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Wednesday, November 19, 2008

TechTalk
SERVING THE MIT COMMUNITY

The case for cap-and-trade

MIT analysis shows how plans can cut greenhouse emissions

Researchers at MIT's Center for Energy and Environmental Policy Research have produced a report concerning key design issues of proposed "cap-and-trade" programs that are under consideration in the United States as a way of curbing greenhouse gas emissions. The first contribution of the three-part study found that, based on an examination of the European Union's system and of similar U.S. programs for other emissions, such a program can indeed be effective in reducing emissions without having a significant economic impact.

MIT helped organize a conference this week that is looking at ways of controlling and reducing greenhouse gases.
Read more on page 8.

"The European experience confirms much of what has been learned from similar U.S. systems for other emissions, namely, that cap-and-trade systems can be constructed, that markets emerge to facilitate trading, that emissions are reduced efficiently, and that the effects on affected industries are less than predicted," said A. Denny Ellerman, the study's lead author and a senior lecturer in the MIT Sloan School of Management.

The study found that the most controversial aspect of the European program was how to allocate the permitted emissions levels to different producers. Initial free allocation of allowances, they found, was the necessary price for gaining political acceptance, as it has been in U.S. systems. Over time, the clearly established trend in the E.U. is to phase out the free allocation of permits in favor of auctioning them.

The second part of the report looked at mechanisms that can be used to control the costs that will be imposed on power producers as a result of implementing a cap-and-trade system. Several alternatives were analyzed, including such things as a "safety valve," banking and borrowing of allowances, and renewable portfolio standards. Rather than a single best choice, the study found that different mechanisms work best for addressing uncertainties

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PHOTO / **DONNA COVENEY**

Herman addresses Diversity Leadership Congress

Former Secretary of Labor Alexis Herman delivers the keynote address Nov. 18 at the Diversity Leadership Congress, which aimed to promote a culture of diversity at MIT by bringing together academic, administrative and student leaders. For more coverage of the congress, please visit the MIT News Office web site at http://web.mit.edu/newsoffice/.

Equipping cells with tiny 'backpacks'

Polymer patches could ferry drugs, assist in cancer diagnosis

Anne Trafton
News Office

MIT engineers have outfitted cells with tiny "backpacks" that could allow them to deliver chemotherapy agents, diagnose tumors or become building blocks for tissue engineering.

Michael Rubner, director of MIT's Center for Materials Science and Engineering and senior author of a paper on the work that appeared online in Nano Letters on Nov. 5, said he believes this is the first time anyone has attached such a synthetic patch to a cell.

The polymer backpacks allow researchers to use cells to ferry tiny cargoes and manipulate their movements using magnetic fields. Since each patch covers only a small portion of the cell surface, it does not interfere with the cell's normal functions or prevent it from interacting with the external environment.

"The goal is to perturb the cell as little as possible," said Robert Cohen, the St. Laurent Professor of Chemical Engineering at MIT and an author of the paper.

The researchers worked with B and T cells, two types of immune cells that can home to various tissues in the body, including tumors, infection sites, and lymphoid tissues — a trait that could be exploited to achieve targeted drug or vaccine delivery.

"The idea is that we use cells as vectors to carry materials to tumors, infection sites or other tissue sites," said Darrell Irvine, an author of the paper and associate professor of materials science and engineering and biological engineering.

Cellular backpacks carrying chemotherapy agents could target tumor cells, while cells equipped with patches carrying imaging agents could help identify tumors by binding to protein markers expressed by cancer cells.

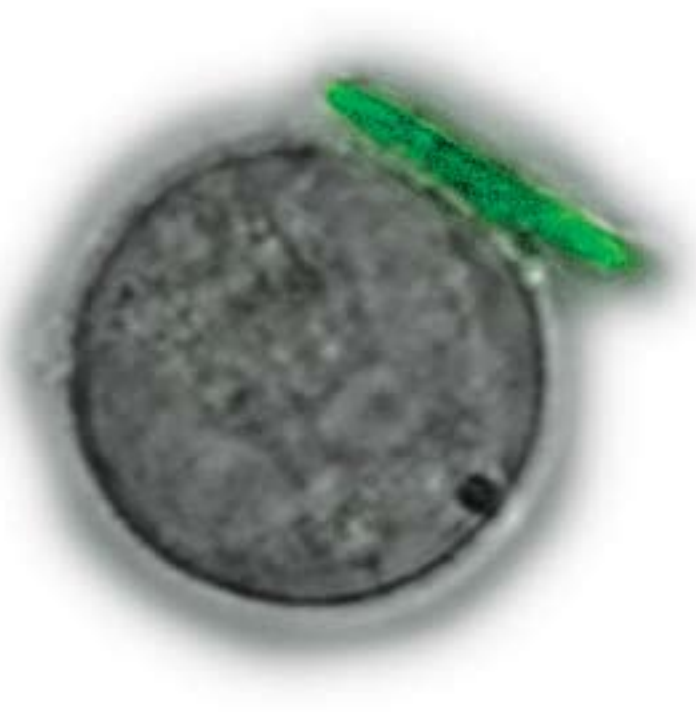

IMAGE / **AMERICAN CHEMICAL SOCIETY**

MIT researchers have developed a technique to attach tiny 'backpacks' to cells.

Another possible application is in tissue engineering. Patches could be designed that allow researchers to align cells in a certain pattern, eliminating the need for a tissue scaffold.

The polymer patch system consists of three layers, each with a different function, stacked onto a surface. The bottom layer tethers the polymer to the surface, the middle layer contains the

▶Please see BACKPACKS, **PAGE 6**

Events at MIT

Today

• **Disintegration: Painting exhibition by Roberto Marrone.** Rotch Library Gallery, Nov. 14-Nov. 24. The exhibition displays paintings and drawings by the Italian painter Roberto Marrone. Most works, based on abstract-figurative subjects, are the results of the reaction between colour and chemical material.

• **Institute faculty meeting.** 3:30-5 p.m. in 10-250. See the agenda on page 7.

• **"Smart Start-ups."** Part of Global Entrepreneurship Week @ MIT. 5-7 p.m. in 1-390. Sherwin Greenblatt, Director of the MIT Venture Mentoring Service, who started as Bose's only employee and eventually became Bose's President, will describe how Bose planned and executed its commercial strategy and remained privately held by bootstrapping its growth, and how your venture might do so.

• **Science Policy and the Obama administration.** From 6-7 p.m. in NE30, Broad Institute Auditorium. School of Science Dean Marc Kastner will speak at an advice session to the Obama administration on science and the future of America.

• **"Einstein's Dreams."** 7:30-10 p.m. in the Central Square Theater (450 Massachusetts Ave., Cambridge). This stage adaptation of MIT Adjunct Professor Alan Lightman's novel portrays Einstein in 1905, a modest but brilliant patent clerk in a new marriage, struggling to make ends meet, while in the back of his mind re-conceiving time.

Two scientists named to Discover's 'Top 20 Under 40' list

Chomsky also cited for lifetime achievement

Discover magazine has named two MIT researchers — Ed Boyden and Sara Seager — among its top 20 scientists under 40.

Boyden, the Benesse Career Development Professor, an assistant professor in the MIT Media Lab and professor in the Department of Biological Engineering and Department of Brain and Cognitive Sciences, is currently working on devising technologies for controlling the processing within specific neural circuit targets in the brain. Boyden, 29, is also an alumnus of MIT, receiving his MEng and dual SBs in 1999.

Discover cited Boyden for his work on "engineering brain implants that can stimulate … with light pulses," which he hopes could help treat brain diseases including Parkinson's.

Ed Boyden

Sara Seager

"There are things that light can do that purely electric stimulators can't," Boyden noted in the magazine.

Seager, 36, the Ellen Swallow Richards Associate Professor of Planetary Science and an associate professor of physics, was cited for her work on the study of extrasolar planets and models that have "helped researchers make the first atmospheric measurements of a distant world."

"What I really want to do is figure out which kinds of gases extraterrestrial life might produce," Seager told Discover. "These gases would accumulate in the atmosphere and might be detectable from afar."

Seager, who joined MIT in 2007, was also part of a team that co-discovered the first detection of light emitted from an exoplanet and the first spectrum of an exoplanet.

The "Top 20 Under 40" list appears in the magazine's December issue. Institute Professor emeritus Noam Chomsky was also cited in the same issue as a lifetime achiever who has "redefined our understanding of ourselves as humans."

MIT football coach Dwight Smith retires

Thirty years after helping to relaunch football at MIT, Dwight Smith has decided to retire from coaching. The 1999 New England Football Conference Coach of the Year, Smith has been on the sidelines for every game in the modern history of Engineer football.

Taking over the reins as head coach of the Tech club program in 1979 after a one-year stint as an assistant, Smith led the Engineers into its first varsity game on Sept. 24, 1988. During Tech's 30-year run on the gridiron, Smith's unit compiled a 102-159-1 mark.

PHOTO / **WES FORNERO**

Dwight Smith

Persevering as the longtime commander of MIT football, Smith has picked up numerous awards and postseason accolades throughout his tenure. In 1983, Smith was named the New England College Football Conference Coach of the Year after guiding the Engineers to a 5-4 record. He was honored by the Eastern Collegiate Football Conference for his contributions to the league at the conclusion of the 1996 season, and was the ECFC Coach of the Year in 1997. In 1999, Smith was named co-Coach of the Year in the New England Football Conference. In 2007, Smith received the Ron Burton Distinguished American Award for Lifetime Achievement sponsored by the Jack Grinold Eastern Massachusetts Chapter of the National Football Foundation.

"So often in college sports, coaches use their current job as a stepping stone to the next job," noted Julie Soriero, director of athletics and head of DAPER. "In Dwight's case, the long history of his career here at MIT speaks to his commitment to his team and this institution; it is admirable. To wrap up this season with a number of unprecedented achievements and career records is a fitting way to conclude his historic career."

Smith, who will remain at MIT as a full-time professor in physical education, enjoyed a tremendous season in 2008 as the Engineers shattered a bevy of team records. MIT set single-season records for points, total offense, rushing yards, touchdowns and first downs while junior DeRon Brown closed out the season as the NCAA Division III leading rusher.

Obituaries

Gordon L. Brownell, professor emeritus, 86

Nuclear Science and Engineering Professor Emeritus Gordon L. Brownell PhD '50, a widely respected physicist and innovator, died at his home Tuesday, Nov. 11, following a long illness. He was 86.

Brownell played a key role in developing positron imaging and positron emission tomography. In the 1950s, together with neurosurgeon William H. Sweet of Massachusetts General Hospital, he pioneered the use of the technology to detect and locate brain tumors in human patients. In addition, Brownell developed boron neutron capture therapy for treatment of brain tumors.

Born in Duncan, Okla., and raised in New York and Pennsylvania, Brownell received his BSc from Bucknell University and his PhD in physics from MIT. During World War II, he served in the Navy Research Group to develop acoustic devices to detect deep-sea mines.

Brownell established the Physics Research Laboratory at MGH in 1950 and served as the honorary physicist in the Department of Radiology at MGH until his death. He was named professor at MIT in 1956 and served as a professor emeritus in the Department of Nuclear Science and Engineering at MIT until his death.

In 2002, Brownell's contributions to science were rewarded with election to the Institute of Medicine. More details on his achievements in imaging instrumentation can be found at www.mit.edu/~glb.

Though Brownell's life was largely consumed with scientific research, he was an avid world traveler and reader. In his later years, he was involved in real estate development in St. John, U.S. Virgin Islands.

In addition to his wife, Anna-Liisa (Pranni) Brownell, he is survived by six children: Wendy L. Silverman of Needham; Peter G. Brownell of Marlborough; David L. Brownell of Medway; James K. Brownell of Waltham; Piia J. DiMeco of Wilmington; and Janne K. Kairento of Beverly. He is also survived by a brother, Roscoe Brownell Jr., of Altoona, Pa., and seven grandchildren.

A funeral was held Saturday, Nov. 15, in the First Church in Salem. In lieu of flowers, memorial contributions may be made to The Gordon L. Brownell Scholarship Fund for the Advancement of Physics, c/o Salem Five Bank Acct. #773048947, 210 Essex St., Salem, MA 01970. For guest book and additional information please visit www.levesquefunerals.com.

Margaret Zarudny Freeman, touched many over long MIT career

Margaret Zarudny Freeman SM '34, who spent more than four decades at MIT as a student and staff member, died Oct. 23, just weeks before her 100th birthday.

Freeman was the oldest of five daughters and one son in a St. Petersburg, Russia, family. In 1919, her father, an engineer and steel factory director, went into self-exile in Manchuria. The rest of the Zarudny children later set out to follow him east across Russia to flee the Soviet Union, a trip she chronicled in her book, "Russia and Beyond: One Family's Journey, 1908-1935."

After arriving in California in 1931 and mastering the English language, she was able to realize her dream of gaining admission as a graduate student to MIT. She received her SM in mathematics in 1934, and although she had hoped to continue her education, the arrival of her four younger sisters in Boston led her to find work instead as a designer of steam turbines for General Electric.

In 1935, she married Harold Freeman, a fellow graduate student who went on to become a distinguished statistician in the MIT Department of Economics. In 1938, Freeman returned to MIT, working as an applied mathematician in the remarkable Wiener-Rosenblith electroencephalography project.

In the 1960s, with the growing interest in the Soviet Union, Freeman introduced Russian language instruction to MIT by volunteering to teach the language. She later led MIT's "language lab" — one of the first of its kind.

After her retirement in 1978, Freeman was named an associate professor emeritus.

Freeman leaves behind her sons, Arthur Freeman of London and Edward Freeman of Los Angeles; two sisters, Katerina Singleton of Providence and Zoya Chambers of New York; numerous nieces, nephews, grandnieces and grandnephews; relatives in Russia; and a host of devoted friends.

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Q&A with Jerry Grochow

In this interview, MIT Vice President for Information Services and Technology Jerrold "Jerry" Grochow shares his insights about the Institute's changing computing infrastructure and how it will benefit the community.

Q. When you talk with members of the community, what information technology (IT) services are they asking for?

A. It depends on who you talk to: Students want better capabilities in their dormitories, more Athena clusters, higher-speed networks. Faculty want advanced computing facilities for research. Administrative staff may talk about applications they use in their jobs — SAP, payroll and student systems.

In my conversations with members of the community, I don't just ask, "What IT services do you want?" but "What do you do here at MIT?" An important part of my job is to anticipate what the community is going to ask for tomorrow. Overlaying knowledge of IT trends with an understanding of what community members are doing helps to define where we should be going.

Q. A lot of research today requires collaboration across disciplines and between institutions. How is MIT's IT infrastructure addressing these needs?

A. IS&T has expanded MIT's computer network to major interconnection points for many research institutions, including CalTech, Argonne National Labs and CERN in Geneva. We can provide virtual dedicated networks to individual researchers in a way that wasn't possible until recently. With the ability to communicate at 10 gigabits a second, a researcher can now control an experiment halfway across the world in near-real time.

Q. Computers use a lot of power. Is IS&T finding ways to reduce the energy footprint on campus?

A. When President Hockfield announced the Energy Initiative, IS&T saw an opportunity to tackle some of these issues. About 8-10 percent of power use on campus is related to computers.

Displays use a lot of power, and IS&T has published guidelines on how to reduce power consumption. We're also changing our backup processes so that computers can be in a very low power state and awaken automatically for backup.

We've brought in virtualization software that allows better utilization of servers in both IS&T's data centers and academic departments. Before, you might have had five computers running different applications with each in use about 20 percent of the time; now you can have all of those applications on one computer. Virtualization reduces the number of physical computers you need which saves on space and power.

PHOTO / **RON HOFFMANN**

Vice President for Information Services and Technology Jerry Grochow

Q. What is IS&T working on now that will benefit the MIT community as a whole?

A. When you ask people what's the most important application they use every day, it's e-mail, with calendars and messaging as close seconds. Members of the community want to be able to use their smart phones to read their e-mail and schedule meetings. They want to push a single button and have that meeting show up on their desktop calendar as well. IS&T is exploring the best ways to provide integrated e-mail, calendaring and messaging, as well as position ourselves for the future of "location-aware" services. We are experimenting with Microsoft Exchange, with other open-source and commercial products, and with outsourced services to see what's most flexible and effective here at MIT.

We need to make sure that while providing diverse capabilities, all members of the community can talk and send messages and schedule meetings with each other. No matter how many options people want, they want them all to work together.

Q. How will the uncertain financial situation affect IT at MIT?

A. Much of MIT's IT spending is paid for from general Institute funds, and most of the rest is from research funds. IS&T is looking for ways to reduce costs by deferring or slowing down projects, and by making changes in our basic operations. Our goal is to serve the priority needs of the Institute. This is a time when the entire MIT community can be working to improve and simplify ways in which we do the business of MIT, including processes involving IT.

Awards&Honors

De Neufville wins Fulbright award; seven others coming to MIT

Richard L. de Neufville, a professor in the Engineering Systems Division and the Department of Civil and Environmental Engineering, was recently named a Fulbright scholar. De Neufville is one of approximately 1,000 faculty and staff from the United States to be given the award, which allows them to lecture and conduct research abroad.

In addition, seven foreign faculty and staff have been awarded Fulbright scholar awards to come to MIT. They are Patricia Almeida de Carvalho, an assistant professor from the Technical University of Lisbon; Luca Iandoli, an associate professor from the University of Naples Federico II; Yasser Revez Omar, an assistant professor from the Technical University of Lisbon; Anthoula Revythiadou, an assistant professor from the University of Aegean; Benoit Roman, a research fellow from the Polytechnical College in Paris; Carmel Rotschild, a doctoral student from the Israel Institute of Technology; and Xueli Wang, an associate professor from Tsinghua University.

MIT researchers receive American Heart Association grants

The American Heart Association announced that it has awarded new grants to four MIT researchers, with each of their awards effective July 1, 2008. The four recipients are Jeroen Saeij, an assistant professor in the Department of Biology; Chung Tin, a graduate student in the Department of Mechanical Engineering (MechE); Chen-rei Wan, a graduate student in MechE; and Eric Weiss, a graduate student in the Harvard-MIT Division of Health Sciences and Technology.

Graduate student wins $10K prize

Garrett Marino, a graduate student in the Department of Earth, Atmospheric and Planetary Sciences, was recently awarded the grand prize from the U.S. Department of Energy's inaugural Science and Energy Research Challenge (SERCh) at Oak Ridge National Laboratory (ORNL). Marino, who also interned at the ORNL this year, won the SERCh national poster competition and a $10,000 science scholarship.

Yoon named USA fellow

J. Meejin Yoon, an associate professor in the Department of Architecture, was named a United States Artists fellow recently, which carries with it a $50,000 prize to further her arts.

Math undergrads honored for excellence

Maria Monks, a junior in the Department of Mathematics, has been chosen to receive the Alice T. Schafer Prize for Undergraduate Women in Mathematics; and Doris Dobi, a senior, will receive an honorable mention. The award honors undergraduate woman for excellence in mathematics.

IS&T wins computing services newsletter award

Robyn Fizz and Lee Ridgway, of MIT Information Services and Technology, were recently honored by the ACM's Special Interest Group for University and College Computing Services (ACM SIGUCCS) for their published newsletter, which is distributed across campus. The awards recognize outstanding web sites, publications and promotional materials produced by higher education computing centers.

MIT Sloan garners international award

The MIT Sloan School of Management was named third-best business school in North America by EDUNIVERSAL, which ranked the top three schools in nine different geographical regions.

MIT EHS Office recognized by City of Cambridge

At the fall annual awards and recognition dinner for the Cambridge Fire Department, the MIT Environment, Health and Safety (EHS) Office, along with the Harvard Department of EHS, were recognized with a Certificate of Appreciation. CFD Deputy Chief Gerald Mahoney, while presenting the certificates, noted his department has "a relationship with both schools' EH&S staffs that allows us to call upon them not just for incidents on their respective campuses, but also to utilize their subject matter expertise at any time for any incident, 24 hours a day, seven days a week."

Events at MIT

Thursday, Nov. 20

• **Kick-Butt Great American Smoke-out Contest.** 12:15 p.m. in E25-Atrium. To mark this year's Great American Smokeout, MIT Medical is sponsoring a "Kick-Butt" contest. The participating teams have each built a deliberately over-engineered mechanical apparatus that will perform the simple task of extinguishing a cigarette in an extremely indirect and convoluted fashion.

• **Judicial Discretion Under the Federal Sentencing Guidelines: The Impact of Changes in the Standard of Review.** Speaker: Joshua Fischman (Virginia School of Law). 4:30-6 p.m. in E53-482.

• **"The Carrot at the End of the Stick: Prizes as Incentives for Innovation."** Part of Global Entrepreneurship Week @ MIT. Speakers: Erika Wagner, Executive Director of the MIT X Prize lab; David Ritter, CTO of InnoCentive; Benjamin Mako Hill, open-source programmer and advocate. 6-8 p.m. in 4-231.

Friday, Nov. 21

• **Futures of Entertainment 3.** All day Friday and Saturday in E51. Convergence culture has moved swiftly from buzzword to industry logic. The creation of transmedia storyworlds, understanding how to appeal to migratory audiences, and the production of digital extensions for traditional materials are becoming the bread and butter of working in the media. Futures of Entertainment 3 once again brings together key industry leaders who are shaping these new directions in our culture and academic scholars immersed in the investigation the social, cultural, political, economic, and technological implications of the changes in our media landscape.

Monday, Nov. 24

• **STS Colloquium: "Technological Leadership and American Hegemony."** Speaker: John Krige, Georgia Institute of Technology. 4-6 p.m. in E51-095. This talk will describe how the United States used its technological advantage in two key strategic domains, nuclear power and space, in an attempt to reconstruct postwar Europe.

Friday, Nov. 28

• **Friday After Thanksgiving: Chain Reaction.** 1-4 p.m. in W33, Rockwell Cage Gymnasium, 120 Vassar St. Whether it's the reaction induced between one creative contraption and another equally crafty contrivance, or the joyful reactions sparked on the faces of the spectators, the MIT Museum's Friday After Thanksgiving (F.A.T.) Chain Reaction is a one-of-a-kind, got-to-be-seen-to-be-believed engineering feat.

Tuesday, Dec. 2

• **2008 MIT Robotics Conference.** 8 a.m.-5 p.m. in E51-Wong Auditorium.

Submit your events!

Log on to events.mit.edu to add your events to MIT's online calendar. Select events will be selected from the online calendar to be published in Tech Talk each Wednesday.

Singing in slow motion

MIT work with songbirds could aid study of humans' timing

Cathryn Delude
McGovern Institute

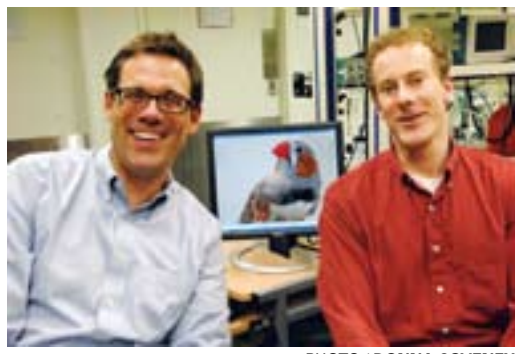


PHOTO / **DONNA COVENEY**

McGovern Institute Investigator Michale Fee, right, and postdoctoral student Michael Long.

As anyone who watched the Olympics can appreciate, timing matters when it comes to complex, sequential actions. It can make a difference between a perfect handspring and a fall, for instance. But what controls that timing? MIT scientists are closing in on the brain regions responsible, thanks to some technical advances and some help from songbirds.

"All our movements, from talking and walking to acrobatics or piano playing, are sequential behaviors," explained Michale Fee, an investigator in the McGovern Institute for Brain Research at MIT and an associate professor in MIT's Department of Brain and Cognitive Sciences. "But we haven't had the necessary tools to understand how timing is generated within the brain."

Now Fee and colleagues have reported in the Nov. 13 issue of Nature a new method for altering the speed of brain activity. And using that technique, "we think we have found the clock that controls the timing of the bird's song," Fee said.

The zebra finch's song is widely studied as a model for understanding how the brain produces complex behavior sequences. Each song lasts about one second, and contains multiple syllables in a highly stereotypic sequence. Two brain regions — the High Vocal Center (HVC) and the robust nucleus of the arcopallium (RA) — are known to be important for singing, because deactivating either region prevents song production. But uncovering the clock mechanism required a more subtle method.

Accordingly, Fee's group devised a technique to slow down different parts of the brain. They took advantage of the fact that all biological processes are influenced by temperature. Just as molasses run slower in January, neurons function more slowly when they are cooled down.

The authors constructed a tiny Peltier cooling apparatus based on a device similar to those used in portable electronic beverage coolers. Then they used this device to produce a small cooling effect localized to precise parts of the brain.

"We suspected that cooling different brain regions involved in singing might alter the song in different ways," explained first author Michael Long, a postdoctoral researcher in the Fee lab.

Cooling the RA brain region had almost no effect on the bird's song. But cooling HVC produced a dramatic effect. The song slowed in proportion to the degree of cooling, with the biggest temperature change (a 10 degrees Celsius reduction) causing the song to stretch out by around 30 percent.

Not only did the overall duration of the song increase, so did each individual syllable, so the overall rhythmic structure was preserved without changing the sounds within the song. The effect can be compared to a music box or piano roll. Rotating the drum more slowly slows the tempo of the music without affecting individual notes.

Following this analogy, HVC corresponds to the mechanism that turns the drum; cooling it is equivalent to reducing the speed of rotation. RA, which receives timing information from HVC, corresponds to the read-out mechanism that translates the sequence of bumps or holes into corresponding notes.

What intrigues Fee and colleagues now is: How does HVC work to control song timing? Their previous electrical recordings of individual HVC neurons suggest it functions like a cascade of falling dominoes, with waves of activity propagating at a fixed speed through the neural circuitry — an idea they are now testing.

"We can also use this cooling technology to discover which brain regions control the timing of different complex behaviors in different animals, something that has been very difficult to assess until now," Fee said. "We know that HVC is related in some ways to [the] human cortex, so it could be showing us a very general mechanism for representing the passage of time within the brain."

BC, MIT scientists find a new class of catalysts

A new class of exceptionally effective chemical catalysts that promote the powerful olefin metathesis reaction has been discovered by a team of Boston College and MIT scientists, opening up a vast new scientific platform to researchers in medicine, biology and materials.

The new catalysts can be easily prepared and possess unique features never before utilized by chemists, according to findings from a team led by professors Amir Hoveyda of BC and Richard Schrock of MIT. The team's findings were reported in the Nov. 16 online edition of the journal Nature.

Catalytic olefin metathesis transforms simple molecules into complex ones. But a chief challenge has been developing catalysts to this organic chemical reaction that are practical and offer exceptional selectivity for a significantly broader range of reactions.

Schrock, the Frederick G. Keyes Professor of Chemistry at MIT who won the 2005 Nobel Prize in chemistry, said the unprecedented level of control the new class of catalysts provides will advance research across multiple fields.

"We expect this highly flexible palette of catalysts to be useful for a wide variety of catalytic reactions that are catalyzed by a high oxidation state alkylidene species, and to be able to design catalytic metathesis reactions with a control that has rarely if ever been observed before," Schrock said.

The findings mark the latest discovery from the long-standing collaboration between the Hoveyda and Schrock labs, work that has been supported by more than $3.5 million in funding from the National Institutes of Health for nearly a decade.

(Adapted from a news release issued by Boston College)

Early warning of dangerous asteroids and comets

Detectors developed at Lincoln Laboratory deployed in powerful telescope

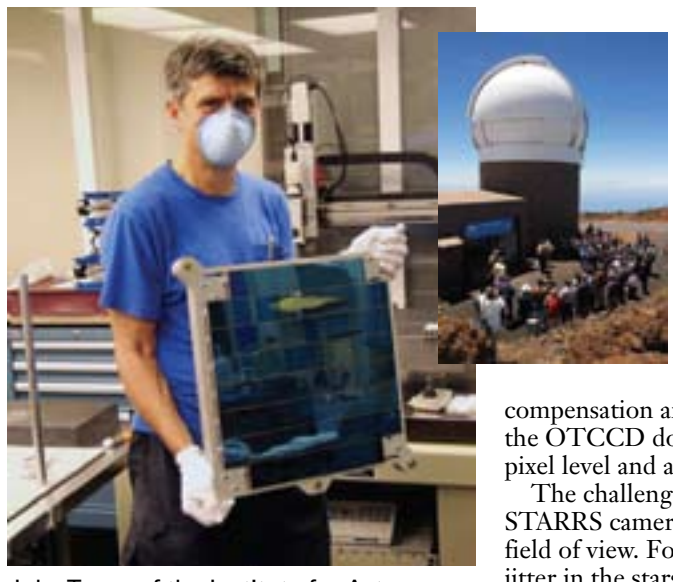
Dorothy Ryan
MIT Lincoln Laboratory Communications Office

Silicon chips developed at MIT Lincoln Laboratory are at the heart of a new survey telescope that will soon provide a more than fivefold improvement in scientists' ability to detect asteroids and comets that could someday pose a threat to the planet.

The prototype telescope installed on Haleakala mountain, Maui, will begin operation this December. It will feature the world's largest and most advanced digital camera, using the Lincoln Laboratory silicon chips. This telescope is the first of four that will be housed together in one dome. The system, called Pan-STARRS (for Panoramic Survey Telescope and Rapid Response System), is being developed at the University of Hawaii's Institute for Astronomy.

"This is a truly giant instrument," said University of Hawaii astronomer John Tonry, who led the team developing the new 1.4-gigapixel camera. "We get an image that is 38,000 by 38,000 pixels in size, or about 200 times larger than you get in a high-end consumer digital camera."

Pan-STARRS, whose cameras cover an area of sky six times the width of the full moon and can detect stars 10 million times fainter than those visible to the naked eye, is also unique in its ability to find moving or variable objects.



John Tonry of the Institute for Astronomy holds an entire array of 60 chips; an array of 60 OTAs will be installed in the focal plane of each of the four cameras in the Pan-STARRS facility. Inset, the Pan-STARRS 1 prototype in Maui.

Lincoln Laboratory's charge-coupled device (CCD) technology is a key enabling technology for the telescope's camera. In the mid-1990s, Lincoln Laboratory researchers Barry Burke and Dick Savoye of the Advanced Imaging Technology Group, in collaboration with Tonry, who was then working at MIT, developed the orthogonal-transfer charge-coupled device (OTCCD), a CCD that can shift its pixels to cancel the effects of random image motion. Many consumer digital cameras use a moving lens or chip mount to provide camera-motion compensation and thus reduce blur, but the OTCCD does this electronically at the pixel level and at much higher speeds.

The challenge presented by the Pan-STARRS camera is its exceptionally wide field of view. For wide fields of view, jitter in the stars begins to vary across the image, and an OTCCD with its single shift pattern for all the pixels begins to lose its effectiveness. The solution for Pan-STARRS, proposed by Tonry and developed in collaboration with Lincoln Laboratory, was to make an array of 60 small, separate OTCCDs on a single silicon chip. This architecture enabled independent shifts optimized for tracking the varied image motion across a wide scene.

"Not only was Lincoln the only place where the OTCCD had been demonstrated, but the added features that Pan-STARRS needed made the design much more complicated," said Burke, who has been working on the Pan-STARRS project. "It is fair to say that Lincoln was, and is, uniquely equipped in chip design, wafer processing, packaging, and testing to deliver such technology."

The primary mission of Pan-STARRS is to detect Earth-approaching asteroids and comets that could be dangerous to the planet. When the system becomes fully operational, the entire sky visible from Hawaii (about three-quarters of the total sky) will be photographed at least once a week, and all images will be entered into powerful computers at the Maui High Performance Computer Center. Scientists at the center will analyze the images for changes that could reveal a previously unknown asteroid. They will also combine data from several images to calculate the orbits of asteroids, looking for indications that an asteroid may be on a collision course with Earth.

Pan-STARRS will also be used to catalog 99 percent of stars in the northern hemisphere that have ever been observed by visible light, including stars from nearby galaxies. In addition, the Pan-STARRS survey of the whole sky will present astronomers with the opportunity to discover, and monitor, planets around other stars, as well as rare explosive objects in other galaxies.

Detailed information about the Pan-STARRS design and its science applications can be found at http://pan-starrs.ifa.hawaii.edu/public/. The project was funded by the U.S. Air Force Research Laboratory.

Untangling DNA regulation

Biologists theorize role for DNA packaging in stem cell development

Anne Trafton
News Office

MIT biologists have discovered that the organization of DNA's packing material plays a critical role in directing stem cells to become different types of adult cells.

The work, published in the journal Cell on Nov. 14, could also shed light on the possible role of DNA packaging in cancer development.

Led by Laurie Boyer, assistant professor of biology at MIT, the researchers examined the role of chromatin — the structure that forms when DNA is wound around a core of proteins called histones.

"We're particularly interested in how chromatin structure influences gene expression and ultimately cell fate," Boyer said. "We hope the studies we are doing can lead to better understanding of development as well as certain diseases."

It has been theorized that cancer cells may overexpress genes involved in early embryonic development, allowing them to proliferate unchecked and regress from adult tissue cells to a stem cell-like state.

Such regression could be partly mediated by changes in chromatin. This packaging is believed to help control DNA transcription because the more tightly wound the chromatin is, the less accessible DNA is to be transcribed.

The new study focused on a variant type of histone known as H2AZ, which other researchers have recently identified as a protein of interest in cancer.

While H2AZ is ubiquitously expressed in many cell types including adult cells, it is essential for normal embryonic development. The new research reveals why: The variant histones are found near the promoter regions of a particular set of genes important for development.

The same genes are also regulated by a group of proteins known as Polycomb group (PcG) proteins, which act as gene silencers.

"It suggests that this histone variant — along with the Polycomb group proteins — may act as some kind of regulatory switch that mediates cell fate transitions," Boyer said. "We hypothesize that they're working together, and that allows these genes to be silent yet poised for activation in stem cells."

In future studies, Boyer's team plans to look at patterns of H2AZ distribution in cancerous cells.

Lead authors of the paper are Whitehead Institute postdoctoral associates Menno Creyghton and Styliani Markoulaki. Other authors are Whitehead postdoctoral associates Stuart Levine and Jacob Hanna; graduate student Michael Lodato; Ky Sha, a postdoctoral associate in biology; Richard Young, professor of biology; and Rudolf Jaenisch, professor of biology and member of the Whitehead Institute.

The research was funded by the Dutch Cancer Foundation, the Helen Hay Whitney Foundation, the National Institutes of Health and Genzyme Corp.

Media Lab creates Center for Future Storytelling

Teams up with Plymouth Rock Studios to reinvent the movies

The MIT Media Laboratory announced Tuesday the creation of the Center for Future Storytelling, made possible through a seven-year, $25 million commitment from Plymouth Rock Studios, a major motion picture and television studio that is expected to open in 2010 in Plymouth, Mass.

With the establishment of the center, whose research program begins immediately, the Media Lab and Plymouth Rock Studios will collaborate to revolutionize how we tell our stories, from major motion pictures to peer-to-peer multimedia sharing. By applying leading-edge technologies to make stories more interactive, improvisational and social, researchers will seek to transform audiences into active participants in the storytelling process, bridging the real and virtual worlds, and allowing everyone to make their own unique stories with user-generated content on the Web. Research will also focus on ways to revolutionize imaging and display technologies, including developing next-generation cameras and programmable studios, making movie production more versatile and economic.

"Storytelling is at the very root of what makes us uniquely human," said Frank Moss, Media Lab director and holder of the Jerome Wiesner Professorship of Media Arts and Sciences. "It is how we share our experiences, learn from our past, and imagine our future. But how we tell our stories depends on another uniquely human characteristic — our ability to invent and harness technology. From the printing press to the Internet, technology has given people new ways to tell their stories, allowing them to reach new levels of creativity and personal fulfillment. The shared vision of the MIT Media Lab and Plymouth Rock Studios allows us to take the next quantum leap in storytelling, empowering ordinary people to connect in extraordinary ways."

"This is a great opportunity to draw on the exceptional intelligence and innovation for which the Media Lab is known worldwide," said David Kirkpatrick, chairman and executive managing officer of Plymouth Rock Studios and former president of Paramount's Motion Picture Group. "Plymouth Rock Studios was conceived as a source for innovation and as a proving ground for new storytelling technologies. This collaboration will transform the movie-making model, and erase some of the technology barriers that constrain the narrative form."

The Center for Future Storytelling will be co-directed by three Media Lab principal investigators: V. Michael Bove Jr., an expert in object-based media and interactive television; LG Associate Professor Cynthia Breazeal, a leader in the field of personal robots and human-robot interaction; and Associate Professor Ramesh Raskar, a pioneer in the development of new imaging, display and performance-capture technologies.

Research will range from on-set motion capture to accurately and unobtrusively merge human performers and digital character models; to next-generation synthetic performer technologies, such as richly interactive, highly expressive robotic or animated characters; to cameras that will spawn entirely new visual art forms; to morphable movie studios, where one studio can be turned into many through advanced visual imaging techniques; to holographic TV. It will draw on technologies pioneered at the Media Lab, such as digital systems that understand people at an emotional level, or cameras capable of capturing the intent of the storyteller.

"We see this as an experiment in collaborative education, but also as a bold adventure in business innovation that could have significance well beyond the motion picture industry," Moss said.

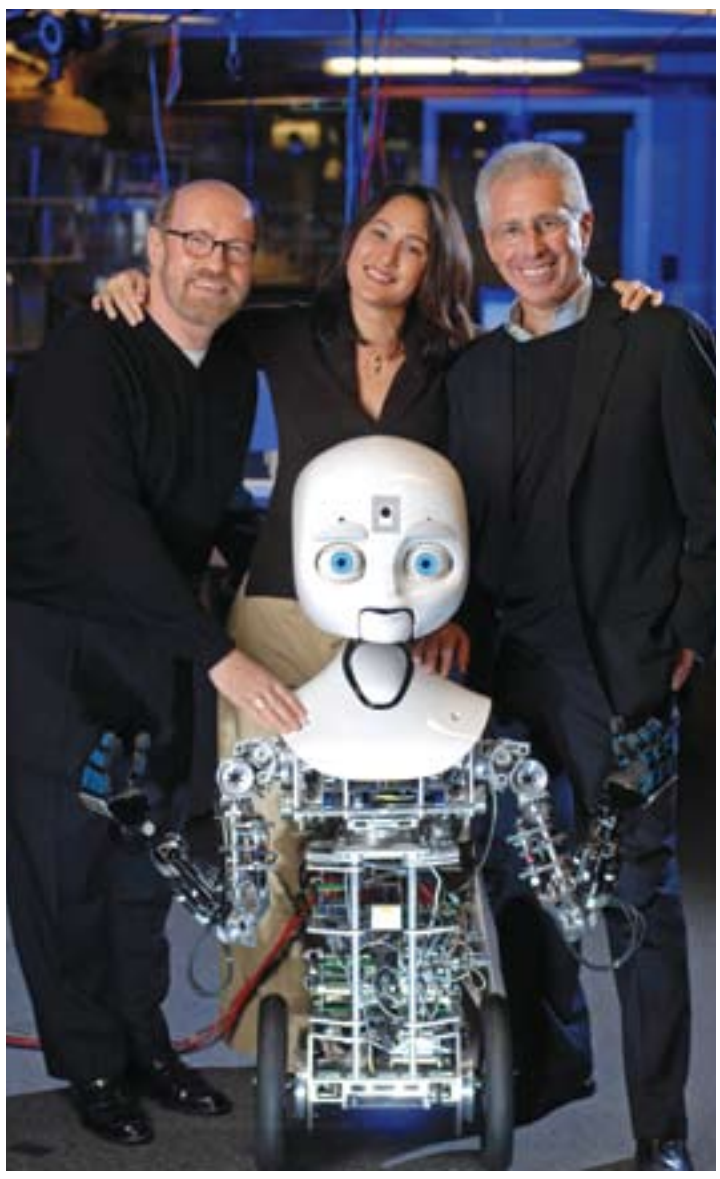


PHOTO / **SAM OGDEN**

From left to right, David Kirkpatrick, chairman of Plymouth Rock Studios, Cynthia Breazeal, co-director of Media Lab's Center for Future Storytelling, and Frank Moss, director of the MIT Media Lab, stand with Nexi, a mobile, dexterous social robot developed by Breazeal's Personal Robots research group.

PHOTO / **DONNA COVENEY**

Senior Paul Blascovich, left, watches a surgical robot operating while teaching assistant Lael Odhner plays with arm. JuniorTony McDonald, back, Junior Ian Rust, center, and instructor Harrison Chin also look on.

Under the (robotic) knife

Engineering students design robots to remove tumors

Anne Trafton
News Office

MIT students will take to the operating table next Monday, Nov. 24, to show off their robotic engineering skills in the final presentations for Course 2.12 (Introduction to Robotics).

Four teams of students have spent the past seven weeks building robotic arms and writing software that will allow them to remotely make an incision in a silicone "organ" and remove a jelly bean masquerading as a tumor.

The final presentation will be held at 3 p.m. Monday in Room 1-005.

Surgery is a rapidly growing sector of robotics business, says Professor of Mechanical Engineering Harry Asada, who teaches the course.

"Augmenting a surgeon's skills and expertise with superb precision and dexterity of robotic devices, we can expect highly reliable, minimally invasive surgical operations," he says. "However, there are many technical challenges to make the system truly useful."

The course emphasis is on learning to design a robot that can perform a specific task and operate within a confined space, says Harrison Chin, laboratory instructor for the class.

Past years' course assignments include building search and rescue robots, and building robots for automated inspection of Big Dig tunnels.

"We try to motivate it with a real world problem," says Lael Odhner, one of the laboratory TAs for the class and a graduate student in mechanical engineering.

Financial crisis could slow energy research

David Chandler
News Office

A panel of experts at an MIT Energy Initiative research conference on Thursday, Nov. 13, tried to assess the likely impact of the ongoing financial crisis on energy issues, and found no simple answers as to what can be expected. But they suggested that falling oil prices and the uncertainties in financial markets could slow the development of new energy technologies and supplies.

David Hobbs, vice president of Cambridge Energy Research Associates, said that the investment cycle for energy development is on such a long time scale that there is a significant lag in responding to changing circumstances. Right now there are major new sources of supply about to come online in oil, natural gas and coal, just at a time when demand is falling, along with prices, because of the troubled economic situation.

For example, an armada of new liquefied natural gas tankers is about to come into service, bringing to market a huge quantity of gas for which "the demand doesn't exist," he said, largely because high prices have led to an influx of new alternative sources. And there is a similar disparity between demand and new sources of supply for coal, he said.

People had predicted that coal would never rise above a price of $30 a ton, but it is now $200 or more. As a result, instead of rising, demand this year has been flat and is expected to be flat next year as well. Meanwhile, forecasts of demand for oil have already been knocked down by 10 million barrels a day, he said, and even that may be an overestimate.

It's a difficult time for any company to invest in developing new energy supplies, because of these long lead times. How can anyone predict "what the economy is going to require in five years?" As a result, he said, "we could see a hiatus in investing in new supplies." But that could lead to a new cycle. "Underinvestment and low prices lead to another spike in prices," he said.

> *This is a situation where the financial sector has experienced a shock that has spilled over into the real economy.*
>
> **John Reed**
> **Retired Citigroup chairman**

Gregory McRae, a professor of chemical engineering at MIT, said that one of the more subtle impacts of the economic crisis is on the way energy companies themselves are valued. Even the definition of such things as "proven reserves" of oil, coal or natural gas can be affected. Proven reserves mean those that "under present economic conditions are recoverable at a reasonable price." But if oil prices continue to plummet, that changes the equation significantly.

Falling oil prices have other effects as well, for example,"whether the alternatives become viable," McRae said. "A lot of alternatives don't look very attractive" when oil prices fall below about $80 a barrel, he said, and they are currently below $60.

But even though the economy is shaky right now, McRae said, at the same time, "there are enormous sets of opportunity" for profitable ventures in the energy sector. Businesses would do well to "focus on energy costs" and ways of reducing them. Many of the models they currently use to analyze their energy use patterns, he said, are quite old and need to be updated.

The genesis of the crisis, said John Reed, retired chairman of Citigroup, had nothing to do with the "real economy," but rather was confined to the narrower world of the financial sector. "This is a situation where the financial sector has experienced a shock that has spilled over into the real economy," he said. "There was nothing in the real economy that had to do with this."

But, Reed said, while people tend to see the money being spent on a federal "bailout" of financial institutions as being money lost, in fact, "the government is going to make a lot of money on this," he said, because it was "able to pick up assets on good terms."

CARBON: MIT analysis shows how cap-and-trade plans can cut greenhouse gas emissions

Continued from **Page 1**

associated with long-term, short-term and start-up costs.

The report's third section examined the relationship between state and federal regulations on greenhouse gas emissions. With no federal policy now in place, many states are moving forward with their own initiatives, which range from commitments to reduce greenhouse gases to a regional, multistate cap-and-trade program slated to begin in 2009.

While federal legislation is expected in the next few years, it is unclear how it will define the relationship between a federal cap-and-trade program and other state or regional initiatives. The report analyzes the economic and environmental impacts of the range of possible interactions between the federal program and state or regional programs.

Differences in the abatement costs among states can create economic inefficiencies that make achievement of the climate goal more costly than it need be. This inefficiency can be avoided by either federal preemption of duplicative state programs, the authors found, or by a "carve out" of more demanding state programs from the federal cap with linkage.

In addition to Ellerman, the research was co-authored by Mort D. Webster, assistant professor of engineering systems in the Engineering Systems Division; John Parsons, senior lecturer at the Sloan School and Executive Director of the Center for Energy and Environmental Policy Research (CEEPR); Henry D. Jacoby, professor of management at the Sloan School and Co-Director, Joint Program on the Science and Policy of Global Change; and Meghan McGuinness, who was a researcher in the CEEPR. The study was funded by the Doris Duke Charitable Foundation.

PHOTO / **YING SHI**

If you build it ...

Earlier this month, MIT student volunteers helped build a home for a family in need in Bedford, Mass. Several of the MIT students took a break from hammering and sawing to explain their role in the project, which can be seen in an audio slideshow available on the News Office web site at web.mit.edu/newsoffice/2008/habitat-1112.html.

BACKPACKS: Cells could ferry drugs

Continued from **Page 1**

payload, and the top layer serves as a "hook" that catches and binds cells.

Once the layers are set up, cells enter the system and flow across the surface, getting stuck on the polymer hooks. The patch is then detached from the surface by simply lowering the temperature, and the cells float away, with backpacks attached.

"The rest of the cell is untouched and able to interact with the environment," said Albert Swiston, lead author of the paper and a graduate student in materials science and engineering.

The researchers found that T cells with backpacks were able to perform their normal functions, including migrating across a surface, just as they would without anything attached.

By loading the backpacks with magnetic nanoparticles, the researchers can control the cells' movement with a magnetic field.

Because the polymer synthesis and assembly takes place before the patches are attached to cells, there is plenty of opportunity to tweak the process to improve the polymers' effectiveness and ensure they won't be toxic to cells, the researchers say.

Other authors of the paper are Soong Ho Um, a postdoctoral associate in the Departments of Materials Science and Engineering and Biological Engineering, and Connie Cheng, a recent Harvard graduate.

The research was funded by the National Science Foundation Materials Research Science and Engineering Center and an NSF Graduate Research Fellowship.

No Tech Talk on Nov. 26

Because of Thanksgiving, there will be no Tech Talk next week. For updated coverage of MIT news, please see our web site at http://web.mit.edu/newsoffice.

MIT helps launch interactive video education project in Jordan

Two MIT professors traveled to Jordan this month to help kick off a new initiative called Blended Learning Open Source Science or Math Studies (BLOSSOMS), a joint international collaboration of educators from the United States, Jordan and Pakistan.

Richard Larson, director of the Center for Engineering Systems Fundamentals and the Mitsui Professor of Engineering Systems and Civil and Environmental Engineering, and Walter Lewin, professor of physics, traveled to meet counterparts in Jordan — including educators from Jordan University, the Jordan University of Science and Technology and the Jordan Educational Initiative — who will help run the BLOSSOMS program.

BLOSSOMS aims to develop a large, free repository of science and math interactive video modules for high school students created by gifted volunteer teachers from around the world, seeded initially by MIT faculty members and partnering educators in Jordan and Pakistan. The project seeks to develop deeper and richer skills in high school students, to enhance their critical-thinking skills and to motivate them to pursue careers in science, math or engineering.

Economics for Obama

PHOTO / **DONNA COVENEY**

Institute Professor emeritus and Nobel Prize winner Robert Solow, right, and Harvard University professor N. Gregory Mankiw PhD '84, left, took part in a panel discussion Thursday, Nov. 13, examining economic policies for President-elect Barack Obama. Mitsui Professor of Economics James Poterba, middle, chaired the panel.

Solow, Mankiw see promising future, short-term problems

Patrick Gillooly
News Office

Two renowned economists agreed Thursday, Nov. 13, that America is facing several major challenges with economic implications — including health care costs, climate change and the credit crunch — but differed on how President-elect Barack Obama should handle those crises efficiently.

MIT Institute Professor emeritus Robert Solow and Harvard economist N. Gregory Mankiw spoke in front of a packed Wang Auditorium on the topic of "Economic policies for the next U.S. president," a forum co-sponsored by the Department of Economics and the Undergraduate Economics Association.

Solow expressed excitement for the new administration ("I voted for Obama and I didn't hesitate for a second") while also noting the troubles that may lie ahead ("I don't expect miracles of economic policy from the Obama administration"). But, he noted, policymaking is about more than one person.

"The two-party system goes against economic miracles," Solow said.

Despite a freezing of "plain-vanilla lending" — commercial and generally safe lending — there is no reason to be completely doom-and-gloom, he said. "The productive capacity of the economy is still there."

"The first order of business ought to be to do something about fending off the recession," he said. "Anything that is done along that line will have to be done through fiscal policy."

Solow also credited the steps already made by Federal Reserve Chairman Ben Bernanke PhD '79, comparing him to Captain Kirk from Star Trek. "He has loaned where no man has loaned before."

Mankiw said he had "a lot of respect for what is going on in the Obama administration," especially since the president-elect has surrounded himself with several advisors who have "Cambridge connections" — either with MIT or Harvard.

But he also said "the long-term budget looks pretty dire," and that seeing Obama put together a long-term budget "is going to be very interesting."

Mankiw agreed with some policies that Obama has expressed support for in the past, including fully auctioned cap-and-trade carbon programs. He was "most skeptical," however, on certain international trade proposals, including one to renegotiate the North American Free Trade Agreement (NAFTA) and on limiting the import of sugar-based ethanol from Brazil.

"My view is that all those views are wrong, and my thought is that the economists advising him think they are wrong. The question is, in what direction will he head?" Mankiw said.

The U.S. also needs to move away from an economy where many top earners come from the financial sector, as it is leading to more inequality, Mankiw said.

"A lot of these high incomes come in the financial services industry, and I think that needs to stop," he said. "Economic growth that is primarily finance based is unsatisfactory."

While taking steps in the short term may pay off now, Solow said it would be unwise to think that results would be immediate.

"Whatever happens now, the federal deficit is going to be close to a trillion dollars."

A brief question and answer session following the forum brought forth the question of General Motors and whether the government should bail it out as it did for Wall Street's financial firms.

"When do you stop? Once you get through the auto industry there will be other industries [asking for money] as well," Solow said, pointing out a bigger problem that is "not about GM, but about fixing a nonsensical system that fixes health care to employment."

Mankiw suggested offering money, but only if there was private investment to back it up.

"There's no point putting public money into a company that no private investor deems viable," he said.

News in brief

Open enrollment closes on Nov. 21

Don't forget that any benefits changes for 2009 must be made by the Open Enrollment deadline, which is at 4 p.m. on Nov. 21. All benefits-eligible faculty and staff are eligible to enroll or make changes to their medical and dental coverage, enroll in flexible spending accounts, and review all benefits at MIT up until this deadline.

To enroll in your 2009 benefits, visit http://web.mit.edu/sapwebss/PS1/benefits_home.shtml.

Global Entrepreneurship Week running this week

More than two dozen MIT departments and student organizations are combining efforts to help celebrate Global Entrepreneurship Week, which started on Nov. 17 and runs until Nov. 23.

The week, spearheaded by the Ewing Marion Kauffman Foundation, is the first-ever international celebration of enterprising behavior as a way to engage young people in entrepreneurship — something that already happens quite naturally across the MIT community. With different events that spotlight networking, entrepreneurial success stories, MIT alumni entrepreneurs and more, Global Entrepreneurship Week at MIT will bring together members of MIT's community to celebrate the unique entrepreneurial energy created by students, faculty, staff and alumni.

For full details and a calendar of events and activities, please go to the Global Entrepreneurship at MIT web site at http://enterpriseforum.mit.edu/eweek.html.

Legatum Center announces IAP Seed Grants

Are you an aspiring entrepreneur who is interested in the role of the private sector in the developing world? Have an idea for a business that you think can make a difference?

Applications are now being accepted for a seed grant from the Legatum Center for Development and Entrepreneurship at MIT and turn these ideas into reality.

MIT undergraduate and graduate students are invited to apply for up to $2,000 in funding to support projects investigating the development of for-profit businesses in low-income countries during the 2008-2009 IAP session. Grants are distributed through a competitive selection process that takes into account the viability and impact of each project proposal. Seed grant applications must be submitted online by 1 p.m. on Nov. 21.

For complete seed grant application instructions, and to learn more about the Legatum Center, please visit our web site at http://legatum.mit.edu/grant.

Blood drive at MIT through Friday

MIT's American Red Cross Team and Network is conducting a blood drive though the rest of this week in La Sala de Puerto Rico on the second floor of the MIT Student Center.

Remaining dates and times for the blood drive are:

Today — noon to 6 p.m.
Thursday, Nov. 20 — noon to 6 p.m.
Friday, Nov. 21 — noon to 6 p.m.

For more information or to make an appointment, visit http://web.mit.edu/blood-drive/www/.

Faculty meeting today

A regular meeting of the faculty will take place today at 3:30 p.m. in Room 10-250 . The agenda includes:

- A proposal to revise the general institute requirements;
- An update on underrepresented minority faculty and graduate student recruitment and retention;
- An update from the Initiative on Faculty Race and Diversity.

CLASSIFIED ADS

Members of the MIT community may submit one ad each issue. Ads should be 30 words maximum; they will be edited. Submit by e-mail to ttads@mit.edu or mail to Classifieds, Rm 11-400. Deadline is noon Wednesday the week before publication.

FOR SALE

1979 Cessna 172N, Bedford. Buy ¼ partnership: $11,625. Dual nav-com radios, ADF, transponder altitude encoder, Loran Northstar M1, Lycoming O-320-H2AD T modification. Airframe 2975 hrs; engine, 1880 hrs. Sanchez 781-981-7821.

Classic antique gate leg table. Excellent condition. Fits snugly against a wall or works well as sofa table. Seats 4 when open. 30"H x 34L" x 13"W when closed, but 50W" when open. Convenient storage with drawer at one end. $150.00. Photos available.

Attractive light-colored oak dining or work table with four folding wooden, cane-seated chairs. Table is 59" long by 33" wide and 30" high with two solid oak trestle-style supports and cross beam of the same finish as top. Caned seats in excellent condition. Table very easily disassembled to store flat, so also ideal for extra seating at the holidays. Asking $140. Must be picked up. Call 781-721-1217.

Keyboard: Technic model SXK700. AC power. MIDI connection, $50. Oriental rug: Hand-woven Indian Oriental. 8 x 12'. Yellow/gold tones. Excellent condition! $150. Garden Fountain: Shell-shaped pool, 2 feet tall. Good condition, $125. Call (978) 474-5059.

Apple i-Touch, 16 GB, about 1 year old, rarely used. There are some light scratches on the back of the case, but otherwise in very good condition. In original box with all accessories. $175. Please contact jward@mit.edu

Sony AM/FM Stereo radio. mdl:STR-DE-197 with Remote. New in Box, NEVER OPENED! 250 watts, 4hz to 20khz, Dolby Pro Logic,2 audio inputs, 1 audio output, AB switching,Fantastic receiver. $95,00. (781) 893-3377, k1cei@comcast.net.

For Sale: Nativity Hummels with Stable. Includes (16) figures up to 7" high, stable 29w x 14h x 12dp. Price $500. Call 617-452-2327.

Winter coat: Ladies' grey tweed-look coat, below-knee length, size 12-14, like new, $35. Men's ties, like-new, $2 each. Rosalie 781-391-1307.

FOR RENT

Waltham: Sunny 6 bedroom townhouse. Newly renovated. 3 full bathrooms, total 10 Rms, new kitchen, off St. parking, hard floor, close to Bus and rail, half hour driving to MIT, $2950, utility not included, no pets, no smoking. Contact feng@psfc.mit.edu

Vermont vacation home for rent. Located at Okemo mountain resort. Newly built 3bdrm plus loft, 2 full baths great location ss kitchen, hardwood floors etc call 617-650-7361

East Boston, 5 Rms, 3Bdrms, w&d, remodeled, Lg Yard and Porch. 5 Min walk to T. No Pets please. $1250/monthly. Call Joanne 617-567-3627 or 857-891-4477

Office and R&D Space for Rent. Excellent office-R&D space in West Newton at Exit 16 of Masspike. 10 minutes from MIT. Ample parking, fully heated and AC. Some office furniture and cubicles available.

MISCELLANEOUS

Wanted: A place to stay (condo, apt., etc.) within 30 minutes of Sunday River, ME. Will be used by 2 adults and 2 children, ages 8 + 10, for weekend ski trips. email: elk@mit.edu or call 603-318-6262.

The 9th International Conference on Greenhouse Gas Control Technologies (GHGT-9), organized by MIT in collaboration with the IEA Greenhouse Gas R&D Programme (IEA GHG), with sponsorship from the U.S. Department of Energy, is taking place this week in Washington, D.C. It features several MIT papers on greenhouse gas control and reduction.

A quicker, easier way to make coal cleaner

Nancy Stauffer
MIT Energy Initiative

Construction of new coal-fired power plants in the United States is in danger of coming to a standstill, partly due to the high cost of the requirement — whether existing or anticipated — to capture all emissions of carbon dioxide, an important greenhouse gas. But an MIT analysis suggests an intermediate step that could get construction moving again, allowing the nation to fend off growing electricity shortages using our most-abundant, least-expensive fuel while also reducing emissions.

Instead of capturing all of its CO2 emissions, plants could capture a significant fraction of those emissions with less costly changes in plant design and operation, the MIT analysis shows.

"Our approach — 'partial capture' — can get CO2 emissions from coal-burning plants down to emissions levels of natural-gas power plants," said Ashleigh Hildebrand, a graduate student in chemical engineering and the Technology and Policy Program. "Policies such as California's Emissions Performance Standards could be met by coal plants using partial capture rather than having to rely solely on natural gas, which is increasingly imported and subject to high and volatile prices."

Hildebrand will present her findings on Nov. 18 at the 9th International Conference on Greenhouse Gas Control Technologies in Washington, D.C. Her co-author is Howard J. Herzog, principal research engineer at the MIT Energy Initiative and chair of the conference organizing committee.

The United States is facing a pressing need for more power plants that run essentially all the time. Renewable sources aren't suited to the task, nuclear plants can't be built quickly enough, and expanded reliance on natural gas raises price and energy-security concerns. Coal, which now supplies more than half of all U.S. electricity, seems the best option.

But as several states have started to regulate CO2 emissions, and others are expected to follow suit, some of the luster has come off coal. Amid the uncertainty, no one wants to be the "first mover" on building a new coal plant incorporating carbon capture and storage (CCS). Depending on the type of plant, carbon capture alone can increase the initial capital cost by 30 to 60 percent and decrease plant efficiency so that the cost per kilowatt-hour rises. That high cost would reduce a plant's economic competitiveness, meaning it might be called on to run on a limited basis, or not at all. Plus, CCS hasn't been proved at full scale, so no one knows exactly what to expect.

In Herzog's view, the call for full carbon capture is "a policy of inaction, a policy that won't move forward either new coal plants or the CCS technology." Partial capture could be a viable intermediate step.

The push for full capture (defined as 90 percent of total plant emissions) is in part economic: Everyone assumed that 90 percent capture would — due to economies of scale — yield the lowest cost per ton of CO2 removed. Anything less than 90 percent would mean a higher per-ton cost.

To investigate that assumption, Hildebrand and Herzog modeled the technological changes and costs involved in capturing fractions ranging from zero to 90 percent. The model takes into account technological breakpoints. For example, carbon capture is achieved by a series of devices that absorb CO2, release it and compress it. Full capture may require two or more parallel series.

The model confirms that the cost per ton of CO2 removed declines as the number of captured tons increases. Not surprisingly, when the second series is added, cost per ton goes up, but it then quickly levels off. Cost per ton is thus roughly the same at, say, 60 percent capture as it is at 90 percent capture. Since there are no economies of scale to be gained by going to 90 percent, companies can remove less — and significantly reduce their initial capital investment as well as the drop in efficiency once the plant is running.

The researchers conclude that as a near-term measure, partial capture looks promising. New coal plants with lower CO2 emissions would generate much-needed electricity while also demonstrating carbon capture and providing a setting for testing CO2 storage — steps that will accelerate the large-scale deployment of full capture in the future.

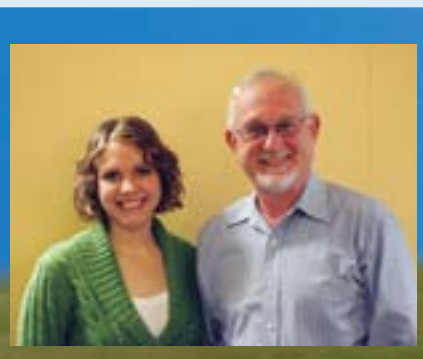


PHOTO / **RAMYA SANKAR**

MIT's Ashleigh Hildebrand and Howard Herzog are working toward a more ecofriendly option for coal power plants.

Burying the greenhouse gas

New tool could aid safe underground storage of CO2

Deborah Halber
Civil and Environmental Engineering

To prevent global warming, researchers and policymakers are exploring a variety of options to significantly cut the amount of carbon dioxide that reaches the atmosphere. One possible approach involves capturing greenhouse gases such as carbon dioxide at the source — an electric power plant, for example — and then injecting them underground.

While theoretically promising, the technique has never been tested in a full-scale industrial operation. But now MIT engineers have come up with a new software tool to determine how much CO2 can be sequestered safely in geological formations.

The work will be reported Nov. 18 at the 9th International Conference on Greenhouse Gas Control Technologies (GHGT-9), to be held Nov. 16-20 in Washington, D.C.

According to the 2007 MIT study, "The Future of Coal," and other sources, capturing CO2 at coal-burning power plants and storing it in deep geological basins will mitigate its negative effects on the atmosphere.

However, injecting too much CO2 could create or enlarge underground faults that may become conduits for CO2 to travel back up to the atmosphere, said Ruben Juanes, assistant professor of civil and environmental engineering (CEE) and one of the authors of the work. "Our model is a simple, effective way to calculate how much CO2 a basin can store safely. It is the first to look at large scales and take into account the effects of flow dynamics on the stored CO2," he said.

Already Juanes and co-author CEE graduate student Michael L. Szulczewski have applied their model to the Fox Hills Sandstone in the Powder River basin straddling Montana and Wyoming. They found that the formation would hold around 5 gigatons of CO2 — more than half of all the CO2 emitted by the United States each year.

A geological basin is a large underground bowl between 100 and 1,000 kilometers wide and 5,000 kilometers deep that has filled over millennia with layers of sand, fine-grained clays and other sediments that are eventually consolidated into porous rock. Some of the layers contain brine and are called deep saline aquifers. CO2 would be injected into the aquifers through wells.

The MIT model predicts how much a plume of CO2 will migrate from its injection well and the path it is likely to take due to underground slopes and groundwater flow.

"A lot of people have done studies at small scales," Szulczewski said. "If we're going to offset emissions, however, we're going to inject a lot of CO2 into the subsurface. This requires thinking at the basin scale."

"Despite the fact that our model applies at the basin scale, it is very simple. Using only pen and paper, you take geological parameters such as porosity, temperature and pressure to calculate storage capacity," Szulczewski said. "Other methods suffer from major shortcomings of accuracy, complexity or scale."

Juanes studies a phenomenon called capillary trapping, through which CO2, liquefied by the pressure of the Earth, is trapped as small blobs in the briny water (picture bubbles of oil in vinegar). The CO2 dispersed throughout the basin's structural pores eventually dissolves and reacts with reservoir rocks to precipitate out into harmless carbonate minerals.

CO2 has been sequestered in small pilot projects in Norway, Algeria and elsewhere. In 2004, 1,600 tons of CO2 were injected into high-permeability brine-bearing sandstone of the Frio formation 1,500 meters beneath the Gulf coast of Texas. Current proposals call for injecting billions of tons within the continental United States.