Square at 7:30 p.m. and is presented in conjunction with the Cambridge Science Festival. Tickets are $10. (Special note: The Volpe Center is a government building. Ticket-holders must bring photo identification and pass through security to enter. Please arrive an hour in advance of the program.)

On Friday, April 27, Harvey will moderate a panel comparing "Jazz Week Then and Now," with Arni Cheatham, Ron Gill, Marianne Solivan and Bob Young at noon at the Boston Public Library's Rabb Lecture Hall.

Harvey and his Aardvark Jazz Orchestra will close the week with a Duke Ellington birthday tribute, "Ellington and Beyond," at the Museum of Fine Arts on Sunday, April 29 at 3:30 p.m. A limited number of free tickets for this concert are available for current MIT students through the generosity of the Council for the Arts at MIT and can be picked up at the Office of the Arts in Room E15-205.

For complete listings, visit www.jazzboston.org and click on "Jazz Week."

No Tech Talk next week

In honor of Patriot's Day, there will be no Tech Talk on Wednesday, April 18. The next Tech Talk will be published on April 25. For ongoing MIT news updates, please go to the News Office web site, web.mit.edu/newsoffice/.

Cohen wins inaugural mentoring award

Robert E. Cohen, the St. Laurent Professor of Chemical Engineering and co-director of the DuPont-MIT Alliance, has been selected as the first recipient of the Capers and Marion McDonald Award for Excellence in Mentoring and Advising. Established by Capers (who earned a master's degree in engineering from MIT in 1976) and Marion McDonald, this award is presented to a faculty member in the School of Engineering, who, through tireless efforts to engage minds, elevate spirits and stimulate high quality work, has advanced the professional and personal development of students and colleagues.

GUGGENHEIM

Continued from Page 1

lished in magazines including The Atlantic Monthly, The New Yorker, The Paris Review, and Poetry.

James G. Paradis, head of the Program in Writing and Humanistic Studies and the Robert M. Metcalfe Professor of Writing and Humanistic Studies, described Funkhouser as an "extraordinary contemporary poet, with a brilliant blend of fact and metaphor in her work."

Goemans does research in discrete algorithms and combinatorial optimization. The award will allow him to continue his work on a problem for which no general method of solution exists—the traveling salesman problem: If a salesman starts at point A, and if the distances between every pair of points are known, what is the shortest route that visits all points and returns to point A?

Naginski is a historian of European art and architecture of the 17th through the 19th centuries whose research interests focus on Enlightenment aesthetics, theories of public space, cultural memory and historic preservation and the critical traditions of the history of art. She is working on a project on graphic arts and the philosophy of history in the 18th century.

Spirn has an international reputation as the preeminent scholar working at the intersection of landscape architecture and environmental planning. She is working on rebuilding the landscape of community.

ROBOT

Continued from Page 3

on in front of it. As the robot's large blue eyes roam across the room, cameras feed information to 12 computers that analyze the input and decide what to focus on.

Domo's visual system is attuned to unexpected motion, allowing it to focus on important stimuli within human environments. For example, locating human faces is critical for social interaction, and people are often in motion. When Domo spots motion that looks like a face, it locks its gaze onto it.

Edsinger recently demonstrated how Domo can interact with people to help them accomplish useful tasks.

Once he captures Domo's gaze, they exchange greetings. "Hey, Domo," Edsinger says, to which Domo responds, "Hey, Domo." "Shelf, Domo," says Edsinger, prompting the robot to find a shelf. Domo looks around until it spots a nearby table that looks promising. The robot reaches out its left hand to touch the shelf, much like a person groping for a light switch in the dark, to make sure the shelf is really there.

Once Domo has located the shelf, it reaches out its right hand towards Edsinger, who places a bag of coffee beans in the open hand. Domo wiggles them a little to get a feel for the object, then transfers the bag from its right hand to its left hand (nearest the shelf). Domo then reaches up and places the bag on the shelf.

Though it seems like a minor movement, wiggling the object is key to the robot's ability to accurately place it

See **ROBOT**
Page 8

Think small! Think fast! Atomistic model helps students get down

Denise Brehm
Civil and Environmental Engineering

Civil engineers by tradition are concerned with the big picture, but some are refocusing their vision, zooming in to solve minute problems we can't see with the naked eye, like tiny fractures in polymers, silicon or the molecular structure of proteins.

This work involves understanding the mechanics of a material—its ability to withstand pulling, twisting and heavy loads—at the atomic level. But the classroom technology for teaching this in a short timeframe doesn't exist—until now, that is.

An educational experiment during IAP demonstrated that students can learn to apply sophisticated atomistic modeling techniques to traditional materials research in just a few classes, an advance that could dramatically change the way civil engineers learn to model the mechanical properties of materials and provide enormous benefit to industry.

"Taking an atomistic approach to the study of materials' design and analysis offers opportunities for making significant improvements in materials' strength, reliability and sustainability," said Markus Buehler, an assistant professor in the Department of Civil and Environmental Engineering who collaborated with Ivica Ceraj, a software developer in MIT's Office of Educational Innovation and Technology (OEIT), to prepare the new simulation techniques.

"While scientists often rely on quantum mechanics in their study of materials, engineers tend to use a more traditional continuum approach that relies on empirical parameters to model processes such as a crack forming, without considering the mechanisms at the atomic scale that give rise to these phenomena," said Buehler.

However, a fracture in a concrete bridge doesn't begin as a long, jagged scar; it starts off as a vibration at the atomic scale and progresses.

Engineering students usually study typical weight-bearing problems during their first years in college, but they aren't taught how a material's response to forces at larger scales relates to its structure and mechanisms at the atomic level. The problem Buehler faced was finding a way to teach students to model the material's atomic response without getting too caught up in the complexities of a computer program.

This is where Ceraj and the OEIT initiative came in. "We are looking to reduce the operational fog and help students focus on the subject they are learning without stumbling over new software tools," said Ceraj.

Buehler and Ceraj employed a web interface called GenePattern, an award-winning software program developed in 2004 by a team at the Broad Institute of MIT and Harvard to help scientists perform gene expression analysis. Ceraj created an interface between GenePattern and the software code Buehler uses in his own research. The interface, a derivative application that Ceraj calls StarGP, provides a simple-to-use, yet very accurate tool for modeling the behavior of materials under extreme loading.

"We are expanding StarGP's use in different fields: civil and environmental engineering, materials science and biology," said Ceraj. "Each discipline has different challenges, but it provides us with the opportunity to bring the latest research tools to undergraduate and graduate students." Ceraj collaborates with Jill Mesirov and Michael Reich at the Broad Institute in his work with StarGP. Mesirov and Reich are part of the original GenePattern development team.

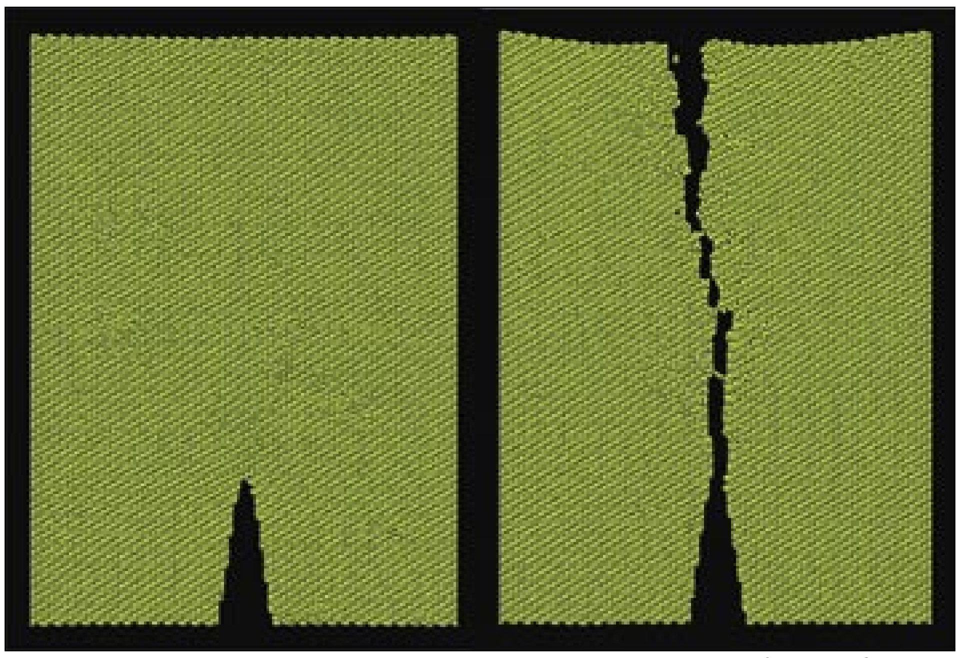


IMAGE / MARKUS BUEHLER

Atomistic simulation provides unparalleled insight into fracture processes. Under the weight of an applied load, a crack in a silicon crystal (left) propagates until the crystal is cleaved.

In Course 1.978 (From Nano to Macro: Introduction to Atomistic Modeling Techniques), Ceraj and Buehler introduced students to the new atomistic simulation program with great success. They found that when using the web interface method, students learned the basics of atomistic modeling quickly, then applied the technique to predict the mechanical properties of silicon, copper nanowire and a structural protein called vimentin that plays a crucial role in stabilizing eukaryotic cells under deformation.

Previously, such simulations required students to learn technical details of a Linux workstation before they could get to the heart of the numerical method. With the web interface, students need enter only a few pieces of key information about how and where a material will be pulled, pushed or twisted, and the program will prepare an accurate video simulation. For instance, one video shows a fracture in one side of a small piece of silicon zig-zagging until it cleaves the material. Another demonstrates a vimentin protein being pulled at both ends until it unwinds from a tight tangle into a long string.

As a result of the class, students not only learned the atomistic simulation quickly, some have already adopted it for their own applications.

Michelle Hyers, who is working toward a Ph.D. in mechanical engineering, took the class to find a more accurate way of modeling at smaller scales. "My research involves modeling self-assembly at the micro and nanoscales, but we currently use macroscale theory with various assumptions to describe the system," said Hyers. "As a result of this class, I formed a collaboration with Professor Buehler to work on a more accurate model for our system than our current approximate methods."

"It is the best class I've had so far at MIT in terms of engaging content, as well as excellent teaching," said Hyers.

Buehler plans to use this method next spring to teach a section of Course 1.021J (Introduction to Modeling and Simulation), an undergraduate class that provides an overview of simulation techniques. This subject will expose undergraduates to state-of-the-art atomistic modeling methods to teach the next generation of engineers how to make a big impact by thinking small.

ROBOT

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on a shelf, Edsinger says. Domo is programmed to learn the size of an object by focusing on the tip of the object, for example, the cap of a water bottle. When the robot wiggles the tip back and forth, it can figure out how big the bottle is and decide how to transfer it from hand to hand or to place it on a shelf.

"You can hand it an object it's never seen before, and it can find the tip and start to control it," Edsinger said.

The human connection

The philosophy behind the team's approach is that humans and robots can work together to accomplish tasks that neither could do all alone.

"If you can offload some parts of the process and let the robot handle the manual skills, that is a nice synergistic relationship," Edsinger said. "The key is that it has to be more useful or valuable than the effort put into it."

For Domo or any robot to safely interact with humans, the robot has to be able to sense when a human is touching it. Domo has springs in its arms, hands and neck that can sense force and respond to it. If you grab its hand and push, the robot will move the way you want it to.

"By placing that spring in there, you get physical compliance that makes the whole body sort of springy, which makes it safer for human interaction," Edsinger said. But if you apply too much force or move Domo's arms in the wrong direction, it voices its displeasure by saying, "Ouch."

If robots are going to be useful in the home, it's also important for them to have a humanoid form, so people will feel more comfortable around them.

Such assistive robots could be very useful in finding solutions to the impending health care crisis caused by the aging of the baby boomers, Edsinger said. Having help with simple tasks, such as getting a glass from a cabinet, could make a big difference for elderly or wheelchair-bound people.

The original work on Domo was funded by NASA, and the project is now supported by Toyota, which is interested in developing partner robots for the home. Another application is in assembly-line production. The idea is that intelligent robots could work together with people to make workers more productive and save manufacturing jobs from being sent overseas, said Edsinger.

Although a life of leisure enabled by robots who perform all manual labor is still securely in the realm of science fiction, Brooks says he can foresee a future where robots specialized for different functions help out with household chores.

"I don't think there's going to be one Rosie the robot doing everything in the home," said Brooks. "It's more likely to be a team of robots doing different things."

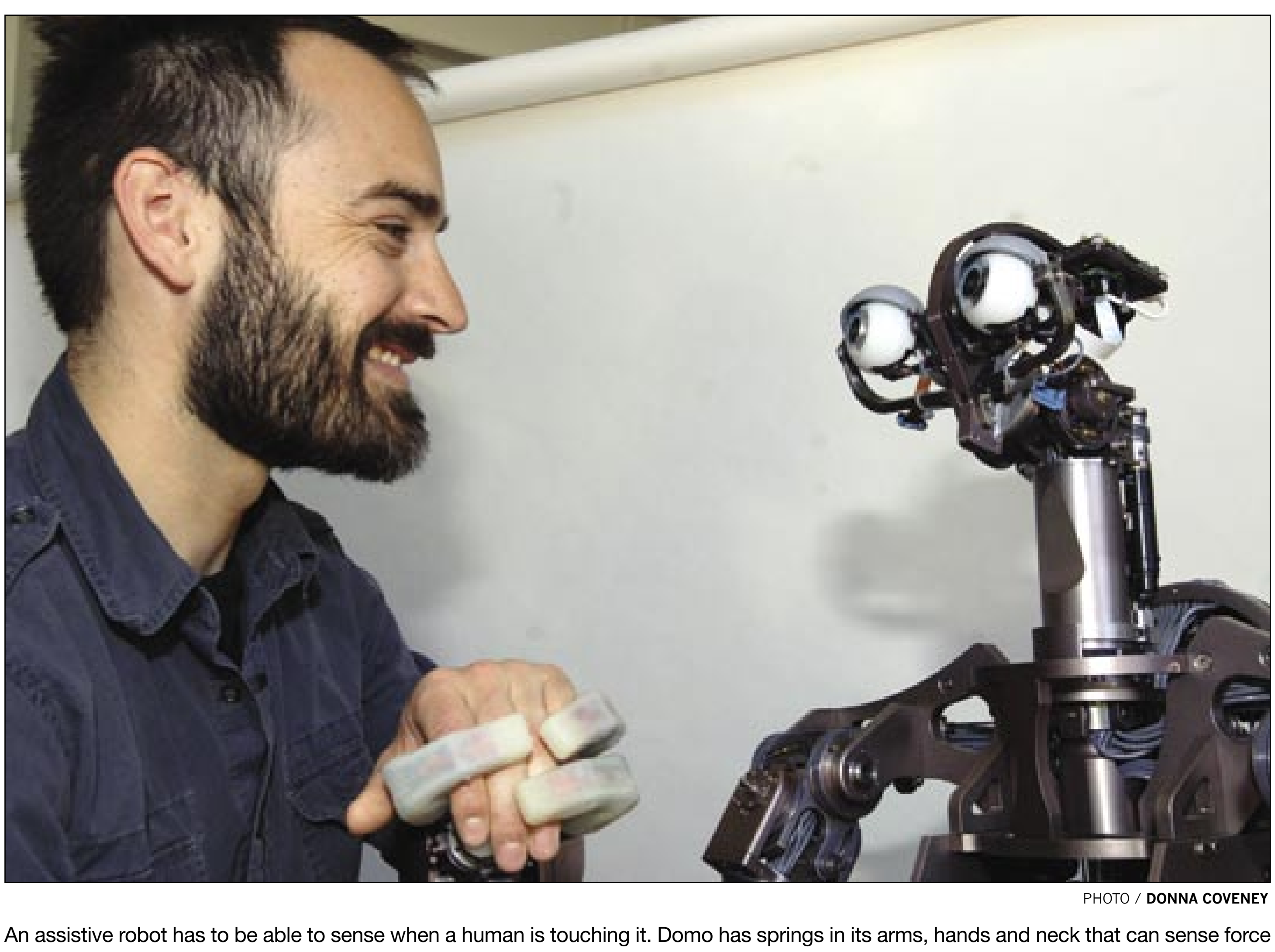

PHOTO / DONNA COVENEY

An assistive robot has to be able to sense when a human is touching it. Domo has springs in its arms, hands and neck that can sense force and respond to it.