Volume 52, Number 8
Wednesday, November 7, 2007

TechTalk

SERVING THE MIT COMMUNITY

PHOTO / **DONNA COVENEY**

Rorschach in the sky

Swirling clouds face their reflection in the Brain and Cognitive Sciences Complex, resembling a Rorschach inkblot test.

A light touch

Researchers move cells on a chip with laser light

David Chandler
News Office

Using nothing but focused beams of laser light, two MIT researchers have found a way to pick up, hold, and move tiny objects—including living cells—on the surface of a microchip.

The new technology could become an important tool for biological and materials research, said Matthew J. Lang and David C. Appleyard, whose work is being published in an upcoming issue of the journal Lab on a Chip.

The idea of using light beams as tweezers to manipulate cells and tiny objects has been around for at least 30 years. But the MIT researchers have found a way to combine this powerful tool for moving, controlling and measuring objects with the highly versatile world of microchip design and manufacturing.

Optical tweezers, as the technology is known, represent "one of the world's smallest microtools," said Lang, an assistant professor in the Department of Biological Engineering and the Department of Mechanical Engineering. "Now, we're applying it to building [things] on a chip."

Appleyard, a graduate student in biological engineering, said the technology could have multiple uses in biology and electronics.

"We've shown that you could merge everything people are doing with optical trapping with all the exciting things you can do on a silicon wafer," he said.

For example, he said, many people are studying how neurons communicate by depositing them on microchips where electrical circuits etched into the chips monitor their electrical behavior. "They randomly put cells down

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PHOTO / **DONNA COVENEY**

Mechanical and biological engineering professor Matthew Lang, left, and graduate student David Appleyard in lab with equipment that shows how optical tweezers can be used to actively assemble tiny objects and cells over silicon wafers.

Hundreds attend iGem Jamboree

Grand prize awarded to Peking University team

Stephanie Schorow
News Office Correspondent

After making a thought-provoking presentation on bioengineering a "bacterial assembly line," a jubilant team from Peking University won the grand prize "BioBrick" award in the fourth annual International Genetically Engineered Machine (iGem) competition held Nov. 3-4 at MIT.

The Chinese team was among 54 from around the world who came to the 2007 iGem Jamboree to present innovative research in synthetic biology with projects that ranged from "Bactoblood" (a bioengineered alternative to human blood) to a "vitrotrap" that defended cells against HIV infection to an "Artificial BioLogic Circuit."

The event focused more on cooperation than competition. The 550 participants from countries such as France, Mexico, Slovenia, Canada and Italy spent the weekend sharing experiences, exchanging e-mails and honing their presentations.

IGem "is one of the best scientific meetings I've ever been to and one of the best scientific communities," said Drew Endy, assistant professor in the Department of Biological Engineering, and one of the iGem founders and organizer.

PHOTO / **STEPHANIE SCHOROW**

Members of the Peking University team are jubilant after winning the "BioBrick" grand prize in the iGem Jamboree at MIT.

The idea for iGem was sparked from a 2003 IAP class in answer to a key question: "Can simple biological systems be built from standard, interchangeable parts and operated in living cells?"

To show the answer is "yes," iGem participants are given a toolkit and "BioBricks," or bits of DNA from the MIT-based Registry of Standard Biological Parts. Each year, more BioBricks become available as the iGem teams add their creations to the stockpile.

"Everyone stands on the shoulders of everyone else," said Randy Rettberg, principal research engineer in the Department of Biological Engineering and iGem director. "Every team holds up the team that follows them."

Interest in the iGem competition has grown so keen that some schools, such as Virginia Tech, have launched credit classes for undergraduates interested in participating, Rettberg said. Teams also included a sprinkling of high school and graduate students.

"This is the biggest design competition for biology," Rettberg said, adding that innovations in the emerging field of synthetic biology innovation have been driven by "undergraduates who don't know what is impossible."

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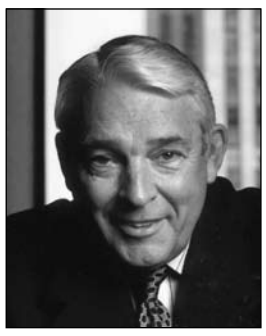
Opinion: Don't require colleges to spend more of their endowments

The following opinion piece was published Oct. 26 in the Chronicle of Higher Education. It was written by Dana G. Mead, chair of the Corporation of the Massachusetts Institute of Technology, and by Jeremy M. Jacobs, chair of the Council of the University at Buffalo, State University of New York, and chair and chief executive officer of Delaware North Companies.



Dana Mead

The demand for higher education and academic research and the costs of providing them have risen in recent years, and the search is on for easy answers to limit the financial burdens on families and the government. The most recent suggestion has been to require colleges and universities, especially large and prestigious ones, to spend more of their endowments. Congress, for example, is considering a proposal to require institutions with big endowments to spend at least five percent of that money each year, the same percentage that nonprofit foundations are required to spend.

So why don't universities spend as much as they can of their endowments to stop tuitions from rising, or to allow more low-income students to attend college, or to reduce the need for federal investment in scientific research?

The short answer is: they already do.

We serve as chairmen of the boards at two of our nation's most-important research universities. As taxpayers, businesspeople, parents and citizens, we strongly support the goals of making college affordable, aiding low-income students and conducting research. And as board chairs, we know that endowments are used for precisely those purposes and more. Last year alone, America's colleges and universities spent more than $15 billion from their endowments to subsidize tuition, make college inexpensive or free to millions of students, raise the quality of education, conduct research, and otherwise improve the services that they provide to students and society. On average higher-education institutions spent 4.6 percent of their endowments last year.

Why don't we spend more? In part, it is because we can't. We have a legal and moral responsibility to honor our donors' wishes and ensure that our institutions' endowments are at least as strong 10, 20 and 50 years from now as they are today, so that they can serve the needs of students and society then as they do now. We take few of our responsibilities more seriously than the stewardship and strengthening of our institutions' endowments.

Indeed, for more than three centuries, endowments have helped colleges and universities assist students, conduct research, construct new facilities, hire faculty members and carry out a host of other activities that otherwise would not have been possible if they relied solely on tuition and government support.

An endowment is typically made up of numerous different funds contributed by separate donors. Individuals, businesses, foundations and others are exceedingly generous to colleges and universities; in the 2006 fiscal year alone, they provided $28 billion in contributions. People contribute for a variety of reasons: out of loyalty, because institutions are an important part of their community or state, or simply because they believe in the missions that the colleges are supporting.

Most of those donors are, in fact, fairly specific about their objectives. They might direct the money to research on a specific disease, to the establishment of a faculty position in a particular area of studies or to financial aid for students. Institutions appreciate their generosity, and they are legally and ethically bound to honor a donor's intent.

Moreover, donors also usually specify that they want their generosity to produce benefits for many years to come. They want their contribution managed so that some of the earnings are spent, while the rest are reinvested to ensure that the endowment rises enough to let the annual payout keep pace with rising costs in good economic times and in bad.

For example, a donor contributes $1 million to create a permanent fund for cancer-related research. She wants the fund to produce research support that keeps up with inflation, regardless of the markets' performance. To do that, the fund must grow larger, even as it is paying out a steady stream of research dollars. Recall Joseph's advice to the Egyptian Pharaoh to store grain during the coming seven years of abundance to feed his people during the drought that would follow. Endowment managers reinvest revenue earned during years of abundance to ensure that spending can keep up with inflation during the lean years, when markets are not so friendly.

The issue is not only one of donor intent, however. Between us, we have served on dozens of corporate, university, foundation and other boards. In each of those positions, we have shared with our colleagues management and fiduciary responsibilities for multimillion-dollar or even multibillion-dollar corporations and other institutions. An essential part of our stewardship of those institutions has been to ensure that they are at least as strong in the future as they are today. Robust endowments are crucial to sustaining colleges' high-quality education and research.

Endowments are, in fact, providing increasing support for current activities. Among the colleges with large endowments, about one-third of annual operating revenue comes from endowment spending and, at Harvard, for example, that figure has grown from 21 percent just 10 years ago, while at Yale it has almost doubled.

For many higher-education institutions, endowment spending is the single largest source of revenue, more than tuition, research grants and clinical income from medical schools. Some institutions with large endowments have undertaken bold initiatives on student aid; Princeton University, the University of Pennsylvania and the University of Virginia, for example, have made a college education virtually free for students from low-income families, as well as from many middle-income ones. Endowment revenue is also indispensable for investments in academic programs that make American universities the envy of the world.

Endowments have grown significantly in recent years, despite what they spend, and that is a good thing. It helps ensure that colleges and universities have the resources to continue to improve and contribute to the well-being of our society. Much of the growth has been a result not only of increased donations but also of sound financial management. But to update Joseph, and paraphrase the warning investors have heard many times, recent growth of investments is no guarantee of future performance. Indeed, average endowments declined nearly 10 percent between 2000 and 2002. Institutions would be irresponsible if they assumed that investment returns will always grow rapidly. And endowment managers are under no illusion that they will.

Strengthening higher education and research in both the short term and the long term is important to our nation's well-being. Forcing endowments to spend more quickly might help in the short run, but it's a recipe for long-term weakening of a major national asset. Too often we see the government ignore long-term needs to meet short-term goals. It shouldn't force us to do the same.

LIGHT

Continued from Page 1

on a surface, and hope one lands on [or near] a [sensor] so its activity can be measured. With [our technology], you can put the cell right down next to the sensors." Not only can motions be precisely controlled with the device, but it can also provide very precise measurements of a cell's position.

Optical tweezers use the tiny force of a beam of light from a laser to push around and control tiny objects, from cells to plastic beads. They usually work on a glass surface mounted inside a microscope so that the effects can be observed.

But silicon chips are opaque to light, so applying this technique to them was not an obvious move, the researchers say, since the optical tweezers use light beams that have to travel through the material to reach the working surface. The key to making it work in a chip is that silicon is transparent to infrared wavelengths of light—which can be easily produced by lasers, and used instead of the visible light beams.

Initially, Lang and Appleyard weren't sure what thickness and surface texture of wafers, the thin silicon slices used to manufacture microchips, to use in their system. Moreover, wafers are expensive and usually available only in high quantities. "Being at MIT, where there is such a strength in microfabrication, I was able to get wafers that had been thrown out," Appleyard said. "I posted signs saying, 'I'm looking for your broken wafers.'"

After testing different samples, they were able to order a set that was just right for the work. They then tested the system with a variety of cells and tiny beads, including some that were large by the standards of optical tweezer work. They were able to manipulate a square with a hollow center that was 20 micrometers, or millionths of a meter, across—allowing them to demonstrate that even larger objects could be moved and rotated. Other test objects had dimensions of only a few nanometers, or billionths of a meter. Virtually all living cells come in sizes that fall within that nanometer-to-micrometers range and are thus subject to being manipulated by the system.

As a demonstration of the system's versatility, Appleyard said, they set it up to collect and hold 16 tiny living E. coli cells at once on a microchip, forming them into the letters MIT.

Lang is an assistant professor in the Department of Biological Engineering and the Department of Mechanical Engineering, and Appleyard is a graduate student in biological engineering.

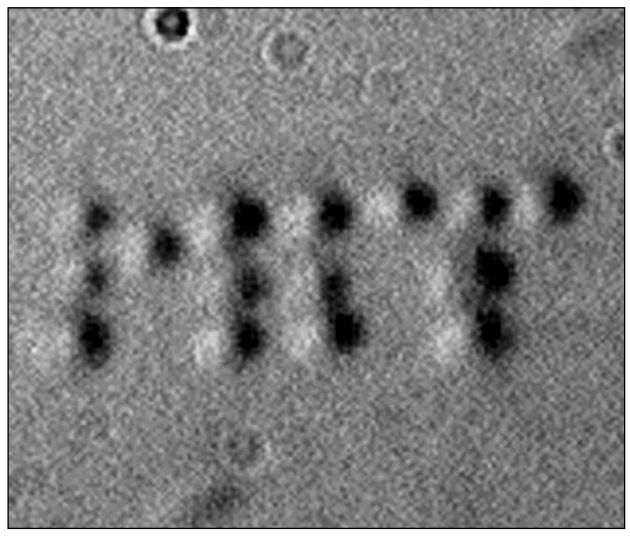


IMAGE COURTESY / **LANG AND APPLEYARD, MIT**

MIT researchers trapped fifteen E. coli cells in place on a silicon chip to form the letters 'MIT' using a 'tractor beam' of light.

iGEM

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Some projects focused directly on real-world applications of synthetic biology: the Italian team, for example, brainstormed a yeast sensor to determine real extra virgin olive oil. A team from the University of California Berkeley attempted to create a cost-effective red blood cell substitute constructed from engineered E. coli bacteria—a blood alternative that could be stored in a freeze-dry state. The team even brought in a crimson bag of "Bactoblood." If perfected, Bactoblood would "benefit a lot of people, especially in the Third World," said Nhu Nguyen, 17, a high school student and member of the UC Berkeley team.

Others wanted to pave the way for other research. Michael Chen of the University of California San Francisco team explained how their project, entitled "Location, Location, Location, " created protein scaffolds and an intracellular membrane-bound chassis for applications in eukaryotic cells.

"We're hoping we'll see a lot of people building off of (our design)," said team member Eric Meltzer.

A team from Paris discussed their work in progress on a new synthetic multicellular bacterium or SMB, a tool for engineering complex biological systems. A team from the University of Glasgow outlined a design for a powering electrochemical biosensor, called an "ElectrEcoBlu." The Scottish team also won kudos for their matching team shirts.

The grand prize-winning team from Peking impressed judges with their construction of a bacterial assembly line with spatial and temporal differentiation. Ultraviolet radiation was used as a turn on/turn off switch and cells were designed to signal each other in proscribed ways. Team members said the process could have medical and engineering applications.

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Printed on recycled paper

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Tech Talk is published by the News Office on Wednesdays during term time except for most Monday holiday weeks. See Production Schedule at web.mit.edu/newsoffice/techtalk-info.html. The News Office is in Room 11-400, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139-4307.

Postmaster: Send address changes to Mail Services, Building WW15, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139-4307.

Subscribers may call 617-252-1550 or send e-mail to mailsvc@mit.edu.

Tech Talk is distributed free to faculty and staff offices and residence halls. It is also available free in the News Office and the Information Center.

Domestic mail subscriptions are $25 per year, nonrefundable. Checks should be made payable to MIT and mailed to Business Manager, Room 11-400, MIT, 77 Massachusetts Ave., Cambridge, MA 02139-4307.

Periodical postage paid at Boston, MA.

Crawley, Schindall to direct Gordon-MIT program

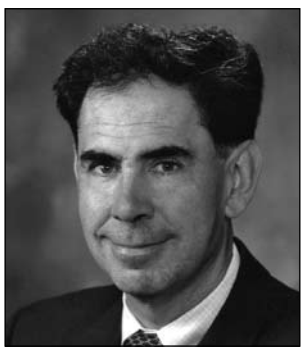
Dean of Engineering Subra Suresh has announced the appointments of professors Edward F. Crawley and Joel E. Schindall to key positions in the school's new Bernard M. Gordon-MIT Engineering Leadership Program. Launched through a $20 million gift by the Gordon Foundation—the largest gift made to the School of Engineering for curriculum development—this program aims to create new approaches to prepare students for engineering leadership.

Professor Crawley will serve as director of the Gordon Leadership Program and Professor Schindall, the interim industry co-director.

Articulating his vision for the program when it was announced, MIT alum Bernard M. Gordon said, "In view of increasing global competition, engineering leadership today should be built on the reinforcement of product engineering education, that is, the education of those who innovate and put products into production. I hope this program will provide additional opportunities for students to develop the practical skills required of 'real' engineers and that foster an attitude of appreciation in them for the demands of engineering leadership."

"I am extremely grateful to Bernie Gordon for the opportunities this magnificent gift makes possible," said Dean Suresh, "and I am delighted to announce the program's leadership by professors Crawley and Schindall. We are embarking on a truly significant initiative to enhance engineering education and to further develop the leadership skills of our talented young people."

The Bernard M. Gordon-MIT Engineering Leadership Program comprises three major components: a progressive set of enhancements to MIT's core educational program with a focus on product development and project engineering, an industry mentoring and practice program for 20-30 students selected as Gordon Fellows each year and an active program to disseminate best practices to other universities.



Edward Crawley

"The Gordon Program affords MIT an extraordinary opportunity," said Crawley. "With this new program, we can strengthen our engineering education by better preparing our students to be leaders in invention and innovation and to shape the technological future."

"Having spent much of my career in industry," said Schindall, "I realize firsthand the importance of product design and engineering leadership, and I am delighted at the opportunity to work with many talented MIT faculty to enhance our training in these areas."

Crawley, the Ford Professor of Aeronautics and Astronautics and Engineering Systems, was previously a MacVicar Faculty Fellow and has served as executive director of the Cambridge-MIT Institute, department head of Aeronautics and Astronautics and co-director of the Systems Design and Management Program.

Joel Schindall

The Bernard M. Gordon Professor of the Practice of Product Engineering in the Department of Electrical Engineering and Computer Science, Schindall serves as associate director of the Laboratory for Electromagnetic and Electronic Systems. His distinguished career in industry includes senior leadership positions at Globalstar, Loral Conic and Watkins Johnson Company.

Dean Suresh thanked Crawley, Schindall and former Dean of Engineering Tom Magnanti for their earlier work, which led to the initial plan for the Bernard M. Gordon-MIT Engineering Leadership Program.

In addition to the professorship currently held by Schindall, Gordon has made endowment gifts to support an additional chair at MIT (Professor W. Eric Grimson is the Bernard M. Gordon Professor of Medical Engineering in Electrical Engineering and Computer Science) and the Bernard M. Gordon Endowed Fund for curriculum development in the School of Engineering.

Gordon, a pioneer of analog-to-digital conversion and high-precision medical instrumentation, is the founder of Analogic and NeuroLogica. He and his wife, Sophia, established the Gordon Foundation, which has made major contributions to engineering education and to other nonprofit organizations in the region. The National Academy of Engineering annually awards the prestigious Bernard M. Gordon Prize for Innovation in Engineering and Technology Education.

To learn more about the Bernard M. Gordon-MIT Leadership Program, go to web.mit.edu/newsoffice/2007/gordon-gift-0720.html.

Q&A: Economist Michael Greenstone

Michael Greenstone

Michael Greenstone, 3M Professor of Economics, has applied statistical techniques he uses in measuring the economic impact of climate change to conduct the first quantitative analysis of the U.S. troop surge in Iraq.

Greenstone's paper, "Is the Surge Working? Some New Facts," credits the troop surge with an immediate reduction in violence and casualties in Baghdad but shows that world financial markets doubt Iraq's future stability, based on Iraqi government bond prices.

"Is the Surge Working?" was discussed in the Oct. 11, 2007, edition of The Wall Street Journal. Greenstone recently spoke with Sarah H. Wright of the MIT News Office about his paper and what inspired him to veer from environmental economics to study of U.S. military strategy in Iraq.

Q. *What is your usual focus, and what inspired you to turn your attention to the war in Iraq?*

A. Most of my work is in measuring the costs and benefits of a clean environment. More broadly, I am interested in empirically determining the proper role for government in our society.

This paper on the surge stems from that broader interest. It shows that even in unconventional wars, it is feasible to measure and analyze important outcomes to learn about the war's success. In wars, the stakes for society are so great that it is crucial that as much information as possible (without sacrificing military strategy) be available to those inside and outside the military so that society can make informed decisions.

Q. *What inspired you to focus particularly on the 30,000-person U.S. troop surge?*

A. As an economist, I found the evidence used by supporters and opponents of the surge less than convincing. An egregious example was Sen. John McCain's announcing on TV news that things in Iraq were improving—as he walked through a Baghdad market, surrounded by armed guards and camera crews.

The fact is that the war is terribly costly both in human and financial terms: Nearly 80 people (Iraqis plus coalition troops) are dying per day, and the U.S. cost of the war may exceed $1.2 trillion. When the stakes are so high, we must have reliable information to make decisions with.

Q. *Do the same tools apply for analyzing the economics of environmental and military 'health'?*

A. Yes. The most important message in the paper is that the same empirical tools that we use in economics can be used to assess how the surge is going. We can use empirical evidence to supplement the qualitative impressions that have largely guided assessments of the Surge. The key thing is that the assumptions be transparent.

Q. *What were the short-term effects of the Surge?*

A. The security situation has improved insofar as violent civilian fatalities have declined without any concurrent increase in casualties among coalition and Iraqi troops. However, other areas, such as oil production and the number of trained Iraqi Security Forces, have either shown no improvement or declined.

Overall, these results suggest that the security situation is improved, but the evidence on the functioning of the Iraqi state is less clear. It is difficult to know what this mixed pictures means in terms of the Surge achieving its goal of laying the foundation for a stable Iraq.

Q. *How did you gauge the long-term effects of the Surge?*

A. I looked at the prices of Iraqi government bonds that trade on world financial markets. Bond prices give a good idea of how traders view the chance that the institution or government offering the bond will be around when the bond comes due. Unlike the other measures, they provide a direct estimate of whether there will be a stable Iraq in the future.

My analysis found that the price of the Iraqi bonds never increased after the Surge, indicating that traders did not foresee the Iraqi government would last long enough to pay its debts. In fact, there is some evidence that the Iraqi bonds declined relative to comparison bonds. This finding suggests that, to date, the Surge is failing to pave the way toward a stable Iraq.

The appeal of using financial markets is that traders' only concern is to make profitable decisions. There is no room for politics or justifying previous decisions in these markets.

Q. *Iraq issued bonds in 2006 as part of a debt-relief plan with the U.S. and others. What happened?*

A. Prior to Iraq's invasion of Kuwait in 1990, Iraq issued about $130 billion in debt. After the Gulf War, the country defaulted on this debt. When the U.S.-led coalition invaded Iraq in 2003, the holders of this debt were spread around the world. The Paris Club held claims of approximately $40 billion; Persian Gulf creditors had another $65 billion; and the remainder was in the hands of commercial creditors.

After the end of combat operations in May 2003, the U.S. government brokered a deal to exchange $1,000 in the existing bonds for $200 worth of new bonds for those creditors who held at least $35 million in Iraqi bonds so that the new Iraqi government would not be hamstrung by this debt. As a result of this debt-relief agreement, the Iraqi government issued roughly $2.66 billion in U.S. dollar-denominated notes in January 2006. These new bonds pay fixed coupons of 2.9 percent twice a year and have a maturity of Jan. 15, 2028.

Q. *What is your response to critics interviewed by The Wall Street Journal who say your analysis did not account for the recent credit-market crisis?*

A. The Journal noted that the decline in the price of Iraqi bonds largely coincided with this summer's credit crisis. But the price of Iraqi bonds did not increase from February through June, a period when the Surge was in force but the credit market crisis hadn't hit yet. The point is that the bond market has never been convinced that the Surge would help Iraq's long-term future.

Further, the finding of a decline in Iraqi bonds remains even when their prices are compared to the price of bonds from other emerging markets.

Q. *What might our government do to widen debate on the war?*

A. They should set in place a rigorous data collection system and then make these data public, so independent researchers can analyze them. The federal government hasn't made the collection and distribution of data from Iraq a priority, so it is very difficult to get reliable indicators of the functioning of the Iraqi state.

Q. *What should voters listen for in discussions of U.S.-Iraq relations?*

A. We should listen for verifiable and robust facts. The stakes are too high to base decisions on anything else.

Race and diversity committee formed

The Campus Committee on Race Relations and the MLK Celebrations Committee will merge and the new committee will be called Committee on Race and Diversity, Chancellor Phillip Clay has announced.

"In combining the two committees, the aim is to strengthen our ability to more effectively advance race relations goals in campus life," Clay said.

The committee's responsibilities will include assessing the community environment and suggesting strategies; developing and sponsoring community initiatives to advance race relations and awarding grant funds to support these; sponsoring or cosponsoring community-wide events and forums including, but not limited to, the MLK Breakfast; and advising the administration on matters that arise.

The new committee will focus on the campus community, while Provost L. Rafael Reif's initiative on faculty race issues will continue to focus on developing approaches to advance faculty diversity.

The new committee will administer the grants program that the former CCRR managed; it will also sponsor the MLK Breakfast in February.

In addition to comprising faculty and student members, the new committee will have representatives from the offices of the provost, chancellor and executive vice president. It will be chaired by J. Philip Thompson, professor in the Department of Urban Studies and Planning.

MIT works toward 'smart' optical microchips

Light-powered micromachines to advance telecommunications, more

Anne Trafton
News Office

A new theory developed at MIT could lead to "smart" optical microchips that adapt to different wavelengths of light, potentially advancing the fields of telecommunications, spectroscopy and remote sensing.

Drawn by the promise of superior system performance, researchers have been exploring the concept of microchips that manipulate light instead of electricity. In their new theory, the MIT team has shown how such chips could feature tiny machines with moving parts powered and controlled by the very light they manipulate, giving rise to fundamentally new functionality.

"There are thousands of complex functions we could make happen by tinkering with this idea," said Peter Rakich, an MIT postdoctoral associate who invented the theoretical concept along with postdoc Milos Popovic. The work was described in the cover story of the November issue of Nature Photonics.

For example, such chips could one day be used to remotely adjust the amount of bandwidth available in an optical network, or to automatically process signals flowing through fiber-optic networks, without using any electrical power, Rakich said.

Co-authors on the paper were Marin Soljacic, assistant professor of physics, and Erich Ippen, the Elihu Thomson Professor of Electrical Engineering and professor of physics.

"The idea that opto-nanomechanical devices can be designed to self-adapt to all-optical control—i.e., by self-aligning their resonances to optical control frequencies and by permitting all-optical tuning and dimension control—is new and exciting," said Ippen.

Earlier this year an MIT team composed of many of the same researchers showed that photonic circuitry could be integrated on a silicon chip by polarizing all of the light to the same orientation. The current work shows how tiny mobile machines can be built on such chips, taking advantage of the substantial pressures exerted by photons as they strike the walls of a cavity.

In the macroscopic world, light waves do not exert significant forces, but in the unique world of the microscopic, coupled with ultrapure laser light, photons bouncing off the walls of a cavity can build up a measurable force called radiation pressure. This is similar to the pressure exerted by gas molecules trapped in an aerosol can.

To take advantage of this radiation pressure, the researchers propose machines built from ring-shaped cavities only millionths of a meter in size located on the chip surface. When pressure on the cavity walls is high enough, the cavity is forced to move. This movement forms a critical part of an optical micromachine, which adjusts its configuration to respond to light in a predesigned way.

A unique application of this concept involves processing data that travels in fiber-optic networks. Today resonators employed in fiber-optic networks have to be synchronized with the incident light to ring at its frequency, in the same way an opera singer has to tune the pitch of her voice to make a wine glass ring.

Remarkably, a "smart" resonator based on the MIT concept could chase the frequency (color) of the laser light incident upon it. As the frequency of the laser beam changes, the frequency of the resonator will always follow it, no matter where it goes.

In other words, this new, unique resonator is like a wine glass that self-adjusts to the pitch of the singer's voice and follows it along throughout a song, Rakich said. He noted that physical systems that adapt to driving light and behave like these nanomachines do not exist elsewhere in nature.

By coupling the resonating cavities with nanoscale cantilevers, optical devices analogous to microelectromechanical systems (MEMS) devices can be created.

Although the researchers focused on ring-shaped cavities, their model could be applied to other structures as well.

"Our objective now is to develop a variety of light-powered micro- and nanomachines with unique capabilities enabled by this technology," explained Popovic. "But the first step will be to demonstrate the concept in practice."

The research was funded in part by the Army Research Office through MIT's Institute for Soldier Nanotechnologies.

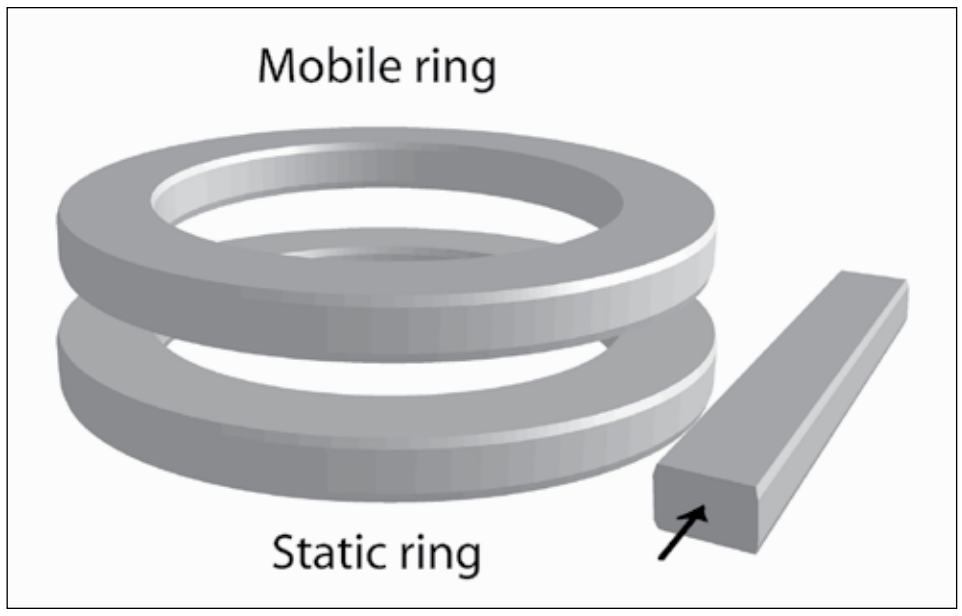


IMAGE COURTESY / **PETER RAKICH**

Rings, one millionth of a meter in size, are the moving parts of a 'smart' micromachine that could be powered and controlled by light on an optical chip. The rings move around and adapt to the color of light that is traveling through the bar, right.

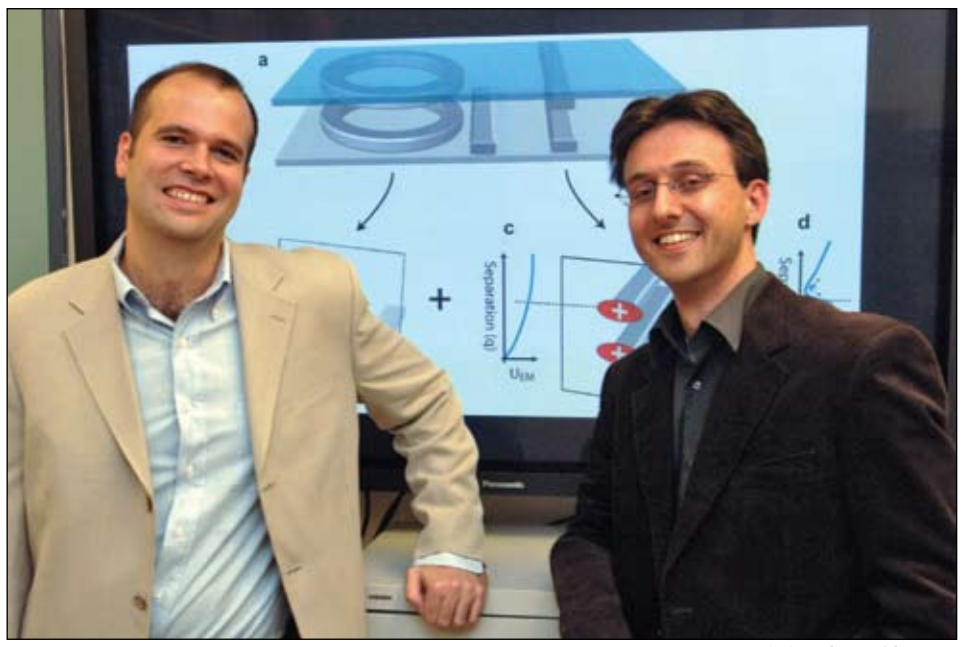


PHOTO / **DONNA COVENEY**

Postdocs Peter Rakich, left, and Milos Popovic of MIT's Research Laboratory of Electronics stand in front of an illustration of their proposed method for controlling microchips with light.

MIT develops lecture search engine to aid students

PHOTO / **DONNA COVENEY**

CSAIL professor Regina Barzilay, right, and principal research scientist James Glass, left, use computer techniques to create a lecture-browsing system.

Anne Trafton
News Office

Imagine you are taking an introductory biology course. You're studying for an exam and realize it would be helpful to revisit the professor's explanation of RNA interference. Fortunately for you, a digital recording of the lecture is online, but the 10-minute explanation you want is buried in a 90-minute lecture you don't have time to watch.

A new lecture search engine developed at MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) could help with this dilemma. Created by a team of researchers and students led by MIT associate professor Regina Barzilay and principal research scientist James Glass, the web-based technology allows users to search hundreds of MIT lectures for key topics.

"Our goal is to develop a speech and language technology that will help educators provide structure to these video recordings, so it's easier for students to access the material," said Glass, who is head of CSAIL's Spoken Language Systems Group.

More than 200 MIT lectures are currently available on the site (www.sls.csail.mit.edu/lectures/). So far, most of the users are international students who access the lectures through MIT's OpenCourseWare (OCW) initiative, which makes curriculum materials for most MIT courses available to anyone with Internet access. Although the lecture-browsing system is still in the early development stages, a recent announcement in OCW's newsletter has drawn increased traffic to the site.

Barzilay and Glass expect the system will be most useful for OCW users and for MIT students who want to review lecture material. MIT World, a web site that provides video of significant MIT events such as lectures by speakers from MIT and around the world, is also participating in the project.

Many MIT professors record their lectures and post them online, but it's difficult to search them for specific topics. Because there is no way to easily scan audio, as you can with printed text, "you end up watching the whole thing, and it's hard to keep focused," said Barzilay, the Douglas T. Ross Career Development Associate Professor of Software Development in the Department of Electrical Engineering and Computer Science.

On the prototype web site, users can search lectures for any term they want and then play the relevant sections.

The lecture transcripts are created by speech recognition software. One major challenge is that the lectures usually contain many technical terms that might not be in the computer program's vocabulary, so the researchers use textbooks, lecture notes and abstracts to identify key terms and feed them into the computer.

"These lectures can have a very specialized vocabulary," said Glass. "For example, in an algebra class, the professor might talk about Eigenvalues."

When properly adapted to a speaker and topic, the lecture-based speech recognizer gets about four out of five words correct, however most of the errors occur in words that are not critical to the lecture topic, i.e., not the key vocabulary terms that people would use to search.

Once the transcript is complete, a language processing program divides the text into sections by topic. Chunks of text, about 100 words each, are compared with each other using a mathematical formula that calculates the number of overlapping words between the text blocks. Each word is weighted so that repetition of key terms has more weight than less important words, and chunks with the most similar words are grouped into sections.

In the future, Barzilay and Glass hope to add a lecture summarization feature to the language processing system. They also want to get users more involved in the project, by incorporating a Wikipedia-like function that would let users correct errors in lecture transcripts and allow them to add lecture notes.

The researchers presented their project at the Interspeech 2007 conference in Antwerp, Belgium, in August. The project was originally funded by Microsoft through the iCampus program and is now funded by the National Science Foundation.

Study charts genomic landscape of lung cancer

Nicole Davis
The Broad Institute

An international team of scientists has produced the most comprehensive view yet of the abnormal genetic landscape of lung cancer, the world's leading cause of cancer deaths. Appearing in the Nov. 4 advance online issue of Nature, the research reveals more than 50 genomic regions that are frequently gained or lost in human lung tumors.

While one-third of these regions contain genes already known to play important roles in lung cancer, the majority harbor new genes yet to be discovered. Flowing from this work, the scientists uncovered a critical gene alteration—not previously linked to any form of cancer—that is implicated in a significant fraction of lung cancer cases, shedding light on the biological basis of the disease and a potential new target for therapy.

"This view of the lung cancer genome is unprecedented, both in its breadth and depth," said senior author Matthew Meyerson, a senior associate member of the Broad Institute of MIT and Harvard and an associate professor at Dana-Farber Cancer Institute and Harvard Medical School. "It lays an essential foundation and has already pinpointed an important gene that controls the growth of lung cells. This information offers crucial inroads to the biology of lung cancer and will help shape new strategies for cancer diagnosis and therapy."

"The genomic landscape of lung cancer gives us a systematic picture of this terrible disease, confirming things we know, but also pointing us to many missing pieces of the puzzle," said Eric Lander, one of the study's co-authors and the founding director of the Broad Institute of MIT and Harvard. "More broadly, the study represents a general approach that can and should be used to analyze all types of cancer. Indeed, the study was designed as a pilot project for an even more comprehensive effort to unearth the genetic causes of cancer."

Each year more than one million people die of lung cancer, including more than 150,000 in the United States. New approaches to treatment rely on a deeper understanding of what goes wrong in cells to spur cancer growth. Through decades of research, it has become clear that lung cancer—like most human cancers—stems mainly from DNA changes that accrue in cells throughout a person's life. But the nature of these changes and their biological consequences remain largely unknown.

To assemble a genome-wide catalog of genetic differences in lung cancer cells, a large-scale project was recently launched in lung adenocarcinoma. The effort, known as the Tumor Sequencing Project (TSP), unites scientists and clinicians throughout the cancer research community.

IMAGE COURTESY / **BANG WONG, BROAD INSTITUTE**

The TSP researchers studied more than 500 tumor specimens from lung cancer patients. Access to this large collection of high-quality samples made it possible to determine the genetic changes shared among different patients—such recurring changes can highlight important genes involved in cancer growth.

To analyze DNA from each lung tumor, the scientists relied on recent genomic technologies to scan the human genome for hundreds of thousands of genetic markers, called single nucleotide polymorphisms or SNPs. This high-resolution view helped pinpoint which parts of the tumor genome were present in excess copies or missing altogether.

From this work, the researchers uncovered a total of 57 genomic changes that occur frequently in lung cancer patients. Of these, only about 15 are linked to genes previously known to be involved in lung adenocarcinoma. The rest, though, remain to be discovered.

Strikingly, the most common abnormality identified in the study involves a region on chromosome 14 that encompasses two known genes, neither of which had been previously associated with cancer. Through additional studies in cancer cells, co-first author Sue-Ann Woo and other researchers at Dana-Farber Cancer Institute revealed that one of the genes, NKX2.1, influences cancer cell growth. The NKX2.1 gene normally acts as a sort of "master regulator"—controlling the activity of other key genes—in a special group of cells lining the lungs' tiny air sacs, called alveoli. This discovery, that a gene functioning in a select group of cells rather than all cells can promote cancer growth, may have broad implications for the design of novel, molecularly targeted cancer drugs.

The second phase of the TSP, now underway, will examine the same lung tumor samples analyzed in the first phase, but at an even greater level of genetic detail. Using high-throughput DNA sequencing methods, the scientists will characterize small changes in the genetic code of several hundred human genes, which are already implicated in other cancers or more generally in cell growth.

Participating institutions in the TSP include three large-scale DNA sequencing centers—Baylor College of Medicine, Broad Institute of MIT and Harvard, and Washington University—and six medical institutions—Brigham and Women's Hospital, Dana-Farber Cancer Institute, M.D. Anderson Cancer Center, Memorial Sloan-Kettering Cancer Center, the University of Michigan, and Washington University. Investigators from Nagoya City University, the Ontario Cancer Institute/Princess Margaret Hospital, and the University of Texas-Southwestern Medical School also participated in the SNP study.

In addition to Matthew Meyerson and Eric Lander, the scientific leaders of the TSP include Harold Varmus of the Memorial Sloan-Kettering Cancer Center, Richard Gibbs of the Baylor College of Medicine, and Richard Wilson of Washington University in Saint Louis.

The TSP is helping to lay the foundation for future large-scale cancer genome projects, including The Cancer Genome Atlas (TCGA) pilot project. In December 2005, the National Human Genome Research Institute and the National Cancer Institute launched the TCGA pilot to test the feasibility of a comprehensive, systematic approach to exploring the genomics of a wide range of common human cancers.

All data generated by the TSP are being made available to the scientific community in public databases, including http://caintegrator-info.nci.nih.gov/csp. Data can also be accessed through the Broad Institute web site, at www.broad.mit.edu/tsp.

Speed plays crucial role in breaking protein's H-bonds

Denise Brehm
Civil and Environmental Engineering

Researchers at MIT studying the architecture of proteins have finally explained why computer models of proteins' behavior under mechanical duress differ dramatically from experimental observations. This work could have vast implications in bioengineering and medical research by advancing our understanding of the relationship between structure and function in these basic building blocks of life.

In a paper published as the cover article of the Oct. 16 issue of the Proceedings of the National Academies of Science (PNAS), the scientists, who work with atomistic models—accurate representations of nature that use fundamental laws of atomistic interactions as their basis—show for the first time the basic rupture mechanisms of protein structures when protein strands unfold in response to pressure.

"We have for the first time simulated the behavior of protein structures under conditions that correspond to those in living biological systems," said Markus Buehler, the Esther and Harold E. Edgerton Assistant Professor in MIT's Department of Civil and Environmental Engineering and lead researcher on the team. "All the different types of proteins we studied exhibit two distinct fracture modes that are dependent on the speed at which force is applied. Now we understand that what seemed unrealistic in the earlier computer simulations was actually a consequence of deformation rates and a change in the way hydrogen bonds respond to pressure."

Researchers had puzzled over the vast difference in the amount of pressure required to unfold proteins in experimental versus computer simulation. Earlier computer models forced researchers to apply force at much faster speeds than are possible in the laboratory. As a result, these earlier models predicted that the hydrogen bonds would rupture in response to pressures so small that proteins would be unstable. This clearly isn't the case. Rather, proteins form the structural basis of most biological materials.

It wasn't until the team, using large-scale computing facilities, was able to slow down the application of pressure in their models by a factor of 10 or 20 that they understood the discrepancy. At those speeds, which are much closer to the speeds at which pressure is applied in living cells and tissues, their study showed a change in behavior of the hydrogen bonds.

Explaining the puzzling phenomenon

Buehler and undergraduate student Xuefeng Chen, graduate student Sinan Keten, and Theodor Ackbarow, a graduate student from the University of Stuttgart working in Buehler's lab at MIT, set up a six-month computer simulation study. They worked with two different types of common proteins: vimentin—an alpha-helical filament protein that plays an important role in cellular signaling and stability—and amyloidal fibrils—beta-folded proteins. These protein motifs form the basis of many natural materials, such as hair, hoof, wool, spider silk and the prions that build up in the brains of Alzheimer's patients.

Hydrogen bonds are the basic chemical bonds that hold together proteins, similar to trusses and beams in buildings, and play a key role in controlling the behavior of these structures.

The researchers placed strain on the proteins by pulling on the ends, trying different pressures applied at different rates. They found that the hydrogen bonds in both the alpha-helical-type vimentin proteins and the beta-fibril-type amyloids behaved similarly. At higher rates, hydrogen bonds began to break apart one at a time, earlier in the process. When the pressure was applied more slowly, the bonds held out longer, but when they finally broke, they went three at a time.

"The slow deformation rate in proteins is most relevant in normal biological function, but the fast rate could be important during tissue injuries such as the shock impact in accidents and during formation of fractures in biological tissues," said Buehler.

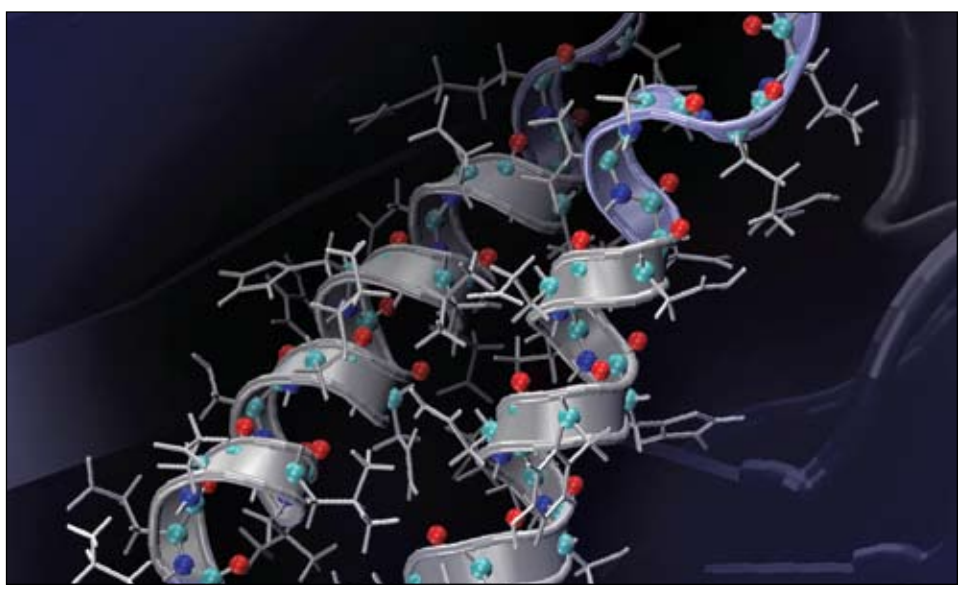


IMAGE COURTESY / **MARKUS BUEHLER**

This figure from an atomistic model shows a protein in the process of unwinding in response to pressure.

This work adds an important piece of knowledge to engineers' understanding of how organic materials work efficiently and provides important insight into how a protein's structure defines its unique mechanical properties. They showed that in order to enhance a protein's mechanical strength, the strands of amino acids should fold so that three or four parallel hydrogen bonds form at each convolution of the protein. Experimental evidence shows that proteins actually do fold so that hydrogen bonds form at the rate of 3.6 bonds per convolution.

In addition to enhanced strength, the protein's geometry also leads to a highly robust structure that provides it with an 80 percent "robustness rate," giving it very high marks from an engineering perspective. (A 100 percent rating could be applied only to a fail-safe structure.) "This 80 percent level of robustness, while simultaneously providing significant mechanical strength, enables the biological structure to minimize the use of materials and make it efficient overall and able to sustain extreme mechanical conditions," said the authors.

By contrast, the lack of robustness in many synthetic materials makes it necessary for engineers to introduce large safety factors that guarantee a structure's functionality under extreme conditions. "For instance, an engineering structure such as a tall building must be able to withstand loads that are 10 times greater than usual, just to protect it in case of one tiny crack," said Buehler. "By studying biological building materials and using a bottom-up structural design and synthesis approach, we hope to discover new ways to create stronger synthetic materials," he said.

"This new understanding could lead to the development of stronger, more robust materials that consume less energy in their manufacturing and transport. Such advances are only possible by including the molecular scale into the engineering design approach," said Buehler.

This work was funded by a National Science Foundation CAREER award, a grant from the Army Research Office, and an MIT Presidential Graduate Fellowship.

J-PAL course in Nigeria promotes science-based approach in poverty fight

MIT's Abdul Latif Jameel Poverty Action Lab (J-PAL) is technically located in E60 on the edge of east campus. But J-PAL's real laboratory is a primary school in a sub-Saharan African town, a household kitchen in a home in rural India, an unemployment line in a suburb of Paris–anywhere antipoverty programs are necessary to improve a population's health and well-being.

J-PAL is dedicated to fighting poverty by ensuring that policy decisions are based on scientific evidence. As part of that effort, J-PAL undertakes, promotes the use of and disseminates the results of randomized evaluations of poverty-alleviating programs.

Randomized evaluations provide clean, simple and reliable estimates of impact that can help policymakers determine what works, and what doesn't work, so that resources can be directed towards effective projects that improve people's lives. For example, J-PAL researchers discovered that a very inexpensive de-worming program in Kenya substantially improved children's health and primary school attendance.

To spread its research and promote the use of randomized evaluations, J-PAL organizes courses at MIT and around the world. Last summer, 40 development practitioners from eight African countries traveled to Abuja, Nigeria, to participate in one such course led by economists and graduate students from J-PAL.

"An important weapon in the fight against poverty is good evidence about what works," said Esther Duflo, J-PAL co-founder and co-director and the Abdul Latif Jameel Professor of Poverty Alleviation and Development Economics.

"The aim of this course was to build the capacity of others—particularly researchers in Africa—to answer questions about what works and to be able to interpret the often complex evidence about the effectiveness of alternative approaches to reducing poverty."

Like previous courses in Cambridge and Chennai, India, the course in Nigeria was designed to provide a thorough understanding of randomized evaluations and pragmatic step-by-step training for conducting one's own evaluation.

Through lectures, group work and case studies, course leaders presented topics such as why and how to randomize evaluations, measurements and outcomes, sample size and data management, managing threats and analyzing data.

Participants came from Ghana, Kenya, Malawi, Niger, Nigeria, Rwanda, Sierra Leone and Uganda. Some were officials from health and education ministries, while others were managers and researchers from development organizations working in Africa.

PHOTO / **TOTAL IN NIGERIA**

Development practitioners from across Africa taking part in a J-PAL course last summer in Abuja, Nigeria.

Participants were expected to apply the knowledge and skills acquired during the training course to evaluate social and development programs in which they are directly involved.

"The workshop opened us up to whole new experiences in conducting evaluations," said Colina Kpayagula of the Institutional Reform and Capacity Building Project in Freetown, Sierra Leone. "It also exposed us to different ways of analyzing issues before, during and after the evaluations, to ensure that the results are accurate. It's interesting to note the importance of preparing for evaluations at the very start of the project and not at the end, as we are used to doing. I believe the workshop is what one will call a once-in-a-lifetime experience, giving you a fresh, new outlook."

The J-PAL course in Nigeria was followed by a World Bank workshop that brought teams from the education ministries of nine different countries together to discuss how education policy can use randomized evaluation to work towards evidence-based policy and programs, and how their countries' education strategies can incorporate randomized evaluations.

The J-PAL course was organized in cooperation with the MIT International Science and Technology Initiatives (MISTI) and sponsored by Total. A sponsor of MISTI's MIT-France Program, Total has contributed graduate fellowships to MIT for students working in energy and social and economic development and for students from African countries, and is actively involved in MIT's Joint Program on the Science and Policy of Global Change.

PHOTO / **ERIC DAMTOFT**

MIT's Solar7 home, designed and built by students and displayed here at the Solar Decathlon contest in Washington, D.C., was popular with visitors and inspired plans for the 2009 competition.

Department of Silver Linings

Sarah H. Wright
News Office

MIT's first Solar Decathlon team has already applied the principles of engineering design to the experience of competing in the 2007 Solar Decathlon contest, sponsored by the Department of Energy and held Oct. 12-20 on the National Mall in Washington, D.C.

Was the machine robust? Did it embody repeatability? What worked? What didn't? And—the most MIT question of all—when can we get started on the next one?

For team member Diana Husmann, a senior majoring in physics, what worked was Solar7's success with the 25,000 visitors who toured the 20 student-built solar homes that competed in the 10-day event.

"Our biggest reward was listening to the everyday people who toured Solar7. Although we got 13th in the competition, we were very popular with the tourists. And since the point of the competition was to show that solar can be both powerful and beautiful, we all agreed that in the end, we were a complete success," she said.

Husmann also noted challenges the team met, including fundraising. "We were one of the smallest and least-funded teams to compete, but it gave us all the chance to learn how to work on basic leadership and money management," she said.

Solar7 faculty adviser Kurt Keville, research specialist at the Institute for Soldier Nanotechnologies, saw MIT's success in a different light—teamwork, energy balance strategy and capacity to bear suspense.

Recalling the night the team made the tough decision to unplug their electric car in order to charge the house battery, Keville said, "It was nail-biting time as we watched the battery charge meter with one eye and the clock with the other. It ended up being the right decision. We ended up first in 'Energy Balance.'"

As for the most MIT question of all, the team is already rolling. Planning for the next Solar Decathlon, to be held in October 2009, begins next month.

"We're going to ask MIT for more support and try to find professors willing to take on the challenge of doing even better the next time around," Husmann said.

'The Greening of MIT' to focus on sustainability

MIT's 14th annual Catherine N. Stratton Lecture on Critical Issues, "The Greening of MIT," will bring together four distinguished advocates for energy sustainability who devote much of their professional lives to the search for energy-efficient solutions to the global warming that threatens our world.

Rebecca Henderson, George Eastman Kodak Leaders for Manufacturing Professor of Management at the MIT Sloan School, will moderate the discussion. As a member of MIT Sloan's Laboratory for Sustainable Business, she works with clients and students to identify challenges and opportunities inherent in moving to a low carbon-intensive economy.

Steven Lanou, deputy director of the Environmental Programs Office at MIT, leads the Institute's campus-wide sustainability program.

A consultant to the U.S. Department of Energy, William Reed is a practicing architect and one of the nation's leading experts on green design.

A LEED (Leadership in Energy and Environmental Design) Accredited Professional, Mark Biedron works nationally and locally to promote ecological thinking on campuses and in community organizations.

The event will take place Nov. 13 at Tang Hall, at 4 p.m., and will be free and open to the public. Following the discussion there will be opportunity for questions from the audience. The lecture series is sponsored by the MIT Women's League to honor Kay Stratton, wife of the late MIT President Julius Stratton. Kay's initiative and energy have enriched Institute life for more than 60 years, earning her lifelong recognition as the First Lady of MIT.

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

One pair of gently used Bose Series IV Bookshelf Stereo Speakers. $125 or best offer. Please contact Mark at x8-0737 or mdamian@mit.edu.

Charlestown home for sale by owner. Brick single, 4 floors, 3+ bedrooms, finished lower level; large living room w/F.P. good storage, custom closets, new maple kitchen, large sunny garden. Over 2000 sq. ft. Contact Ann Saydah or Alan Moyes: 617-242-7588 or a.moyes@comcast.net

Brazilian artist to visit MIT

Lynn Heinemann
Office of the Arts

Brazilian installation artist Ana Maria Tavares will be the 2007 Ida Ely Rubin Artist-in-Residence at MIT, visiting the campus from Nov. 12 to Nov. 17, and from March 2 to March 15.

Tavares will present a public program titled, "Suspension, Mobility, Displacements and Rotations: Art and Architecture as Still Life" at 7 p.m. Nov. 15 in the Broad Institute Auditorium (NE30, 7 Cambridge Center).

Tavares' work stands at the crossroads of sculpture and urban design. She is known internationally for her imaginative, often disorienting use of prosaic urban materials such as steel, glass and mirrors in structures that resemble street furniture or architectural fittings. Often, these invented structures form puzzles or mazes for the visitor to explore.

Born in Belo Horizonte, Brazil, in 1958, Tavares currently works and lives in São Paulo. She describes her artistic themes as urban architectural grammar and the dislocations implicit in modern mobility.

"I'm very interested in the idea of passage of nonpermanence; in other words, in the way we live our lives today. We are surrounded by places of passage, places that are nonplaces: shopping malls, bus stations, toll booths. We are bombarded by appeals to us and by excess," she said.

Airports and departure lounges are a recurrent theme in her work—places that symbolize exit from everyday life, getting ready to depart, floating, meditating and the overlap of the real and the virtual.

Two of Tavares' works show how the artist transforms real sites into installations that convey the weirdness of, well, real sites. Two recent works illustrate this: "Strategies for Enchantment" (2001), in which she placed a piano, mirror and seats in a glass-walled room, and "Middelburg Airport Lounge with Parede Niemeyer" (2001), in which she used mirrors and video projection to transform De Vleeshal in the Netherlands into a futuristic airport lounge.

"Arte/Cidade: São Paolo" (2002) is one of Tavares' most ambitious projects. Part group exhibition, part political and social manifesto, it features numerous site-specific artworks scattered throughout the desperately poor east side of the city.

"Labirinto," a dramatic work in a former textile factory that hosted the main part of the exhibition, is one segment of "Arte/Cidade." "Labirinto" comprised a network of walkways and spiral staircases that passed through floors and ceilings, connecting different areas and three different levels of the building. The structure functioned as a device that offered a radically different way of navigating the building, mixing surprise and entrapment in the visitor's experience.

Tavares attained an M.F.A. degree from the School of the Art Institute of Chicago and a Ph.D. from the University of São Paulo. In 2001, she was awarded a John Simon Guggenheim Foundation Grant.

The Ida Ely Rubin Artists-in-Residence Fund was established in 1998 by MIT benefactor Margaret McDermott in honor of art historian, arts consultant and author Ida Ely Rubin, a founding member of MIT's Council for the Arts and former president of the Americas Foundation. The fund supports artists-in-residence programs in the visual arts at MIT.

PHOTO / **JOÃO MUSA**

PHOTO / **JOÃO MUSA**

Known internationally for her imaginative, often disorienting use of prosaic urban materials such as steel, glass and mirrors, Ana Maria Tavares presents a public program Nov. 15. Examples of her work include 'Paradise II' (from the 'Bunker, o Homem Ilha' series), 2005, pictured above, with modeling by Pedro Perez Machado. Pictured below is 'Enigmas de uma Noite com Midnight Daydreams' (from the 'Dream Stations' series), 2004.

A conversation with Ana Castillo

Sarah H. Wright
News Office

MLK Visiting Professor Ana Castillo is a novelist, poet, essayist and painter who has used every means necessary—the clack of typewriters, the flap of mimeograph machines, the thwip of copiers, the tick of e-mail and her personal blog—to tell the tales that had to be told.

"I used whatever technology we had to talk about social inequalities," Castillo said in an interview in her office at MIT. "Forty years ago, I was that insurgent radical, taking advantage of mimeo-machines in basements, getting the word out. Since then, my work has been to put creativity and social action together."

Castillo's published books include the award-winning "My Daughter, My Son, the Eagle, the Dove" (2000); "Peel My Love Like an Onion" (2000), and "My Father Was a Toltec (Poems)" (1995).

She will read from her fifth novel, "The Guardians," an exploration of family life along the U.S.-Mexico border, at 7 p.m. on Nov. 8 in Room 6-120.

A Chicago native who lives in New Mexico, Castillo, 54, came of age as a writer and an activist in 1968—the year Martin Luther King Jr. and Robert Kennedy were assassinated and Chicago police battled anti-Vietnam War protesters at the Democratic Convention.

"I decided where I fit in this life that year. By that time, I was 15, and Latino activists were out there, demanding things like better schools. I'm a product of the Chicago public schools, and I agreed with them. I was nourished by that generation of activists—some were distant mentors to me," she said.

Castillo cites Chinese-American author Maxine Hong Kingston and African-American author Nikki Giovanni as among her distant mentors. Both women wrote from their own experience, and both wrote for years before mainstream publishers discovered their work.

"When I saw Kingston on television, when Giovanni came to my community college to speak, I thought, 'That's who I want to be for Latinas!'" she said.

Castillo, whose MIT residence is Simmons Hall, spends most weekends on book tours, reading and signing "The Guardians" and giving workshops to young writers. She laughs at the thought that she might have watched what she prayed for as the frequent-flier miles add up.

"When I was young, my only plan was not to work in a factory. I spent the years writing when Latinas weren't published. I didn't go to writers' workshops, and it was my third novel—not my first—that 'crossed over.' I appreciate my success. And I'm still on the periphery of writers, telling about what people must overcome," she said.

Castillo received her B.A. from Northeastern Illinois University, her M.A. from the University of Chicago in 1979 and her Ph.D. from the University of Bremen, Germany.

Her journey to MIT began at a conference in which she spoke on the role of ecology in literature; a participant encouraged her to consider the Institute.

By that time, she had published "So Far From God," her 1994 novel portraying the devastation of border communities by toxic waste dumping, by the comings and goings of sweatshops thrown up in towns like Juarez, which have since moved offshore entirely, leaving workers literally high and dry.

"Depletion starts with poor communities. The sweatshops use toxic materials, dump the waste, and move on, leaving depleted soil, depleted water table, depleted people. We hear, 'Las Vegas needs water!' It's a desert!" Castillo declared.

As an MLK Visiting Professor, Castillo will be teaching two writing courses. She is also using her year on campus to begin work on "The Last Goddess Standing," a novel about women during the Conquest of Mexico.

She prepares for this project by reading omnivorously—everything from Esquire to "The Da Vinci Code" to old books on the conquest of Mexico, she says.

She also turns to songs that remind her of her personal and artistic mission. On a gray day, what could be better than listening to Chicana singer Perla Batalla's tales of romance and politics, performed in English and Spanish?

"God blessed her with song. Her voice is a great picker-upper on a Friday afternoon in New England," Castillo said, looking out her office window.

But her gaze never really strays from the margin, the border towns that keep her activist spirit burning. "Right now, Immigration is walking through my friend's classroom in New Mexico, looking for kids who don't belong there. I'm always with them when I write."

Castillo's reading at MIT is sponsored by the programs in Writing and Humanistic Studies and in Women's and Gender Studies. The event is free and open to the public. For more information, call (617) 253-7894.

PHOTO COURTESY / **ANA CASTILLO**

Ana Castillo

NEWS YOU CAN USE

Events Fair today

Learns the ins and outs of planning an event at MIT at the Events Fair '07, which is being held between 12 noon and 2:00 p.m. Nov. 7 in Kresge Lobby. Check out caterers, services, spaces and more. Other features include free food, samples and the chance to win an iPod. The fair is being organized by the Campus Activities Complex (CAC); for more information on event planning and CAC facilities, please call (617) 253-3913 or visit web.mit.edu/campus-activities/www/.

The Future of Engineering

As part of the MacVicar Education Seminar Series, James J. Duderstadt, President Emeritus and Professor of Science and Engineering at the University of Michigan, will be presenting "The Future of Engineering Practice, Research and Education: A 21st Century Flexner Report."

Powerful forces, including demographics, globalization and rapidly evolving technologies, are driving profound changes in the role and nature of engineering in society. During the past several years, numerous studies by the National Academies, federal agencies, business organizations and professional societies suggest the need for new paradigms in engineering practice, research and education to better serve a rapidly changing world. This talk will describe an effort to pull together these many perspectives and recommendations into a contemporary analog to the famous Flexner Report of 1910 that dramatically changed the nature of medical practice and education.

The MacVicar Education Seminar Series, in collaboration with the Office of the Dean for Undergraduate Education and the Teaching and Learning Laboratory, features speakers from both inside and outside of MIT who share information on topics of educational innovation with the MIT community.

The talk takes place Nov. 9, from 2:00 p.m. to 3:00 p.m., at Marlar Lounge 37-252. For more information, please visit web.mit.edu/tll/duderstadt_flyer.pdf.

Great American Smokeout

The American Cancer Society's Great American Smokeout is coming up, and MIT Medical, in association with MIT's Community Health Working Group, wants to help you or someone you care about to quit smoking. On Nov. 15, look for information booths with tobacco treatment resources and free quit kits in Lobby 10, the E25 Atrium and Wolk Lobby in Sloan. For more information, contact Lauren Mayhew at the Center for Health Promotion and Wellness at MIT Medical by phone at (617) 258-6965 or by e-mail at mayh@med.mit.edu.

MIT finishes fourth in DARPA challenge for robotic vehicles

David Chandler
News Office

There was one fender-bender, and a few cars had to be physically removed from competition when they lost control. But in the end, this year's robotic vehicle race in California was a great success, with six driverless cars making it through a daunting drive in the equivalent of downtown traffic.

Packed with computers and electronic sensors, MIT's automated Land Rover finished fourth in the DARPA Grand Challenge, a road race for robotic vehicles. The MIT vehicle, competing for the first time, was one of only six to complete the challenging 55-mile course, out of 89 original applicants and 35 that were selected to compete in the finals.

The first-, second- and third-place cars, from Carnegie Mellon, Stanford and Virginia Tech, respectively, were built by teams that had finished in the top 10 in the 2005 race.

"My heartfelt congratulations to the top three teams," said MIT team leader John Leonard, professor of mechanical engineering. "They were all repeat performers, and there are some things you can only learn by doing it. But I'd like to think we brought in some fresh approaches."

There were two overall challenges the vehicles had to contend with, Leonard said: navigation, which emphasizes locating the roads, lanes and intersections, and traffic avoidance, which deals with other moving vehicles. For safety reasons, Leonard said, DARPA chose to emphasize the traffic issues, whereas the MIT vehicle's greatest strength lies in its navigational abilities.

MIT's Land Rover, called Talos, carried "about twice as many" computers and sensors as the other vehicles, Leonard said, including 10 quad-core computers, along with 15 radar systems, six cameras and a dozen lasers.

Only 11 vehicles survived several qualifying rounds to make it to the final contest, which involved driving through an urban environment complete with moving traffic, stop signs and traffic lights. An abandoned military base served as the racecourse, which had been set up to resemble a busy downtown area.

Except for emergency cutoff switches held by the race judges, all control of the vehicles was completely in the hands of their onboard computers once the race began. Despite the challenges of driving through traffic with totally autonomous systems, there were only two collisions in the race. In the first, a German-built car sustained serious damage when it crashed into MIT's entry and was eliminated from the race.

In the second, which Leonard called "almost humorous," the MIT car barely made contact with one from Cornell. The other car had stopped after getting confused in a traffic circle. The MIT car tried to pass it, but just then the other car started up again, and the two "nudged up against" each other and "their noses just touched," said one of the MIT team's co-leaders, professor Jonathan How of aeronautics and astronautics. (The other co-leaders were Seth Teller, a professor in electrical engineering and computer science, and Professor David Barrett [Ph.D. 1996] of Olin College.) The encounter, which caused no damage, was deemed a "no-fault accident" by the race organizers.

DARPA (the U.S. Defense Advanced Research Projects Agency) has organized the robotic vehicle races as a way of spurring the development of technology that could provide an important new capability in future battles, just as automated pilotless aircraft have already begun to play an important role in warfare.

But some of the innovations could also find their way into ordinary passenger cars, which is why all the major car companies have been involved in sponsoring teams. "They see that this technology, if it can be channeled toward improving safety, is going to have a huge impact," How said. "It could revolutionize the way people drive."

PHOTO / **JASON DORFMAN**

Left to right: John Leonard and Seth Teller speak to the media after finishing the DARPA Urban Challenge.

PHOTO / **JASON DORFMAN**

Vehicles from MIT and Cornell make contact in what organizers deemed a 'no-fault accident.' Both vehicles fared well and were able to continue the competition.

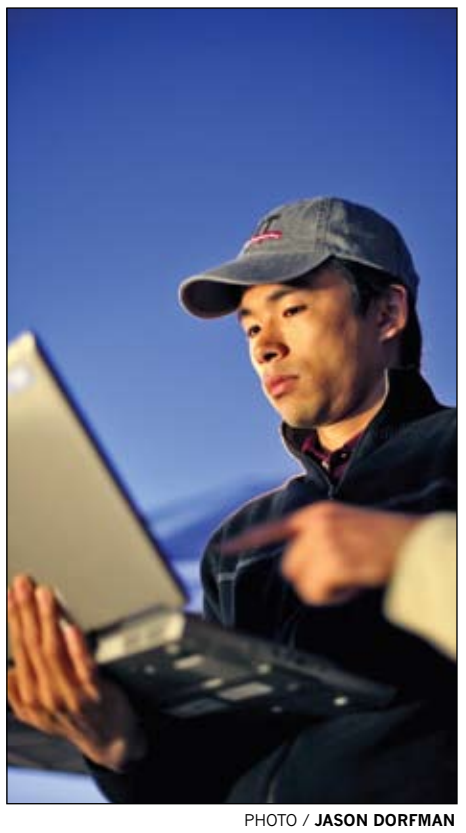


PHOTO / **JASON DORFMAN**

Yoshiaki Kuwata puts the final touches on a code modification.

PHOTO / **JASON DORFMAN**

Team MIT poses for a shot in the starting pits after completing the DARPA Urban Challenge.

PHOTO / **JASON DORFMAN**

Left to right: Jonathan How, Matt Antone and Ed Olson watch the progress of their bot via webcast.