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TechTalk
SERVING THE MIT COMMUNITY

6 win Rhodes, Marshall scholarships

PHOTOS / **PATRICK GILLOOLY (L), DONNA COVENEY (R)**

Matt Gethers, left, and Alia Whitney-Johnson were both named recipients of the prestigious Rhodes scholarship, and will spend next year studying at the University of Oxford in Great Britain.

Greg Frost
News Office

Six MIT students have been awarded prestigious Rhodes and Marshall scholarships, offering them the chance to pursue graduate studies at British universities.

Seniors Matt Gethers and Alia Whitney-Johnson were awarded Rhodes Scholarships, while seniors Richard Lin, Anjali Tripathi, Nathaniel Sharpe and graduate student David Reshef won Marshall Scholarships.

With four winners, MIT led U.S. colleges and universities in the number of students awarded the prestigious scholarships this year.

Linn Hobbs, chair of the Presidential Committee on Distinguished Fellowships, and Kimberly Benard, program advisor for Distinguished Fellowships, said they were delighted by MIT's success this year. They noted that the combination of six Rhodes and Marshall winners in one year tied MIT's previous high-water mark, set in 1999 and 2005.

"From our perspective, it is gratifying to have been able once again to demonstrate to MIT students that they can be really competitive in these distinguished competitions, and that what they have done in their lives and will do in the future is recognized as making a real difference to our world," said Hobbs, who is also a professor of materials science and engineering and nuclear science and engineering.

"MIT students are demonstrably good at the latter, and there are many more of our students out there who could be so recognized," Hobbs continued. "From our winning students' perspective, these are life-changing opportunities, and we are

▶Please see SCHOLARSHIPS, **PAGE 7**

RoboClam: Can you dig it?

New MIT-designed robot could lead to 'smart' anchors, more

Elizabeth Thomson
News Office

The simple razor clam has inspired a new MIT robot that could lead to a "smart" anchor that burrows through the ocean floor to reposition itself and could even reverse, making it easier to recover.

The so-called RoboClam is being developed to explore the performance capabilities of clam-inspired digging, as well as to shed light on the behavior of the real animal.

"Our original goal was to develop a lightweight anchor that you could set then easily unset, something that's not possible with conventional devices," said Anette "Peko" Hosoi, an associate professor in the Department of Mechanical Engineering whose collaborators on the work are Amos Winter, a graduate student in her lab, and engineers at Bluefin Robotics Corp.

Such devices could be useful, for example, as tethers for small robotic submarines that are routinely repositioned to monitor variables such as currents and temperature. Further, a device that can burrow into the seabed and be directed to a specific location could also be useful as a detonator for buried underwater mines.

Winter presented the team's latest results Nov. 23 at a meeting of the American Physical Society.

▶Please see ROBOCLAM, **PAGE 4**

PHOTO / **DONNA COVENEY**

The RoboClam, right, designed by Mechanical Engineering Professor Anette Hosoi and graduate student Amos Winter, was inspired by the razor clam, left, which can dig and wedge itself far deeper than previously thought.

PHOTO / **DONNA COVENEY**

Planetary scientist Maria Zuber

Zuber named to list of 'best leaders'

U.S. News honors luminaries in arts, science and politics

David Chandler
News Office

MIT planetary scientist Maria T. Zuber, who was selected last year by NASA as one of the two first women to head major space missions, has been named this year by the magazine U.S. News and World Report as one of "America's Best Leaders."

Zuber, the E.A. Griswold Professor of Geophysics and head of MIT's Department of Earth, Atmospheric and Planetary Sciences, is the Principal Investigator for a new mission to map the interior of the moon in unprecedented detail. The project, called GRAIL (Gravity Recovery And Interior Laboratory), is a $425 million twin-satellite mission that will be launched in 2011. It will provide information about the moon's geological history and details of its gravitational field that will be essential for the safe landing of the upcoming generation of

▶Please see ZUBER, **PAGE 3**

Events at MIT

Today

• **"Riverscapes"** a photo exhibit of significant waterwheels in Syrian and Chinese landscapes by Department of Architecture postdoc Adriana de Miranda. Running now through Dec. 16 at the Rotch Library Gallery.

• **MIT Robotics Conference.** 8-12:30 p.m. in E51-Wong Auditorium.

• **MIT Enterprise Forum/MIT Energy Club Lecture Series: "The War for Water."** 5:30-9 p.m. in 32-123.

Thursday, Dec. 4

• **100K: Executive Summary Deadline.** 6 a.m.-noon. Please submit online at mit100k.org.

• **Simple Person's Applied Mathematics Seminar.** 5-6 p.m. in 4-231. SPAMS is a long-running seminar series in the MIT Applied Math department, which is run by graduate students, for graduate students.

Friday, Dec. 5

• **"The Science of the Human Past**," a Multidisciplinary Symposium. 9 a.m.-5 p.m. in NE30-1120. Knowledge of the human past has entered a new age of discovery which is rewriting the history of the human race. Ancient material remains and modern genomes are yielding dramatic new insights under the powerful scrutiny of the natural sciences.

• **"Public-Private Partnerships**: **When and How."** Speaker: Professor Eduardo Engel, Department of Economics, Yale University. Noon-2 p.m. in W20-307.

• **"Predictive Understanding of Disasters."** Speaker: Professor Vladimir Keilis-Borok, Department of Earth and Space Sciences, UCLA. 4-5 p.m. in 54-915. Part of the EAPS Lecture Series.

Monday, Dec. 8

• **MacVicar Education Speaker Series**: "Engineering Education for the Global Economy." Speakers: Jack R. Lohmann, vice provost for faculty and academic development at Georgia Tech; and Leah H. Jamieson, dean of the College of Engineering at Perdue University. 4 p.m., Room 9-057.

Tuesday, Dec. 9

• **MIT Sloan Dean's Innovative Leader Series**. Speaker: Terri Kelly, President & CEO, W.L. Gore & Associates. Noon-1 p.m. in E51-Wong Auditorium.

Wednesday, Dec. 10

• **Holiday Greens Sale.** From 8:30 a.m.-2 p.m. in Lobby 10. The MIT Women's League will have decorated wreaths, mantel pieces and fresh holly to decorate your homes. We will be joined by the MIT Endicott House with their beautiful houseplants, and holiday gifts for sale.

Awards&Honors

American Institute of Chemical Engineers honors two MIT researchers

In a ceremony during its Annual Meeting in Philadelphia, the American Institute of Chemical Engineers (AIChE) presented awards to 14 leaders and innovators in the chemical engineering field, including two from MIT.

Institute Professor Robert Langer was presented the AIChE's highest honor, the Founder's Award for Outstanding Contributions to the Field of Chemical Engineering. Michael S. Strano, the Charles (1951) and Hilda Roddey Associate Professor of Chemical Engineering, received the Allan P. Colburn Award for Excellence in Publications by a Young Member of the Institute.

Ortiz named to National Security Science and Engineering Faculty Fellowship

Christine Ortiz, an associate professor in the Department of Materials Science and Engineering, was recently awarded a 2009 National Security Science and Engineering Faculty Fellowship (NSSEFF) by the Department of Defense for her research project titled "Natural Armor: An Untapped Encyclopedia of Engineering Design for Protective Defense Applications."

NSSEFF provides grants to distinguished, top-tier faculty and scientists from U.S. universities to conduct long-term, unclassified basic research addressing some of the most challenging technical issues underpinning the DoD. The award includes a $600,000 grant, in direct funds, each year for five years. NSSEFF fellows will be engaged with senior DoD officials, as well as scientists and engineers in DoD laboratories in order to share their expertise and explore potential collaborations in DoD-relevant topical areas.

Ortiz was also selected to the 2008-2009 Defense Science Study Group (DSSG), run through the Institute of Defense Analysis and sponsored by the Defense Advanced Research Projects Agency. The DSSG introduces outstanding young professors of science and engineering to national security challenges. During the two-year program (around 22 days a year), DSSG members visit military bases, DoD laboratories, industrial facilities, government organizations, intelligence agencies and Congress.

MIT scientist, professor win postdoctoral grants

The Camille and Henry Dreyfus Foundation recently selected Jesse Kroll, a visiting scientist in the Department of Civil and Environmental Engineering, and Stephen J. Lippard, the Arthur Amos Noyes Professor in the Department of Chemistry, as award recipients to the Postdoctoral Program in Environmental Chemistry. The award provides $120,000 over two years to leading environmental chemistry faculty to appoint a postdoctoral fellow.

Swager wins John Scott Award

Timothy M. Swager, the John D. MacArthur Professor and head of the Department of Chemistry, has been selected to receive the 2008 John Scott Award. This award is given to the most-deserving men and women whose inventions have contributed in some outstanding way to the "comfort, welfare and happiness" of mankind.

Architecture professor wins $10,000

Department of Architecture Professor Joan Jonas was one of five recipients of the Francis J. Greenburger Awards, which were presented on Nov. 17. The $10,000 award honors artists who have made important contributions to the fields of contemporary art but for one reason or another have not been fully recognized by the world at large.

DCM director wins AALAS honor

James Fox, the director of the Division of Comparative Medicine and a professor in the Department of Biological Engineering, received the 2008 Charles A. Griffin Award from the American Association for Laboratory Animal Science (AALAS). The award is presented for outstanding accomplishments in the improvement of care and quality of animals used in biologic and medical research.

MIT scientists wins Air Force grants

Two MIT researchers have been named among the 39 recent recipients of the Air Force Office of Scientific Research's Young Investigators Research Program award. Lalana Kagal, a research scientist in the Computer Science and Artificial Intelligence Laboratory, and Paulo Lozano, an assistant professor in the Department of Aeronautics and Astronautics, will both receive a $100,000 a year grant for three years to conduct basic research in their fields.

SolSource garners award from Clinton initiative

Members of the SolSource Tibet project, which won last year's MIT IDEAS competition and aims to develop a solar cooker and heater that could be distributed in the remote Himalayan regions of China, won a $5,000 award through the Clinton Global Initiative University, a new project of the Clinton Global Initiative.

Arguing their point

MIT debate team wins prestigious U.K. tournament

Patrick Gillooly
News Office

Don't call it beginners' luck: In its first time competing in one of the world's most prestigious debate tournaments, MIT's debate team captured first place.

Junior Adam Goldstein and teammate Bill Magnuson, the president of the debate team and an MIT senior, won the Cambridge Intervarsity Championship on Nov. 15, beating teams from several top international universities, including the University of Oxford and Trinity College Dublin, along the way.

The competition, sponsored this year by international law firm Cleary Gottlieb, takes place annually in Cambridge, England. This year's tournament drew students from more than 10 countries.

Goldstein noted that MIT's team does surprisingly well at debate competitions — surprising mostly to their competitors.

"Most people who are on the debate circuit are studying philosophy or political science or something like that … but by far the majority of our team is engineers and scientists," he said.

See the interview with Adam Goldstein at web.mit.edu/newsoffice

To earn their win, Goldstein and Magnuson, a senior, first had to get through five preliminary rounds of British-style debate, which includes four teams arguing one topic, with judges ranking the teams first through fourth based on their performance. In the U.S., only two teams face off at one time.

At the start of the elimination rounds, MIT and Bates College were the only U.S. teams remaining, with MIT ranked 11th overall. The first two elimination rounds had the team facing queries on topics related to organ selling and immigration for the wealthy.

For the final round, it was MIT that got to choose the topic for debate: Would the U.N. be better off selling Security Council seats to the highest bidder? Their argument solidified the first-place win, with Goldstein also taking seventh individually and Magnuson taking 10th.

The debate team holds no tryouts and is made up of a mix of students, Goldstein said. They host a web site at web.mit.edu/debate/www for students interested in signing up.

Goldstein said the team's success in this tournament and others is a reflection of how MIT students learn, study and achieve.

"We think that it casts a nice light on MIT that we can have both rigorous scientific types and also debaters," he said.

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MIT students take top prizes in 2008 Collegiate Inventors Competitions

Lu awarded $25,000 grand prize, Schroll takes top undergraduate honors

Anne Trafton
News Office

Two MIT students won top honors recently in the 2008 Collegiate Inventors Competition, one of the most prestigious honors available to college and university innovators.

Timothy Lu, a graduate student in the Harvard-MIT Division of Health Sciences and Technology, was awarded the $25,000 grand prize for a new method of combating antibiotic-resistant bacteria. He invented processes that enhance antibiotic effectiveness and help to eradicate bacterial layers that can breed on surfaces of medical, industrial and food processing equipment.

Greg Schroll, a 2008 MIT graduate, won the competition's top prize for undergraduates for his invention of a new spherical robot that could have many potential uses including surveillance, reconnaissance and disaster-zone assessment, especially in situations where conditions on the ground may not yet be safe for people.

The National Inventors Hall of Fame Foundation made the announcement Wednesday, Nov. 19, at the Kauffman Foundation in Kansas City as part of Global Entrepreneurship Week. The competition is sponsored by the U.S. Patent and Trademark Office and the Abbott Fund.

PHOTO COURTESY OF THE NATIONAL INVENTORS HALL OF FAME FOUNDATION

From left to right: Richard Maulsby, Timothy Lu, Greg Schroll, Paul Podsiadlo, Neil Conan and Jeff Pan at the award ceremony for the 2008 Collegiate Inventors Competition.

Lu started working on the problem of antibiotic resistance after witnessing infectious outbreaks in many patients while doing his clinical rotations. Such infections can lead to lengthened hospital stays and additional treatment, increasing health care costs.

"That experience drove me to look for a solution to this problem," said Lu, who also received the $30,000 Lemelson-MIT Student Prize in February for his discovery.

Working in the new field of synthetic biology, Lu engineered bacteriophages — viruses that infect bacteria — that work in conjunction with existing antibiotics to make them much more effective.

He also engineered bacteriophages to produce enzymes that break down the protective coating surrounding biofilms, enabling deep penetration into biofilms and increased killing of bacterial cells.

Lu, who graduated from MIT in 2003 with bachelor's and master's degrees in electrical engineering and computer science, received his PhD in February and expects to receive his MD in 2010.

Schroll, who majored in mechanical engineering at MIT, won $15,000 for his new robot design, which uses gyroscopes to store and dispense angular momentum to aid in climbing hills, obstacles and stairs.

"I saw how gyroscopes can behave in ways that seem to defy gravity as a result of the principle of gyroscopic precession. I applied this principle to a spherical robot to allow it to also appear to defy gravity," he said.

Schroll is currently a graduate student at Colorado State University.

ZUBER: MIT planetary scientist named to list of 'best leaders'

Continued from **Page 1**

human lunar missions.

While this is the first entire mission that Zuber will be heading, she has already been the principal investigator for key instruments or experiments for several other planetary missions, including the Mars Observer, Clementine, Mars Global Surveyor, Near-Earth Asteroid Rendezvous, Mars Reconnaissance Orbiter and Mercury MESSENGER missions. As a result, Zuber has made frequent appearances at NASA press conferences announcing new findings from Mars and Mercury. She won NASA's Distinguished Public Service Medal in 2004.

This month, Zuber will take part in a small symposium of leaders from government, academia and business to be held at Princeton, led by U.S. House Speaker Nancy Pelosi, to discuss the importance of enhancing research in the areas of physical sciences and energy.

Zuber says she is particularly delighted that as part of the GRAIL project she was able to enlist the help of former astronaut Sally Ride, America's first woman in space, to run a public outreach program connected to the mission. "We'll unleash her creativity to target middle-school girls" and help pique their interest in science, she says.

Middle school is a crucial time for such outreach, Zuber says, "because that's when people have to decide whether to take the hard math that leads to calculus in high school." To help get young people interested in planetary science, she says, the GRAIL spacecraft will include still and video cameras that can be remote-controlled in real time by undergraduate students, and even schoolchildren will be able to recommend sites to be photographed.

Alan Stern, the former NASA Associate Administrator for Science who was responsible for selecting the GRAIL mission, says Zuber is "just an outstanding scientist, an outstanding expert in space flight, a tremendous leader. I was really proud to be able to pick her mission, and I hope that more and more women are able to go into the space sciences."

The 24 leaders on the U.S. News list "who embody and define leadership today," according to the magazine, were chosen by a nonpartisan independent committee, convened by the Center for Public Leadership at Harvard's John F. Kennedy School of Government. The magazine says the list "provides an objective look at the 'best of the best' in leadership and what it means for the complex times in which we live."

The selection of 24 top people in politics, business, art and science was released in the magazine on Nov. 24, when the group was also honored at a press conference in New York. The list features an eclectic mix ranging from popular culture icons to leaders in science, business, politics and academia. Besides Zuber, it includes movie director Steven Spielberg, jazz musician Herbie Hancock, Amazon.com founder Jeff Bezos, bicycling champion Lance Armstrong, U.S. Secretary of Defense Robert Gates, alternative energy pioneer Amory Lovins, and biologist (and former MIT professor) David Baltimore.

The complete list of honorees, along with profiles and essays, can be read online at www.usnews.com/leaders.

Night art: Hologram exhibit to illuminate MIT Museum at dusk

The MIT Museum's newest exhibit opens Dec. 5, but don't go looking for it during the day; you'll never find it.

From dusk until 2 a.m. every night, the pieces of contemporary, 3-D holographic artwork will be projected through the windows of the museum's Mark Epstein Innovation Gallery. Titled "Luminous Windows: Holograms for the 21st Century," the exhibition features works by six artists from five countries and represents advancements in the field of display holography.

See an audio slideshow on the new exhibit at web.mit.edu/newsoffice

"The MIT Museum holds one of the most significant collections of holography in the world and is committed to communicating and educating about this fascinating 3-D imaging technology," MIT Museum Director John Durant said. "The MIT Museum's Mark Epstein Innovation Gallery, with floor-to-ceiling windows right on Mass. Ave., provides an excellent opportunity to excite the public about holographic art and technology, while filling the street and winter nights with the colorful luminosity of 21st-century holography."

The MIT Museum extended a call to the international holography community for works that demonstrate the most recent artistic and technical advancements in holography and which would inspire a new generation of artists and scientists to further explore the potential of holography. The six artists chosen to display their work in this exhibition comprise Michael Bleyenberg of Germany; Betsy Connors of the United States; Paula Dawson of Australia; Pearl John of England; Ikuo Nakamura of Japan; and Sally Weber of the United States.

Seth Riskin, organizer of the exhibit, said, "The Luminous Windows exhibition is a bright, evocative urban-scale offering of light through the nights of winter that will re-ignite holography in the public imagination as a medium of expression and a vehicle of communication."

A grand outdoor opening celebration will be held at the MIT Museum from 5-7 p.m. on Friday, Dec. 5. The event is free and open to the public and will include official window lighting at 5:30 p.m., street festivities and refreshments.

The exhibit is scheduled to run through March 31, 2009. For more information regarding the MIT Museum and the "Luminous Windows" exhibition go to http://web.mit.edu/museum or for more information about the holography collection at the MIT Museum go to http://web.mit.edu/museum/exhibitions/holography.html.

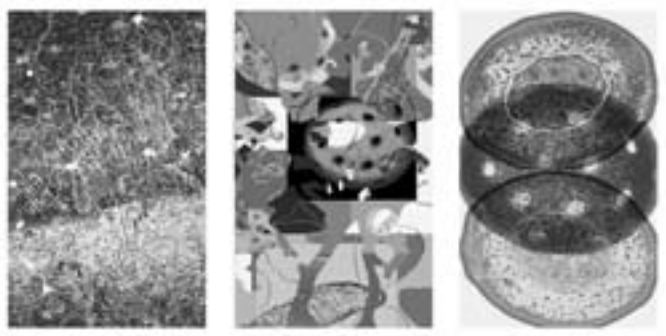

IMAGE COURTESY OF THE MIT MUSEUM

ABOVE: One of the hologram exhibits on display, 'Insights' by Michael Bleyenberg. BELOW: 'ANN' by Paula Dawson.

Obituaries

Linnea Farquhar Layton, former administrative assistant, secretary, 83

Linnea Farquhar Layton, who worked in the provost's office and the School of Science dean's office during the 1980s and early 1990s, died on Nov. 15 after a short illness. She was 83.

From 1981 to 1985, Layton worked at MIT in the provost's office as an administrative assistant to Louis Menand; from 1985 to 1991 she worked as an administrative secretary to Gene Brown, the former School of Science dean.

A private memorial service is planned. Interment will be at Christ Church in Dover, Del. Memorial donations may be made to the Boston office of Reach Out and Read, which provides first books for children in pediatric waiting rooms across the state.

News in brief

Log off, drop in, rev up: Take a 'winter break'

On Wednesday, Dec. 10, from 4-5 p.m. in Lobby 7 there will be a special break-from-winter event, complete with music, refreshments and more. The event is sponsored by the Undergraduate Association, the Graduate Student Council and the Office of the President. Open to MIT faculty, staff and students.

MIT Portugal professor wins Crioestaminal Prize

Lino Ferreira, an MIT Portugal Program bioengineering faculty member and a former MIT postdoctoral fellow, has received the prestigious Crioestaminal Prize. Since 2005, the prize has been awarded in recognition of the best biomedical basic research project carried out in Portugal each year.

Ferreira was honored for the work his laboratory is conducting with human embryonic stem cells. Specifically, Ferreira is in the early stages of developing new stem cell therapies to regenerate cardiac muscle in individuals who have survived a heart attack, and to prevent the heart muscle deterioration that is a hallmark of this pathology. The project is scheduled to continue for the next four years.

Boosting the power of solar cells

New research could lead to higher output, lower cost

David Chandler
News Office

New ways of squeezing out greater efficiency from solar photovoltaic cells are emerging from computer simulations and lab tests conducted by a team of physicists and engineers at MIT.

Using computer modeling and a variety of advanced chip-manufacturing techniques, they have applied an anti-reflection coating to the front and a novel combination of multilayered reflective coatings and a tightly spaced array of lines — called a diffraction grating — to the backs of ultrathin silicon films to boost the cells' output by as much as 50 percent.

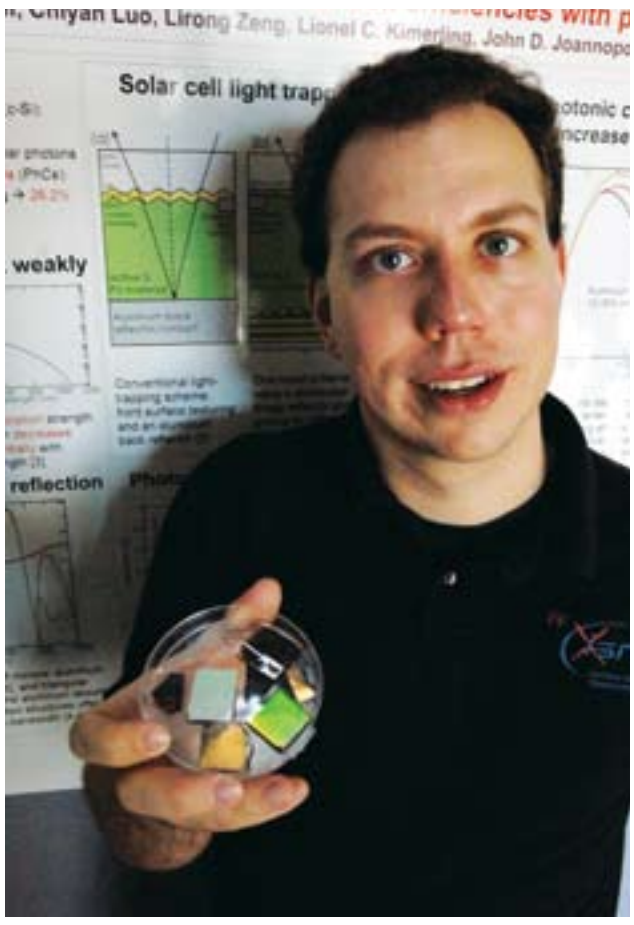

PHOTO / **DONNA COVENEY**

Research Laboratory of Electronics postdoctoral student Peter Bermel shows off solar chips he helped design.

The carefully designed layers deposited on the back of the cell cause the light to bounce around longer inside the thin silicon layer, giving it time to deposit its energy and produce an electric current. Without these coatings, light would just be reflected back out into the surrounding air, said Peter Bermel, a postdoctoral researcher in the Research Laboratory of Electronics who has been working on the project.

"It's critical to ensure that any light that enters the layer travels through a long path in the silicon," Bermel said. "The issue is how far does light have to travel [in the silicon] before there's a high probability of being absorbed" and knocking loose electrons to produce an electric current.

The team began by running thousands of computer simulations in which they tried out variations in the spacing of lines in the grid, the thickness of the silicon and the number and thicknesses of reflective layers deposited on the back surface. "We use our simulation tools to optimize overall efficiency and maximize the power coming out," Bermel said.

"The simulated performance was remarkably better than any other structure, promising, for 2-micrometer-thick films, a 50-percent efficiency increase in conversion of sunlight to electricity," said Lionel Kimerling, the Thomas Lord Professor of Materials Science and Engineering, who directed the project.

The simulations were then validated by actual lab-scale tests. "The final and most important ingredient was the relentless dedication of graduate student Lirong Zeng, in the Department of Materials Science and Engineering, to refining the structure and making it," Kimerling said. "The experiments confirmed the predictions, and the results have drawn considerable industry interest."

The team will reported the first reduction to practice of their findings on Dec. 2 at the Materials Research Society's annual meeting in Boston. A paper on their findings has been accepted for publication in Applied Physics Letters.

The work is just a first step toward actually producing a commercially viable, improved solar cell. That will require additional fine-tuning through continuing simulations and lab tests, and then more work on the manufacturing processes and materials. "If the solar business stays strong," Kimerling said, "implementation within the next three years is possible."

IMAGE / **ISTOCKPHOTO**

The MIT Deshpande Center selected the project for an "i-team" study to evaluate its business potential. The team analyzed the potential impact of this efficient, thin solar cell technology and found significant benefits in both manufacturing and electrical power delivery, for applications ranging from remote off-grid to dedicated clean power.

And the potential for savings is great, because the high-quality silicon crystal substrates used in conventional solar cells represent about half the cost, and the thin films in this version use only about 1 percent as much silicon, Bermel said.

This project, along with other research work going on now in solar cells, has the potential to get costs down "so that it becomes competitive with grid electricity," Bermel said. While no single project is likely to achieve that goal, he said, this work is "the kind of science that needs to be explored in order to achieve that."

In addition to Kimerling, Bermel and Zeng, the work was done by John Joannopoulos, the Francis Wright Davis Professor of Physics, and by research engineer Bernard A. Alamariu, research specialist Kurt A. Broderick, both of the Microsystems Technology Laboratories; postdoctoral associate Jifeng Liu; Ching-yin Hong and research associate Xiaoman Duan, both of the Materials Processing Center. Funding was provided by the Thomas Lord Chair in Materials Science and Engineering, the MIT-MIST Initiative, the Materials Research Science and Engineering Center Program of the NSF and the Army Research Office through the Institute for Soldier Nanotechnologies.

ROBOCLAM: New MIT-designed robot inspired by the digging habits of the razor clam

Continued from **Page 1**

For several years, Hosoi's research has focused on novel propulsion mechanisms inspired by nature. So when faced with the anchor problem, "We thought, 'is there an animal that's well adapted to moving through sediments on the seafloor?'"

The first stage of the research, Winter said, involved "looking at all the organisms I could find that dig into the ocean bottom, stick to it or cling to it mechanically."

He found what the researchers dub the Ferrari of underwater diggers: the razor clam. The animals, about seven inches long by an inch wide, "can go about a centimeter a second, so you have to dig fast to catch them," said Winter, who became a licensed clam digger as a result of the research.

Another reason razors make a good model for novel anchors: They can dig deeply (up to about 70 centimeters). Plus, in a measure of anchoring force, or how hard you pull before an anchor rips out of the soil compared to the energy required to embed the anchor, "razor clams beat everything, including the best anchors, by at least a factor of 10," Winter said.

Research subject in hand, one of the team's first tests gave perplexing results. They pushed a clam shell cast in epoxy into "sand" composed of glass beads and compared the amount of force necessary to do so to what the living animal is capable of. They found a major discrepancy between the two.

"They're much too weak to do what they do," Hosoi said. "So we knew they were doing something tricky."

To find out what, Winter created a glass-sided box filled with water and beads, added a living clam, and watched the animal burrow. It turns out to be a multistep process. The animal's tongue-like "foot" wiggles down into the sand, then the animal makes a quick up-and-down movement accompanied by opening and closing its shell. Together these movements propel it.

> *They're much too weak to do what they do. So we knew they were doing something tricky.*
>
> **Associate Professor Anette Hosoi on razor clams' ability to dig**

By filming the movement of the beads, Winter made a startling discovery. The clam's quick up-and-down, opening-and-closing movements turn the waterlogged "sand" around it into a liquid-like quicksand. Experiments showed that "moving through a fluidized substrate [the quicksand] rather than a packed granular medium [ordinary sand] drastically reduces the drag force on the clam's body, bringing it to a point within the animal's strength capabilities," Winter reported.

This past summer, Winter finished the RoboClam itself. Although only about the size of a lighter, it is supported by a large apparatus of pressure regulators, pistons and more that control such things as how hard the robot is pushed in each direction.

"Right now we're getting it up and running" for tests, Winter said. Among them, "we want to use RoboClam to verify the theory we've generated to describe how to dig like a clam."

PHOTO / **DONNA COVENEY**

Mechanical Engineering Associate Professor Anette 'Peko' Hosoi, right, stands with graduate student Amos Winter and their RoboClam in the background.

Tiny steps

Engineers show how cell proteins generate force to 'walk'

Anne Trafton
News Office

MIT researchers have shown how a cell motor protein exerts the force to move, enabling functions such as cell division.

Kinesin, a motor protein that also carries neurotransmitters, "walks" along cellular beams known as microtubules. For the first time, the MIT team has shown at a molecular level how kinesin generates the force needed to step along the microtubules.

The researchers, led by Matthew Lang, associate professor of biological and mechanical engineering, reported their findings in the Nov. 24 online early issue of the Proceedings of the National Academy of Sciences.

Because kinesin is involved in organizing the machinery of cell division, understanding how it works could one day be useful in developing therapies for diseases involving out-of-control cell division, such as cancer.

The protein consists of two "heads," which walk along the microtubule, and a long "tail," which carries cargo. The heads take turns stepping along the microtubule, at a rate of up to 100 steps (800 nanometers) per second.

In the PNAS paper, Lang and his colleagues offer experimental evidence for a model they reported in January in the journal Structure. Their model suggests — and the new experiments confirm — that a small region of the protein, part of which joins the head and tail, is responsible for generating the force needed to make kinesin walk. Two protein subunits, known as the N-terminal cover strand and neck linker, line up next to each other to create a sheet, forming the cover-neck bundle that drives the kinesin head forward.

"This is the kinesin power stroke," Lang said.

Next, Lang's team plans to investigate how the two kinesin heads communicate with each other to coordinate their steps.

The lead author of the PNAS paper is Ahmad Khalil, graduate student in mechanical engineering. Other MIT authors of the paper are David Appleyard, a graduate student in biological engineering; Anna Labno, a recent MIT graduate; Adrien Georges, a visiting student in Lang's lab; and Angela Belcher, the Germehausen Professor of Materials Science and Engineering and Biological Engineering. This work is a close collaboration with authors Martin Karplus of Harvard and Wonmuk Hwang of Texas A&M.

The research was funded by the National Institutes of Health and the Army Research Office Institute of Collaborative Biotechnologies.

IMAGE COURTESY OF AHMAD S. KHALIL; KATHLEEN M. FLYNN; AND WONMUK HWANG

PHOTO / **PAUL RIVENBERG**

From the control room, two graduate students perform experiments on the Alcator C-Mod fusion reactor.

Making advances on fusion power

David Chandler
News Office

Research carried out at MIT's Alcator C-Mod fusion reactor may have brought the promise of fusion as a future power source a bit closer to reality, though scientists caution that a practical fusion power plant is still decades away.

Fusion, the reaction that produces the sun's energy, is thought to have enormous potential for future power generation because fusion plant operation produces no emissions, fuel sources are potentially abundant, and it produces relatively little (and short-lived) radioactive waste. But it still faces great hurdles.

"There's been a lot of progress," says physicist Earl Marmar, division head of the Alcator Project at the MIT Plasma Science and Fusion Center (PSFC). "We're learning a lot more about the details of how these things work."

The Alcator C-Mod reactor, in operation since 1993, has the highest magnetic field and the highest plasma pressure of any fusion reactor in the world, and is the largest fusion reactor operated by any university.

One of the most vexing issues facing those trying to construct a fusion plant that produces more power than it consumes (something never achieved yet experimentally) is how to propel the hot plasma (an electrically charged gas) around inside the donut-shaped reactor chamber. This is necessary to keep it from losing its heat of millions of degrees to the cooler vessel walls. Now, the MIT scientists think they may have found a way.

Physicist Yijun Lin and principal research scientist John Rice have led experiments that demonstrate a very efficient method for using radio-frequency waves to push the plasma around inside the vessel, keeping it from losing heat to the walls and preventing internal turbulence that can reduce the efficiency of reactions.

"That's very important," Marmar says, because presently used techniques to push the plasma will not work in future, higher-power reactors such as the planned ITER (International Thermonuclear Experimental Reactor) now under construction in France, and so new methods must be found. "People have been trying to do this for decades," he says.

Lin says that "some of these results are surprising to theorists," and as yet there is no satisfying theoretical foundation for why it works as it does. But the experimental results so far show that the method works, which could be crucial to the success of ITER and future power-generating fusion reactors. Lack of a controllable mechanism for propelling the plasma around the reactor "is potentially a showstopper," Rice says, and the ITER team is "very concerned about this."

Rice adds that "we've been looking for this effect for many years," trying different variations of fuel mixture, frequency of the radio waves and other parameters. "Finally, the conditions were just right." Given that the ITER project, which will take 10 years to build, is already underway, "our results are just in time for this," Lin says. These results are being published in Physical Review Letters on Dec. 5.

A number of other recent findings from Alcator C-Mod research could also play a significant role in making fusion practical, and several papers on these new results were presented at the Plasma Physics Divisional meeting of the American Physical Society held in November.

One of these is a method developed by Dennis Whyte and Robert Granetz for preventing a kind of runaway effect that could cause severe damage to reactor components. When a fusion reactor is in operation, any disruption of the magnetic field that confines the super-hot plasma could cause a very powerful beam of "runaway electrons," with enough energy to melt through solid steel. This would not be dangerous to personnel because everything is well shielded, but it could cause hardware damage that would be expensive and time consuming to repair.

But Whyte and Granetz have developed a kind of high-powered fire extinguisher for such runaway beams: a way of suddenly injecting a blast of argon or neon gas into the reactor vessel that turns the plasma energy into light, which is then harmlessly absorbed by the reactor walls, and suppresses the beam by apparently making the magnetic fields more disorganized.

For about a thousandth of a second, Whyte says, this brilliant flash of light is the world's brightest light — the equivalent of a billion-watt bulb — though it's in a place where nobody can directly see it.

Because the Alcator C-Mod's design is very closely matched to that of ITER, "we are uniquely positioned to explore what happens when these disruptions occur," Whyte says. ITER will be 10 times the diameter and produce a thousand times the energy of the Alcator C-Mod, so if this quenching system is used there it would produce a trillion-watt bulb — for a fleeting instant, nearly equivalent to the total electricity output of the United States.

MIT research digest

Study sees challenges for integrating new neurons into brain

Using adult stem cells to replace neurons lost because of brain damage and disease could be more difficult than previously thought, according to MIT researchers, because newly formed brain cells receive messages before they are capable of sending them.

The work, published in a recent issue of the Proceedings of the National Academy of Sciences, has implications on the treatment of conditions such as Alzheimer's and Parkinson's.

Scientists have long speculated that replacing neurons damaged by neurological disease, brain injury or spinal-cord trauma would be an efficient way to reverse the negative effects of those conditions. But Carlos E. Lois, of the Picower Institute for Learning and Memory, found that adding new neurons to existing circuits would be akin to trying to integrate a new memory card into a running computer.

"Most likely, the computer software will crash because of the sudden addition of a new part to the hardware," said Lois, who is also an assistant professor of neuroscience in the departments of brain and cognitive sciences and biology. While new parts can be added to an off-line computer, the brain can never be shut down. "The addition and elimination of connections of new neurons would be disruptive to the existing brain circuit," he said.

MIT Sloan students are finalists in X-Prize video contest

David Chandler
News Office

A video clip made by three graduate students in MIT's Sloan School of Management is one of three finalists in a competition for ideas for a new environmental X-Prize to be offered in the future. The winner will be determined by votes cast on its web site, and anyone can view the entries on YouTube.

Their YouTube video calls for a contest for the best overall reduction of energy use by a community (which could be a town, a neighborhood or a school district). Entrants could use any means at their disposal, from installing more efficient light bulbs or adding insulation to their walls to more creative energy-saving measures.

Team member Jonathan Dreher says their idea was based on the fact that a great deal of money and effort is being spent on devising new, cleaner ways to produce energy, but "not enough people are addressing the growing need to reduce our inefficient demand for energy. Though some Americans have started taking action on their own, we hope an X-Prize based on our entry will provide the necessary incentive to get a majority of Americans to think about their excessive energy consumption habits."

While new energy technologies may take a decade or more to have an impact, he says, "Our prize proposal allows for immediate action at a massive scale, and allows everyday Americans to participate by simply making a trip to their local hardware store. The steps are simple and no change of lifestyle or sacrifice of comfort is necessary."

The three team members, Dreher, Jeremy Stewart and Michael Norelli, are students in the Leaders for Manufacturing Program in the Sloan School's System Design and Manufacturing Program. Online voting for the award has ended, and the winning team will be announced in January, when they will receive a $25,000 prize in addition to having their proposal considered for the creation of a new major X-Prize award.

"We were inspired by the sheer number of ideas and inquiries from the YouTube community," said Peter H. Diamandis '83, SM '86, chairman of the X-Prize Foundation. "Narrowing the list to three finalists was difficult."

Bringing the power of information to the people

New software helps locals deal with natural gas companies

David Chandler
News Office

When representatives from natural gas companies knock on doors in rural areas to try to lock up deals for drilling rights, they typically hold most of the cards. They have the knowledge and experience about the process, while the landowner often has little or no information about what kinds of deals other residents in the area have agreed to — or about such issues as toxic chemicals that have been used in other drilling sites and the health effects residents say they have experienced. Currently, there is no easy way to find such information.

A team of MIT researchers hopes to remedy that. They are developing a suite of software applications to extract information from government and corporate databases, along with input from citizens in the affected areas, and make it all available in a clear, easy-to-navigate form. "This is an experiment to see if we can develop new tools to help communities self-organize," says Chris Csikszentmihályi, co-director of MIT's Center for Future Civic Media.

This month, the MIT team will begin tests of one of their new software tools, Landman Report Card (LRC), with small groups of landowners in Colorado and Ohio, and eventually extend the tests to New York, Pennsylvania and West Virginia, all of which are experiencing new booms in natural gas exploration.

"People often will sign the day the land man (company representative) shows up at the door," Csikszentmihályi says. "There are lots of negotiations that people can do, that they often don't know they can." For example, while in some states they have no power to prevent drilling on their land, they can negotiate such things as replacement of topsoil or water quality monitoring once the drilling is done.

In rural Pennsylvania, some local Mennonite farmers have "negotiated for incredibly cheap leases, below market price," says Sara Wylie, a graduate student in the Science, Technology, and Society Program who has been co-directing the software project. "They can be victims of the fact that they don't know the real value, and what the process is like."

LRC and the other tools in the suite aim to ameliorate some of the information imbalances by recording existing data about the drilling operations. Also, by gathering data from local people about their experiences and health effects, the resulting database could become an important tool for government regulators and public health officials. Now, the experiences of people living near the wells "are not being captured anywhere," Csikszentmihályi says. "By recording it, each landowner's data will then help other people."

Making information accessible could make a big difference. For example, before signing a lease to allow drilling for natural gas on their land, the owners might want to know that natural gas drilling operations are allowed to pump millions of gallons of fluid into the ground to fracture the rock and help force the gas out. The chemical composition and ultimate disposal of these fluids are largely unregulated, and have been the subject of lawsuits claiming adverse health effects in people who live near drilling sites. And the quantities involved are enormous: Each of the thousands of wells in just one state is legally allowed to use a greater volume of unregulated chemicals than the total amount dumped at the infamous Love Canal superfund site, Csikszentmihályi says.

"Many of the state laws governing oil and gas focus on technical issues related to extraction, while providing few protections for those who must live with the noise, noxious fumes, waste pits, contamination and other impacts associated with oil and gas production," says Lisa Sumi, an environmental consultant who has worked with the nonprofit Oil and Gas Accountability Project. "Because of this technical focus, governments have not done a good job of tracking the environmental and health impacts associated with oil and gas development."

Even basic information that is available is often so hard to extract from government web sites that it is essentially useless to the landowners. For example, to find the locations of existing wells can require typing in the township, section and range designations of a given location — details the landowners often don't know. Instead, "we want to be able to let a person type in their address, and have all the details about drill sites near their home that industry has and more." says Csikszentmihályi.

The research was partly funded by the Knight Foundation.

PHOTO / **DONNA COVENEY**

MIT Media Lab Professor Chris Csikszentmihályi, co-director of MIT's Center for Future Civic Media, and STS graduate student Sara Wylie.

MIT, King Fahd University of Petroleum and Minerals in collaboration

Two schools launch program on clean water, clean energy

Solar energy, seawater desalinization and other technologies related to the production of fresh water and low-carbon energy will be the focus of a seven-year research and educational program launched between faculty in MIT's Department of Mechanical Engineering (MechE) and King Fahd University of Petroleum and Minerals (KFUPM) in Dhahran, Saudi Arabia.

The joint program will lead to the creation of the Center for Clean Water and Clean Energy at MIT and KFUPM. The center, too, will focus on issues such as desalination, solar energy and advanced manufacturing. The center is expected to perform 16 joint research projects and eight joint educational projects over seven years. These joint projects will be funded by KFUPM.

The new center will be directed by Professor John H. Lienhard V, co-directed by Professor Kamal Youcef-Toumi, and housed in MechE. Participants in center research projects will team up with faculty at KFUPM to conduct research on topics of mutual interest. Approximately 20 MIT faculty will be involved in the center's projects during the first year, with a similar number participating at KFUPM.

In addition, faculty and graduate students from KFUPM will have the opportunity to spend one or two semesters at MIT, and faculty from MIT will visit KFUPM for periods of one to two weeks each year. The center also includes a unique outreach program that will bring Saudi women engineers and scientists to MIT to participate in its research and educational projects.

The research contract was signed on June 15 in Dhahran by Lienhard and KFUPM Rector Khalid S. Al-Sultan. Also participating in the launch ceremonies were Youcef-Toumi; Mary C. Boyce, the Gail E. Kendall Professor of Mechanical Engineering and head of the Department of Mechanical Engineering; and Karen K. Gleason, the Alexander and I. Michael Kasser Professor of Chemical Engineering and the associate dean of engineering for research. The many KFUPM participants included Mechanical Engineering Department Head Amro M. Al-Qutub and Nesar Merah, who together spearheaded the development of the program at KFUPM.

The initial research efforts of the center will include:

- Photovoltaic power including silicon and polymer devices and systems,
- Desalination of seawater by advanced membranes and by thermal and solar power,
- Applications of nanotechnology to solar and thermoelectric energy conversion,
- Design and manufacturing of solar power systems and desalination systems,
- Advanced sensors for leak detection in water distribution networks, and
- Technologies for carbon capture.

The center originated from a visit made by Youcef-Toumi to KFUPM in 2006 to participate in a workshop on design in mechanical engineering. Subsequent visits by six other MIT mechanical engineering faculty during 2007 led to a formal proposal for the center during the fall of that year.

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Richard Lin

David Reshef

Nathaniel Sharpe

Anjali Tripathi

SCHOLARSHIPS: 2 MIT students win Rhodes; 4 win Marshall

Continued from **Page 1**

honored to have played some role in helping to bring them to these immensely and talented and deserving young individuals."

With the latest awards, the cumulative number of MIT students to receive Rhodes Scholarships stands at 40, while a total of 58 MIT students have been awarded Marshall Scholarships.

Rhodes Scholars are selected through a decentralized process by which regional selection committees choose 32 scholars each year representing the 50 states. Marshall Scholarships, given every year since 1953, are awarded by the British government as a national gesture of thanks to the United States for aid received under the post-World War II Marshall Plan. Up to 40 American students are selected each year to study at graduate level at a British institution in any field of study.

Rhodes scholarships are normally for two or three years while Marshall scholarships allow two years of study; both take place at universities in Britain.

The six students come from various backgrounds at MIT:

Gethers, a biological engineering major with a concentration in political science, has been involved in multiple research opportunities during his time at MIT and has engaged in a variety of public service work throughout his undergraduate career. After successful training by the MIT Emergency Medical Service, Gethers became a third rider for the MIT ambulance, logging more than 50 hours per semester. Gethers will now travel to Oxford University to read for a degree in the Philosophy, Politics, and Economics Programme.

Lin, a double major in materials science and engineering and biology, with double minors in history and applied international studies, has a great passion for traveling to developing countries, gaining an understanding of people's needs and engineering devices to make their lives better. While studying abroad at Oxford University, Lin allied himself with Oxfam International to engineer a new device that would provide a low-cost solution to the problem of cholera outbreaks in rural regions of developing countries. Lin plans to dedicate his life to similar service efforts and will join Oxford's School of Public Health before entering medical school.

Tripathi, a physics major, arrived at MIT having already proven herself as a gifted scientist, through two internships with NASA's Jet Propulsion Lab and a research project in Caltech's Seismological Laboratory. Those who know Tripathi universally characterize her as an independent thinker who thrives on tackling the most ambiguous and difficult astrophysics and astronomy questions. Tripathi will travel to Cambridge University to study at the Institute of Astronomy and then to earn an advanced certificate in mathematics.

Reshef graduated from MIT in June with a bachelor's degree in electrical engineering and computer science and is currently completing the requirements for an MEng degree in the same field. He has supplemented his academic training with research in the field at both Johns Hopkins School of Public Health and Harvard Medical School-Massachusetts General Hospital. In a project with Pardis Sabeti '97, a former Rhodes scholar, Reshef has been using his computational skills to detect epidemiological patterns in malaria outbreaks. He wishes to pursue a doctorate in epidemiology at Oxford University.

Sharpe, a mechanical engineering major, has supplemented his coursework with academic research and a technical internship. After participating in an engineering design course where he developed a robotic arena that placed third in an MIT competition of 135 participants, Sharpe was invited to compete in the 2007 International Design Competition, Robocon, in Thailand. An award-winning juggler, Sharpe also traveled to Israel this past summer to lead a beginners' workshop on juggling for children at the Al-Rowwad Cultural and Theatre Training Center in the Aida Refugee Camp. He plans to use his mechanical engineering skills in his future career in designing sustainable energy solutions, and therefore proposes to earn two degrees: an MPhil in engineering for sustainable development and an MPhil in engineering.

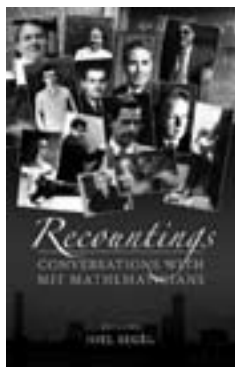
Whitney-Johnson, a senior in civil and environmental engineering, a former Truman Scholar and one of Glamour Magazine's Top Ten College Women, founded Emerge Global in 2005, a nonprofit organization that seeks to empower young Sri Lankan mothers — many of them children themselves — made pregnant through rape and incest. Whitney-Johnson's ultimate goal, however, is not solely to enlarge Emerge Global, but to extend its key concept: empowerment. She will undertake the MSc course in development studies at Oxford's Queen Elizabeth House.

More information on the Rhodes and Marshall winners can be found on the News Office's web site at web.mit.edu/newsoffice.

Numbers and words

New book chronicles rise of MIT math department

A new book, "Recountings: Conversations with MIT Mathematicians," tells the story of the rise of MIT's Department of Mathematics through the eyes of 13 influential MIT mathematicians.



"Recountings" is an oral history based on recollections of and about those 13 faculty members, including Norman Levinson, Isadore M. Singer, Arthur P. Mattuck, Hartley Rogers, Gilbert Strang, Kenneth M. Hoffman, Alar Toomre, Steven L. Kleiman, Harvey P. Greenspan, Bertram Kostant, Michael Artin, Daniel J. Kleitman and Sigurdur Helgason.

The book traces the development of these individuals, who describe their first attraction to mathematics and the inspiration of past giants in the field.

MIT's math department is one of the strongest in the world, representing a broad spectrum of fields ranging from the traditional areas of pure mathematics such as analysis, algebra, geometry and topology, to applied mathematics areas such as combinatorics, computational biology, fluid dynamics, theoretical computer science and theoretical physics. The department currently has about 50 faculty members, many of whom have received the highest distinctions including an Abel Prize, a National Medal of Science, two MacArthur Awards, and Bôcher, Cole, Veblen, Fulkerson and Steele prizes.

"Recountings: Conversations with MIT Mathematicians," is edited by Joel Segel, a writer whose father, Lee Segel, received a PhD in applied mathematics from MIT in 1959. The book will be published by AK Peters on Dec. 31.

OCW welcomes 50 million visitors

MIT's ambitious program hits key milestone

MIT's OpenCourseWare (OCW) has now shared MIT course materials with more than 50 million visitors worldwide, indicating how OCW has grown from a bold idea into a global movement that is reshaping the role of the university in the digital age.

Launched in 2002, OCW is MIT's ambitious program to share course materials — including syllabi, lecture notes, assignments and exams — from virtually all of the Institute's classes, freely and openly on the Web. Through the main MIT OpenCourseWare site (http://ocw.mit.edu) and through translation affiliate sites, OCW materials have been accessed by an estimated 50 million individuals from more than 200 countries and territories worldwide. The OCW site alone has been visited by more than 30 million individuals, who have viewed more than 350 million pages. Affiliates have translated more than 600 of OCW's 1,800 courses into languages including Chinese, Spanish, Portuguese, Thai and Persian.

About 40 percent of traffic to the MIT site comes from outside of North America, with significant levels of traffic from East Asia, Europe and South Asia. Seventeen percent of respondents to site surveys describe themselves as educators, 30 percent as students and half as independent learners. Visitors to the site have been as young as 11 and as old as 70.

Traffic to the site has originated from more than 3,000 universities in the world and the site is also heavily used by top companies in the technology, defense and finance industries.

Visitors use the site in a wide variety of ways to support formal and informal learning. Lekshmi, a professor at the University of Kerala in India, shares OCW with her students and describes it as "an excellent tool to motivate my students to think outside their prescribed syllabi and gives them access to a wider knowledge base." Oystein, a Norwegian student, has improved his academic performance with OCW videos. "These lectures gave me a deeper understanding of the subject, and without them I'm pretty sure I would not have received my 'A' in my local algorithms course," he says.

OCW has also inspired hundreds of other universities to share their course materials openly. Leading universities from more than 20 countries have come together through the OpenCourseWare Consortium (http://ocwconsortium.org) to publish a body of more than 7,800 courses in six different languages.

The MIT OpenCourseWare site has grown from a 50-course proof-of-concept site launched in September 2002 to a resource that shares materials from all of MIT's academic departments at both the undergraduate and graduate levels. The site contains the core academic materials for MIT's courses, voluntarily provided by MIT faculty under an open license that allows site users to download and modify the materials for noncommercial use.

The OpenCourseWare site contains notes from more than 1,500 lectures, 9,000 assignments, and 900 exams. Many courses include enhanced multimedia content, including 31 that contain complete video recordings of course lectures.

These videos have generated tremendous public acclaim for MIT professors, including physics professor Walter Lewin and math professor Gilbert Strang. Each has course materials on OCW that have individually received more than 1 million visits, and both have been featured in major media in the U.S. and abroad. "To most people outside, MIT was like the forbidden city. They had no idea what happened inside," says Lewin. "And with OCW, the bridge was lowered. They now see MIT in a completely different way."