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TechTalk

SERVING THE MIT COMMUNITY

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A new vision for people in space

Report outlines goals for future of human space program

David Chandler
News Office

A team led by MIT researchers released on Monday, Dec. 15, the most comprehensive independent review of the future of the nation's human spaceflight program undertaken in many years. The report recommends setting loftier goals for humans in space, focusing research more clearly toward those goals, and increasing cooperation with other nations and private industry.

After conducting preliminary briefings with various stakeholders in Washington, team members say it has been enthusiastically received by political leaders, a National Research Council panel, and the Obama transition team, among others.

PHOTO / **DONNA COVENEY**
David Mindell

"We need to rethink the rationales for human spaceflight," says the report's lead author David Mindell, professor of engineering systems and director of the program in Science, Technology and Society at MIT. He says that after the Washington briefings, "we sensed a great deal of uncertainty in DC about how to proceed with the Bush vision and human spaceflight in general. Our paper speaks to those problems in a clear way and offers some new ideas."

The report offers "primary objectives" for sending human beings into space as those that can only be accomplished through the physical presence of human beings and are worthy of significant risk to human life. Says Mindell, "we argue for including notions of risk, human experience and remote presence into the fundamental rationales for sending people into space. The results show that the United States might want a rather different human spaceflight program from the one now planned."

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HST names new MIT director

Sasisekharan appointed effective Dec. 10

Vice President for Research and Associate Provost Claude Canizares last week announced the appointment of Ram Sasisekharan as the new director of the Harvard-MIT Division of Health Sciences & Technology at MIT.

"It is with great pleasure that I announce the appointment of Professor Ram Sasisekharan as director of the Division of Health Sciences and Technology at MIT. Professor Sasisekharan will also become the Edward Hood Taplin Professor of Biological Engineering and Health Sciences & Technology. The appointment is effective Dec. 10, 2008," Canizares said. "Professor Sasisekharan brings a tremendous depth and breadth of experience to HST, having bridged across disciplines and between universities, government and industry."

Ram Sasisekharan

Sasisekharan, currently the Underwood-Prescott Professor of Health Sciences and Technology and Biological Engineering at MIT, is a member of the Koch Institute for Integrative Cancer Research and the Center for Environmental Health Sciences. He joined the MIT faculty in 1996, following appointments as an instructor at HMS and as an HST postdoctoral fellow. He holds a PhD in medical sciences from Harvard Medical School, an MS in biophysics from Harvard University and a BS in physical sciences from Bangalore University in India.

Sasisekharan's research objective is to contribute to the discovery and distribution of therapeutics that alleviate suffering and promote human health. His research is highly multidisciplinary, integrating a broad range of technologies for the study of complex polysaccharides that are involved in many disease processes. His work has laid the foundation for the development of novel therapeutics for applications to problems as diverse as stroke and bird flu, and which has led to the creation of several companies.

"Professor Sasisekharan has

▶Please see DIRECTOR, **PAGE 2**

Team sheds light on Alzheimer's mystery, work could lead to new treatments for debilitating disease

Deborah Halber
Picower Institute

In work that could lead to new drugs to target Alzheimer's disease, MIT researchers and colleagues have shed light on one of the molecular mysteries surrounding this common form of dementia.

The work, reported in the Dec. 11 issue of Neuron, helps explain the perplexing behavior of some cells in the hippocampus, thought to be the center of learning and memory in the brain. In Alzheimer's disease, stroke and other neurodegenerative conditions, some neurons suddenly start to replicate their DNA as if they were about to divide. This causes them to die.

It is thought that most of the neurons within our brains have formed and exited the cell cycle during gestation and the early postnatal period. No one knows why this sudden reprisal of the cell cycle occurs in adult neurons in Alzheimer's patients. Now, researchers led by Li-Huei Tsai, the Picower Professor of Neuroscience, are starting to understand the events that precede the death of the cells.

Tsai and colleagues found that these aberrant events occur when an enzyme called HDAC1, which configures chromatin, the structural component of chromosomes, is blocked.

Conversely, "increasing levels of this enzyme protects neurons from re-entering the cell cycle, losing genomic integrity and dying," said Tsai, who has appointments in MIT's Department of Brain and Cognitive Sciences and the Picower Institute for

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PEOPLE

Discover-ies abound

Research by four MIT professors have made Discover magazine's list of the top 100 stories for 2008.

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RESEARCH

Catch the wave

Researchers eye clean-energy possibilities along the Portuguese coast.

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NEWS

3 Questions on the recession

MIT economist and NBER head James Poterba answers questions on the economy.

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Events at MIT

Faculty meeting today

The monthly faculty meeting will be held from 3:30 p.m. until 5:30 p.m. today in Room 10-250. The following items will be on the agenda:

- A vote to revise the General Institute Requirements;
- A discussion of the 2009-2010 financial aid situation with Provost Rafael Reif;
- A report on the status of the Special Task Force on Open Access Publishing;
- and an update on the budget planning process from Chancellor Phillip Clay.

Today

• **A conversation with Prof. Harvey Lodish.** 10:30 a.m.-11:30 a.m. in 68-181. A discussion with MIT biology professor Harvey Lodish about his life in science.

Friday, Dec. 19

• **Astronomy in the City.** 6-8:30 p.m. in 32-123. Youth from the Boston area invite the MIT community to an evening of astronomy activities, oral presentations, planetarium shows and science-theater performances. Presenters are currently attending astronomy out-of-school time programs by the MIT Kavli Institute for Astrophysics and Space Research.

Monday, Jan. 5

• **Feynman Film Series.** Noon-1 p.m. in 6-120. Films will focus on the law of gravitation.

• **Physics IAP Lecture Series.** 1:30-2:30 p.m. in 6-120. Prof. Gabriella Sciolla will speak.

Wednesday, Jan. 7

• **The Benefits of Going Global: Marketing your International Experience to Employers.** Speaker: John Nonnamaker. 2-3:30 p.m. in 4-159. Many skills are developed as a result of participating in an international educational experience. These skills are of particular benefit to employers but job candidates need to learn how to articulate these skills and represent them on their resumes and during interviews. This presentation will help students identify and articulate the skills acquired through their international experience and practice how to highlight these skills in their job or internship search.

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.

Obituaries

Lauren Tsai, member of Class of 2004, 26

Lauren Tsai, who graduated from MIT with a bachelor's degree in mechanical engineering in 2004, was killed Saturday in a car crash in Newton. She was 26.

Lauren was the sister of senior Geoffrey Tsai and of Michael Tsai '02, MNG '02. She was originally from Etna, N.H., but lived in Waltham and worked for Raytheon.

As a student, Lauren had been a member of the MIT field hockey and basketball teams.

"Lauren was a valued member of this community and we look forward to a time when we can formally celebrate her life here at MIT," said Chaplain to the Institute Robert Randolph. "Our hearts go out to her family and especially to Geoffrey and Michael."

A viewing will occur from 6-8 p.m. Saturday, Dec. 20, at the Rand-Wilson Funeral Home in Hanover, N.H. A funeral service will be held at 10 a.m. the following day in Rollins Chapel at Dartmouth College in Hanover. Following the service, there will be a reception at the "Top of the Hop" at the Hopkins Center at Dartmouth College

Flowers may be sent to the Rand-Wilson Funeral Home, 11-1/2 School Street, Hanover, NH 03750. Contributions may be made in Lauren's name to benefit children's literature at the Howe Library, 13 South Street, Hanover, NH, 03755.

If you have memories or photos that you would like to share with Lauren's family and friends, or if you have questions about the arrangements, please e-mail contact@laurentsai.com.

Former Dean for Student Affairs Daniel Nyhart, 77

Former Dean for Student Affairs John Daniel Nyhart, who helped build community ties at MIT during a time of great unrest on American college campuses, died on Dec. 6. He was 77.

Nyhart, who was born in 1931 in Indianapolis, graduated in 1953 from Princeton and received an LLB in 1958 from Harvard Law School. He subsequently conducted research on the roles of banking and law in developing countries, including spending two years in Uganda and Nigeria studying development banking.

Nyhart was appointed research associate in the MIT Sloan School of Management in 1960 and went on to serve the Institute for 41 years in a variety of roles. Nyhart served as dean for student affairs between 1969 and 1972 — a challenging time in U.S. higher education, as opposition to the Vietnam War culminated in a massive student strike in 1970 that shut more than 450 university, college and high school campuses across the country.

As dean during this turbulent time, Nyhart devoted his attention to developing and strengthening relationships between faculty and students. A profile article published in MIT's Technique yearbook in 1970 described him as "an energetic man who came [to office] with ideas of how to work with students, how to make the student experience more meaningful and how to get students and the rest of the Institute relating to each other."

Among those who remembered Nyhart's contributions as dean was Bonny Kellermann '72, now MIT director of special constituencies.

"At a time when many college campuses were in turmoil and there was a lot of distrust between students and administration on most campuses, Dean Nyhart created a wonderful sense of community where students and administrators usually felt that they were on the same side, working for a common purpose," Kellermann said.

In 1972, Nyhart undertook new responsibilities as special assistant to the chancellor for law-related studies and preprofessional noncurricular programs. He ultimately received tenure with appointments in the Sloan School and the Department of Ocean Engineering.

Nyhart is survived by his wife of 54 years, Virginia (Nina Gibbon), of Brookline; three devoted children and their spouses: Nicholas (Kathleen McTigue), Lynn (Tom Broman), and Andrew (Angie Hurlbut); and seven grandchildren.

A memorial service will be held at a future date.

Winifred T. McDonough, 82

Winifred T. McDonough, who spent more than 30 years in various administrative positions at the Institute, died on Monday, Dec. 8. She was 82.

A graduate of Emmanuel College, McDonough began her employment with MIT in 1966 as a secretary in the treasurer's office. In 1986, she was promoted to recording secretary and she retired — for the first time — in June 1994, and became an active retiree/administrative staff member in July of that year. She re-retired in June 1996.

She was elected an honorary member of the MIT Alumni Association in 1987 and was also the treasurer for the MIT Quarter Century Club.

A memorial Mass will take place at 8 a.m. Sunday, Dec. 21, at Sacred Heart Chapel, 32 Summer St., Yarmouthport, MA.

William W. Kaufmann, professor emeritus of political science, 90

William W. Kaufmann, an MIT professor emeritus of political science who was one of the country's leading experts on defense analysis in the nuclear age, passed away Dec. 14. He was 90.

Born in New York, Kaufmann was a graduate of Yale University and was a U.S. Army Air Corps veteran of World War II. After the war, Kaufmann taught government and history at Yale and Princeton before joining the RAND Corporation in 1956. In 1961, he came to MIT and taught in the Department of Political Science until his retirement in 1984.

A central player in the development of nuclear strategy, Kaufmann served as a Pentagon consultant in every administration from John F. Kennedy to Jimmy Carter, according to Slate columnist Fred Kaplan SM '78, PhD '83, who was one of Kaufmann's students during his time at MIT.

"There is a whole generation of defense analysts who studied under Bill Kaufmann," said Kaplan. "As a thinker and a teacher, he had tremendous impact."

In 1986, an article in Foreign Affairs referred to Kaufmann as "the man who may well be the most knowledgeable individual in this country on the defense budgets of the past quarter-century."

Having witnessed a boom in military spending during the 1960s and 1970s, he turned more circumspect in his later years. In "A Reasonable Defense" (1986), Kaufmann argued for reorganizing the U.S. military and saving billions of dollars in the process. He expanded on that theme in "Glasnost, Perestroika, and U.S. Defense Spending" (1990), in which he laid out a plan to slash the U.S. military budget by half.

Services for Kaufmann will be held at a later date. In lieu of flowers, memorial donations may be made to the USO, P.O. Box 96860, Washington, DC 20077.

DIRECTOR: Ram Sasisekharan named director for MIT HST

Continued from **Page 1**

received many honors, holds numerous patents, and has been a leader in the development of highly successful interuniversity research programs," Canizares said. "Just last year, he successfully galvanized an international team of researchers to rapidly identify the toxic contaminant in batches of the blood-thinner heparin that had caused dozens of deaths. This work potentiated methodologies to prevent such contaminations in the future, and resulted in the critical joint publication between the FDA and academic researchers." A follow-up study to this research was published in the New England Journal of Medicine on Dec. 4.

Sasisekharan will share the leadership of HST with David E. Cohen, the director for HST at Harvard, associate professor of medicine and HST at Harvard Medical School, and director of hepatology at Brigham and Women's Hospital.

"The integration of science, medicine and engineering — the founding principle of HST — is at the core of Ram's research," Cohen said. "I look forward to working with him to perpetuate the tradition of excellence within HST and to shape its bright future."

"HST produces some of the best minds in translational medicine, and it is poised to contribute much more to the advancement of human health," Sasisekharan said. "As director, I will work to collaborate with my colleagues to sustain an exciting intellectual environment for our graduate students and research pioneers."

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MIT discoveries top magazine's list of year's best

Five discoveries from MIT have been named to Discover Magazine's Top 100 Stories of 2008. The list appears in the magazine's December issue.

Coming in at #21 is Professor Daniel Nocera's discovery of a simple, inexpensive method to split water into hydrogen and oxygen, which can be stored to power a fuel cell. The process, reported in Science in August, could lead to a practical way to store solar energy for use when the sun is not shining.

See the stories on each of these discoveries at web.mit.edu/newsoffice

Another solar advance made #26 on the list: Associate Professor Marc Baldo's development of a "solar concentrator" that collects sunlight from a large area and focuses it onto a much smaller area. The work appeared in Science in July.

Research by Professor Edward Gibson came in at #39. In June, Gibson reported that an Amazonian language with only 300 speakers has no word to express the concept of "one" or any other specific number. That work was published in the journal Cognition.

Coming in at #74 is a paper by professors Paula Hammond, Yet-Ming Chiang and Angela Belcher describing a way to use viruses to build and install microbatteries. The team reported the method in the Proceedings of the National Academy of Sciences in August.

At #86 is work by Aude Oliva showing that the human memory has a much larger capacity for visual detail than previously believed. The research was published in the Proceedings of the National Academy of Sciences in September.

In addition, Discover's #2 story of the year was the launch of the Large Hadron Collider in Geneva, Switzerland, which MIT scientists played a key role in launching.

PHOTOS / **CAMERA FOR US**

Anna Kotova, shown in the second and fourth photos, with kids she came across in a recent visit to some villages in India. Arka Dhar, seen in the first and third photos, on a trip to in the Himalayan foothills. Both are among those who recieved grants from the Legatum Center.

Legatum Center announces grant recipients

The Legatum Center for Development and Entrepreneurship at MIT is pleased to announce the recipients of its 2008-2009 seed grant program.

Teams of students from across the Institute submitted proposals for innovative projects on renewable energy, health, water, biotechnology, mobile services and a host of other promising enterprise solutions to development challenges in low-income countries. Of the 32 proposals received, 13 grantees were selected by the Legatum Center to receive funding.

Teams will use these grants to fund market research, project scoping and pilot studies during MIT's 2009 Independent Activities Period (IAP).

"MIT students are full of creative ideas. This is a way of harnessing and advancing some of these ideas toward our goal of promoting bottom-up development in low-income countries," said Legatum Center Founder and Director Iqbal Z. Quadir.

"These grants are meant to both recognize and propel MIT students who are applying their innovation and entrepreneurialism to improving the lives of ordinary citizens in low-income countries," said Michael F. Maltese, managing director of the Legatum Center.

Grantees chosen through the competitive selection process range in industry and geographical focus.

Alexander Sappok, CEO of Filter Sensing Technologies, won a grant for his work on an inexpensive fuel quality sensor that will increase availability of clean renewable fuels in low-income countries. "The Legatum IAP Seed Grant will enable the development and demonstration of a prototype system, as well as research into the most effective paths to market in these countries," Sappok said.

Sarina Siddhanti's student-team will use its grant to explore micro-equity development in Mexico. "Our project explores the possibility of micro-equity as a source of financing entrepreneurs in developing countries," Siddhanti said. "The Legatum IAP Seed Grant will be essential in enabling us to travel to Mexico and begin the preliminary field analysis for our model."

With his grant, Joseph Mugisha Mushoka plans to found a software company that leverages open-source databases to provide record management systems for insurance companies in Africa. "The Legatum IAP grant will enable me to identify five insurance companies in Kenya that I can learn from and develop the initial product," he said.

The Legatum Center's seed grants have been made possible through the generous support of MIT alumnus Jack Hennessy, who was previously a board member of the MIT Corporation, the chairman and CEO of Credit Suisse First Boston, and assistant secretary of the U.S. Treasury.

Founded in 2007 by Quadir, the Legatum Center is based on the belief that economic development and good governance in low-income countries emerge from entrepreneurship and innovations that empower ordinary citizens.

For a full list of recipients, please visit the Legatum Center web site at http://legatum.mit.edu/

Awards&Honors

Minervini honored by American Nuclear Society

Joseph V. Minervini, head of the Fusion Technology and Engineering Division of the MIT Plasma Science and Fusion Center, has received the 2008 Technical Accomplishment Award from the American Nuclear Society, Fusion Energy Division. Minervini was honored for technical accomplishments achieved in developing superconducting magnet technology for magnetic confinement fusion experiments; specifically for the development of large-scale cable-in-conduit-conductor (CICC) technology for the ITER magnets, as well as for the successful design, fabrication and testing of the Central Solenoid Model Coil for ITER, a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power.

PHOTO / **PAUL RIVENBERG**

Joseph V. Minervini, head of the Fusion Technology and Engineering Division of the MIT Plasma Science and Fusion Center.

Two professors up for ALA presentation award

Two MIT professors — Klavs Jensen and Mehmet Yanik — have been named finalists in the Association for Laboratory Automation's (ALA) $10,000 Innovation Award at LabAutomation2009, which will take place Jan. 24-28.

Jensen, the Warren K. Lewis Professor and department head of chemical engineering and a professor of materials science and engineering, is up for his work on "Microfluidic Synthesis of NanoMaterials at High Pressures and Temperatures."

Yanik, the Robert J. Shillman Career Development Assistant Professor of Electrical Engineering, was named a finalist for his work on "High Performance Magnetic Separation in Microfluidic Channels."

The ALA Innovation Award recognizes LabAutomation2009 podium presenters whose work demonstrates outstanding innovation and contributes to the exploration of automation technologies in the laboratory. The winner will be announced Wednesday, Jan. 28, 2009, at 12:30 p.m.

A handful of MBA students are learning by doing — running SloanGear

Amy MacMillan
MIT Sloan School of Management

Looking for a gift this holiday season that is not just fashionable but also supports the education of MIT students? Look no further than SloanGear, the MIT Sloan student-run company that sells Sloan brand apparel and gifts.

SloanGear may look like a typical retail business at first glance, but how many businesses do you know that change their ownership and management each year? Like an annual rite of passage, SloanGear (www.sloangear.com) is auctioned off each spring from second-year MBA students to teams made up of the next graduating class. The students who win invest their own money in SloanGear, and the profit goes back into the company. At the end of the year, the owners-operators get their money back — assuming they sell it to the next team for at least as much as they paid.

This arrangement creates an incentive for the current owners to improve the company each year, as well as develop individual sales and marketing skills, says Shintaro Okuno, CEO and one of SloanGear's 10 current owner-operators.

Okuno formerly worked as a consultant for a wide variety of industries at Bain & Company Inc. and had no retail experience prior to his SloanGear stint. But the Tokyo native says he pursued SloanGear because he wanted a real learning opportunity and the chance to lead a business.

"Since running a company as management is my career goal, this experience — running a real business as CEO with very diversified partners — definitely gives me the opportunity for training and simulation for the future," says Okuno, who plans to return to Bain after graduation.

"Now I have the experience of running a company, and that will give me a deeper perspective to work with my clients and team members," he says.

Each year, the new SloanGear owners tweak the business slightly but do not radically change it. This year, for instance, owners doubled the frequency of lobby sales in E51 —traditionally the company's biggest sales opportunity. The current team also forged an exclusive partnership with Tiffany & Co. to offer 10 percent discounts on gift certificates at the luxury jewelry store.

"We want to make it bigger in a 'controlled' sort of way. It's a balancing act, because it's a for-profit business, but it does have aspects of a club," Damian Wisniewski, custom sales manager for SloanGear, says of the company's growth. "We may have more sales, more partnerships, and more products, but we focus mainly on keeping the business sound."

SloanGear products can be purchased online at http://www.sloangear.com/. The company's next lobby sale will be held the second week of February.

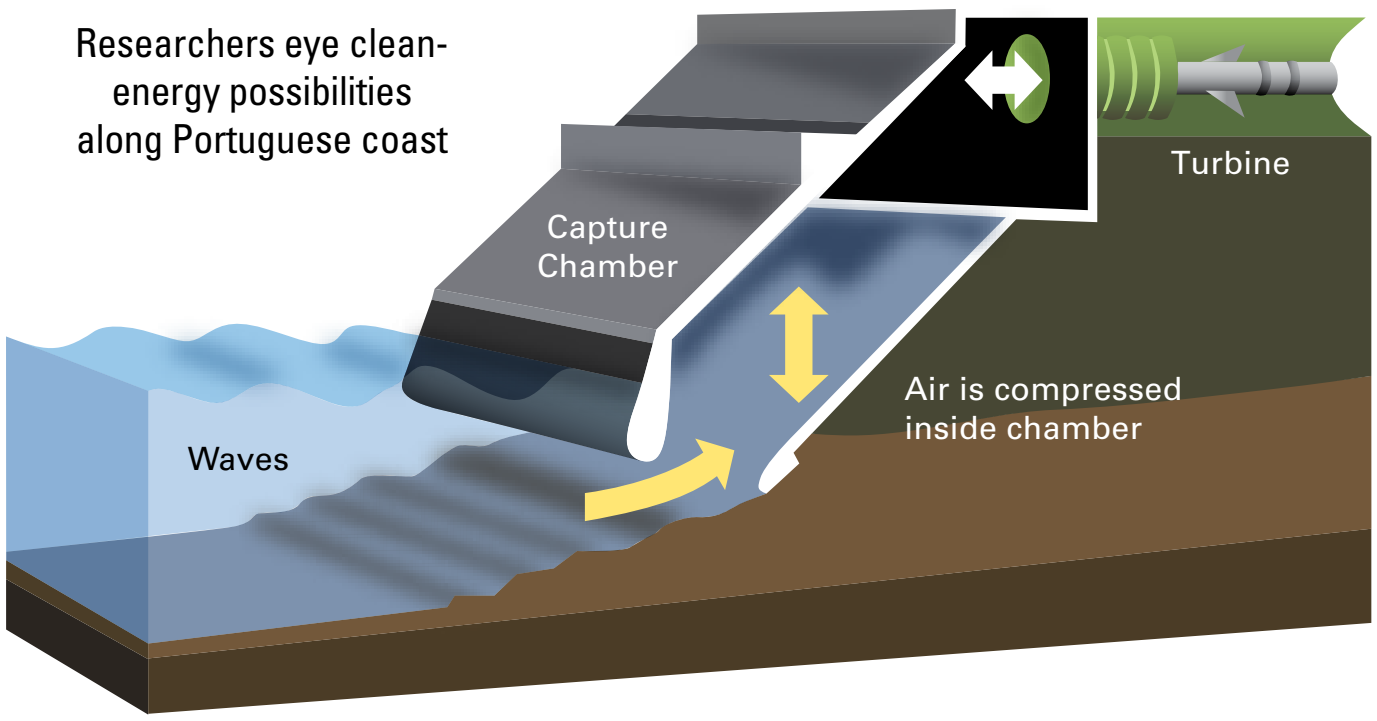
(This article was adapted from a longer version originally published in News@MITSloan)

No Tech Talk until Jan. 14

Because of the holiday recess, there will be no issues of Tech Talk until Jan. 14, when we will resume publishing for the spring semester. For up-to-date MIT news and information, go to web.mit.edu/newsoffice.

CATCH the WAVE

Researchers eye clean-energy possibilities along Portuguese coast



Schematic of an oscillating water column. Waves enter through a subsurface opening into the chamber with air trapped above. The wave action causes the captured water column to move up and down, pushing the trapped air into an electricity-generating turbine. The turbine turns continuously, despite the changing direction of the airstream as the waves come in and out.

Nancy Stauffer
MIT Energy Initiative

MIT researchers are working with Portuguese colleagues to design a pilot-scale device that will capture significantly more of the energy in ocean waves than existing systems, and use it to power an electricity-generating turbine.

Wave energy is a large, widespread renewable resource that is environmentally benign and readily scalable. In some locations — the northwestern coasts of the United States, the western coast of Scotland, and the southern tips of South America, Africa and Australia, for example — a wave-absorbing device could theoretically generate 100 to 200 megawatts of electricity per kilometer of coastline. But designing a wave-capture system that can deal with the harsh, corrosive seawater environment, handle hourly, daily and seasonal variations in wave intensity, and continue to operate safely in stormy weather is difficult.

Chiang Mei, the Ford Professor of Engineering in the Department of Civil and Environmental Engineering, has been a believer in wave energy since the late 1970s. After the recent oil-price spike, there has been renewed interest in harnessing the energy in ocean waves.

To help engineers design such devices, Professor Mei and his colleagues developed numerical simulations that can predict wave forces on a given device and the motion of the device that will result. The simulations guide design decisions that will maximize energy capture and provide data to experts looking for efficient ways to convert the captured mechanical energy to electrical energy.

One country with a good deal of expertise in wave energy research and development is Portugal. For the past three years, Mei has been working with Professors Antonio Falcao, Antonio Sarmento and Luis Gato of Insitituto Superior Tecnico, Technical University of Lisbon, as they plan a pilot-scale version of a facility called an oscillating water column, or OWC. Situated on or near the shore, an OWC consists of a chamber with a subsurface opening. As waves come in and out, the water level inside the chamber goes up and down. The moving surface of the water forces air trapped above it to flow into and out of an opening that leads to an electricity-generating turbine. The turbine is a design by A.A.Wells in which the blades always rotate in the same direction, despite the changing direction of the airstream as the waves come in and out.

The Portuguese plan is to integrate the OWC plant into the head of a new breakwater at the mouth of the Douro River in Porto, a large city in northern Portugal. Ultimately, the installation will include three OWCs that together will generate 750 kilowatts — roughly enough to power 750 homes. As a bonus, the plant's absorption of wave energy at the breakwater head will calm the waters in the area and reduce local erosion.

The challenge is to design a device that resonates and thus operates efficiently at a broad spectrum of wave frequencies — and an unexpected finding from the MIT analysis provides a means of achieving that effect. The key is the compressibility of the air inside the OWC chamber. That compressibility cannot be changed, but its impact on the elevation of the water can — simply by changing the size of the OWC chamber. The simulations showed that using a large chamber causes resonance to occur at a wider range of wavelengths, so more of the energy in a given wave can be captured. "We found that we could optimize the efficiency of the OWC by making use of the compressibility of air — something that is not intuitively obvious," Mei says. "It's very exciting."

He is currently working with other graduate students on wave power absorbers on coastlines of different geometries and on how to extract wave power from an array of many absorbers.

Mei continues to be enthusiastic about wave energy, but he is not unrealistic in his expectations. Although costs have been falling in recent years, wave energy is unlikely to be commercially viable for a long time — perhaps several decades. Nevertheless, Mei is adamant that more attention should be given to this renewable source of energy, and he would like to see a team of MIT experts in different fields — from energy capture and conversion to transmission and distribution — working collaboratively toward making large-scale wave energy a reality.

"Given the future of conventional energy sources, we need lots of research on all kinds of alternative energy," he says. "Right now, wind energy and solar energy are in the spotlight because they've been developed for a longer time. With wave energy, the potential is large, but the engineering science is relatively young. We need to do more research."

Research on the OWC was supported by the MIT-Portugal Alliance.

(This article was adapted from a longer version that appeared in the autumn 2008 issue of Energy Futures, the newsletter of the MIT Energy Initiative.)

MINDELL: New report looks at the future of spaceflight

Continued from **Page 1**

And it is essential that whatever goals are set for human spaceflight, the funding should be adequate. "Trying to do too much with too little is exactly what caused the last two shuttle accidents," he says.

Among the report's major conclusions are that the United States should be cooperating more on human spaceflight, both with other nations — including China and India — and with commercial ventures such as private rocket companies. The nation should also set ambitious goals for long-term exploration, and make sure that near-term work is geared toward those ends. In addition, a comprehensive strategy of basic research is needed to lay the groundwork for these longer-range goals.

Some of the key recommendations from the MIT report:

- Congress and the White House should reduce the "too much with too little" pressure on NASA by ensuring that resources match expectations. They should begin a public conversation on the ethics and acceptable risk of human spaceflight at current levels of support and ambition.
- NASA should continue to support commercial and European development of crew and cargo alternatives, particularly for cargo return.
- The United States should develop a broad, funded plan to utilize the International Space Station through 2020 for research, including development of technologies to support exploration for both moon missions and long-duration Mars flights.
- A new human spaceflight policy should clarify the balance among the moon, Mars, and other destinations. It should be more, not less ambitious. A new policy should also review the Constellation (shuttle replacement) architecture to ensure compatibility with long-range exploration missions.
- NASA should re-establish a fundamental research program focused on science and technology for human spaceflight and exploration.
- The United States should begin engagement with China on human spaceflight in a series of small steps, gradually building up trust and cooperation.

The report, called "The Future of Human Spaceflight," was prepared by the Space, Policy and Society Research Group at MIT, which Mindell directs.

The group includes MIT aeronautics and astronautics professor and former space shuttle astronaut Jeffrey Hoffman; Apollo Program Professor of Astronautics Laurence Young; Aeronautics and Astronautics Professor Dava Newman; Jerome C. Hunsacker Assistant Professor of Aeronautics and Astronautics and Engineering Systems Annalisa Weigel; lecturer in science, technology and society Slava Gerovitch; postdoctoral associate Scott Uebelhart; graduate students Eph Langford, Teasel Muir-Harmony, Sherrica Newsome, Zakiya Tomlinson and Rebecca Perry; Lawrence McGlynn, president of Insurance Services of New England; Asif Saddiqi, assistant professor of history at Fordham University; John Tylko, vice president at Aurora Flight Sciences; and John Logsdon of the Smithsonian Air & Space Museum.

Researchers finger the cause of 'gravity fingers'

CEE team offers elegant solution to long-standing fluid mechanics problem

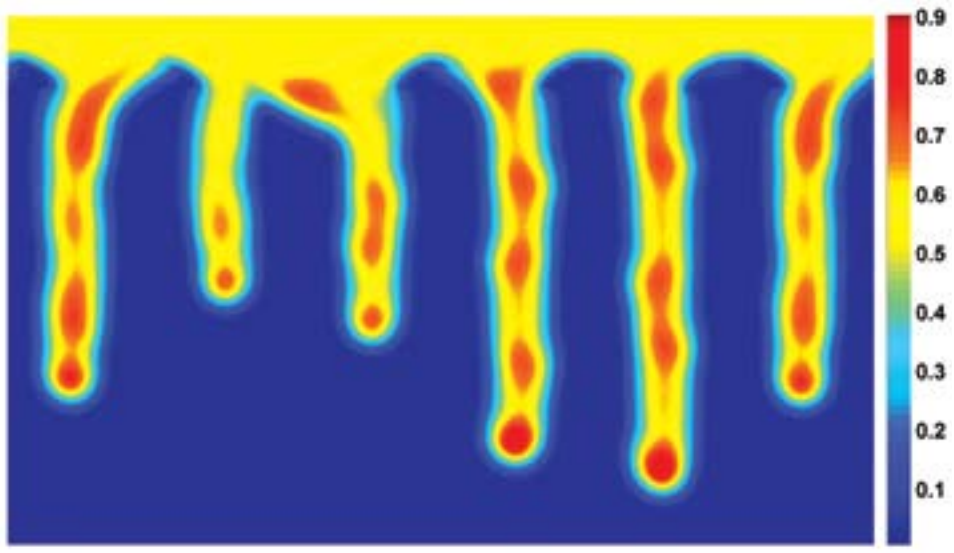
Denise Brehm
Civil and Environmental Engineering

MIT researchers have found an elegant solution to a sticky scientific problem in basic fluid mechanics: why water doesn't soak into soil at an even rate, but instead forms what looks like fingers of fluid flowing downward.

Scientists call these rivulets "gravity fingers," and the explanation for their formation has to do with the surface tension where the water — or any liquid — meets the soil (or other medium). Knowing how to account for this phenomenon mathematically will have wide-ranging impact on science problems and engineering applications, including the recovery of oil from reservoirs and the sequestration of carbon underground.

The solution, reported in the Dec. 12 issue of Physical Review Letters, involves borrowing a mathematical phrase from the description of a similar problem — a solution both simple and elegant that had escaped the notice of many researchers in earlier attempts to describe the phenomenon.

Co-authors Luis Cueto-Felgueroso and Ruben Juanes of the MIT Department of Civil and Environmental Engineering discovered the solution while studying the larger question of how water displaces oil in underground reservoirs (petroleum engineers commonly flush oil reservoirs with water to enhance oil recovery).



GRAPHIC / **LUIS CUETO-FELGUEROSO**

Saturation maps from a numerical simulation of the proposed model show that the flow dynamics and the distinctive saturation overshoot at the tip of the fingers agree with experimental observations.

"Our paper addresses a long-standing issue in soil physics," said Cueto-Felgueroso. "Lab experiments of water infiltration into homogeneous, dry soil, repeatedly show the presence of preferential flow in the form of fingers. Yet, after several decades, the scientific community has been unable to capture this phenomenon using mathematical models."

"This was the type of problem that required someone from a different research discipline to take a look at it and come up with the solution," said Juanes, the ARCO Assistant Professor in Energy Studies. "Luis applied his expertise to a fluid mechanics problem in another medium — porous media flows — and quickly figured out the solution."

Cueto-Felgueroso, a postdoctoral associate who has previously worked primarily on airflow fluid mechanics problems, had a eureka moment when he realized that gravity fingers in soil (or clay or sand) look very similar to water flowing down a window pane, a fairly well-understood phenomenon. He and Juanes then pulled the mathematical explanation (think of it as a phrase of words or music) from the equation describing water on a window, and included that mathematical phrase in the equation describing liquid moving downward through soil.

After rigorous comparison of data produced by the new mathematical model with observed phenomena, the two realized they'd found the solution, a solution described by one scientist reviewing the paper in Physical Review Letters as "simple and elegant" and a "major breakthrough" in the field.

The Cueto-Felgueroso and Juanes solution also describes one aspect of the water-flowing-down-a-windowpane phenomenon that previously was not understood by scientists, who actually refer to this as "the flow of thin films": Why does water build up at the tips of the fingers?

Again, the answer has to with the surface tension. Before the water can flow down the film, it must build up enough energy to overcome the tension that is holding it in place.

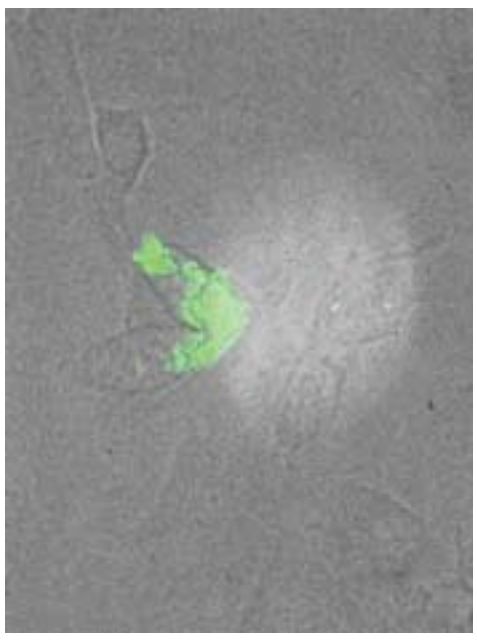
So what was missing from earlier models of water moving downward through soil that made it appear to move as a steady, horizontal front, rather than in finger-like paths — even when the soil was homogenous in particle size and shape?

The missing mathematical phrase describes the surface tension of the entire finger of water, which may be several centimeters in width, as opposed to the tension existing at the micron-scale of pores between soil particles.

And that phrase will sound like music to the ears of physicists and engineers.

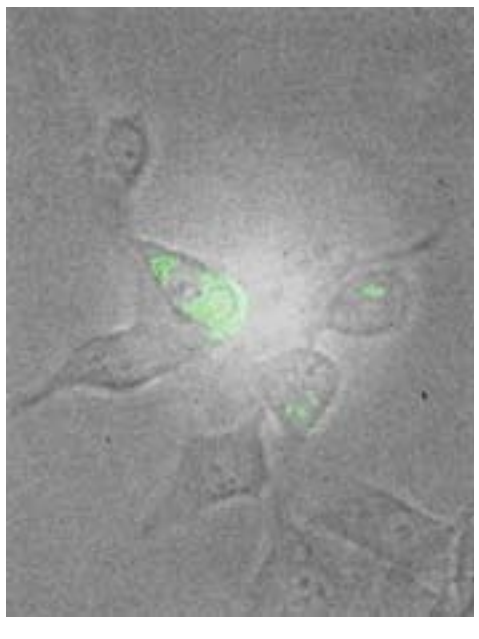
The work was supported by the Italian energy company Eni.

Nanotubes sniff out cancer agents in living cells



IMAGES / **STRANO LAB**

These two images show carbon nanotubes inside a mammalian cell. The nanotubes can detect the presence of certain molecules, in this case, hydrogen peroxide. ABOVE: The cell before hydrogen peroxide is added. BELOW: The cell after hydrogen peroxide is added. The change in fluorescence provides a 'fingerprint' that allows different molecules to be identified.



Chemical engineers use carbon nanotubes to monitor chemotherapy, detect toxins at the single-molecule level

Anne Trafton
News Office

MIT engineers have developed carbon nanotubes into sensors for cancer drugs and other DNA-damaging agents inside living cells.

The sensors, made of carbon nanotubes wrapped in DNA, can detect chemotherapy drugs such as cisplatin as well as environmental toxins and free radicals that damage DNA.

"We've made a sensor that can be placed in living cells, healthy or malignant, and actually detect several different classes of molecules that damage DNA," said Michael Strano, associate professor of chemical engineering and senior author of a paper on the work that appeared in the Dec. 14 online edition of Nature Nanotechnology.

Such sensors could be used to monitor chemotherapy patients to ensure the drugs are effectively battling tumors. Many chemotherapy drugs are very powerful DNA disruptors and can cause serious side effects, so it is important to make sure that the drugs are reaching their intended targets.

"You could figure out not only where the drugs are, but whether a drug is active or not," said Daniel Heller, a graduate student in chemical engineering and lead author of the paper.

See the interview with Strano and Heller at web.mit.edu/newsoffice

The sensor can detect DNA-alkylating agents, a class that includes cisplatin, and oxidizing agents such as hydrogen peroxide and hydroxyl radicals.

Using the sensors, researchers can monitor living cells over an extended period of time. The sensor can pinpoint the exact location of molecules inside cells, and for one agent, hydrogen peroxide, it can detect a single molecule.

The new technology takes advantage of the fact that carbon nanotubes fluoresce in near-infrared light. Human tissue does not, which makes it easier to see the nanotubes light up.

Each nanotube is coated with DNA, which binds to DNA-damaging agents present in the cell. That interaction between the DNA and DNA disruptor changes the intensity and/or wavelength of the fluorescent light emitted by the nanotube. The agents produce different signatures that can be used to identify them.

"We can differentiate between different types of molecules depending on how they interact," Strano said.

Because they are coated in DNA, these nanotube sensors are safe for injection in living cells. (Nanotubes can come in many different lengths and can be coated with different materials, which influences whether they are safe or toxic, Strano said.)

In future studies, the researchers plan to use the sensors to study the effects of various antioxidants, such as the compounds in green tea, and learn how to more effectively use toxic chemotherapy drugs.

Other authors of the paper include MIT graduate student Hong Jin of the Department of Chemical Engineering. Researchers from the University of Illinois at Urbana-Champaign also contributed to the work, which was funded by the National Science Foundation.

Close encounters with 3-D cell growth

Engineers' new microfluidic device could help with drug development

Anne Trafton
News Office

MIT engineers have built a device that gives them an unprecedented view of three-dimensional cell growth and migration, including the formation of blood vessels and the spread of tumor cells.

The microfluidic device, imprinted on a square inch of plastic, could be used to evaluate the potential side effects of drugs in development, or to test the effectiveness of cancer drugs in individual patients.

Roger Kamm, MIT professor of biological and mechanical engineering, and his colleagues reported their observations of angiogenesis — the process by which blood vessels are formed — in the Oct. 31 online issue of the journal Lab on a Chip.

Microfluidic devices have been widely used in recent years to study cells, but most only allow for the study of cells growing on a flat (two-dimensional) surface, or else lack the ability to observe and control cell behavior. With the new device, researchers can observe cells in real time as they grow in a three-dimensional collagen scaffold under precisely controlled chemical or physical conditions.

Observing angiogenesis and other types of cell growth in three dimensions is critical because that is how such growth normally occurs, said Kamm.

Working with researchers around MIT, Kamm has studied growth patterns of many types of cells, including liver cells, stem cells and neurons. He has also used the device to investigate the pressure buildup that causes glaucoma.

The device allows researchers to gain new insight into cell growth patterns. For example, the researchers observed that one type of breast cancer cell tends to migrate in a uniform mass and induces new capillaries to sprout aggressively toward the original tumor, while a type of brain cancer cell breaks from the primary tumor and

▶Please see 3-D, **PAGE 7**

Ancient bacteria offer new line of attack on cystic fibrosis

MIT researchers have found that the pigments responsible for the blue-green stain of the mucus that clogs the lungs of cystic fibrosis (CF) patients are primarily signaling molecules that allow large clusters of the opportunistic infection agent, Pseudomonas aeruginosa, to organize themselves into structured communities.

The research team, led by Dianne K. Newman, the John and Dorothy Wilson Professor of Biology and Geobiology, will report the findings Tuesday at the American Society for Cell Biology annual meeting in San Francisco.

For decades, these pigments, called phenazines, have been wrongly regarded as antibiotics, generated by P. aeruginosa to kill off the microbe's bacterial competitors in the lungs. This new insight about the leading cause of death of people with CF suggests that the phenazine-processing machinery could become a potential target for drugs to treat P. aeruginosa infections in CF patients, according to Newman and postdoctoral fellow Lars Dietrich.

P. aeruginosa appears as a classic opportunistic infection, easily shrugged off by healthy people but a grave threat to those with CF, which chokes the lungs of its victims with sticky mucus.

"We have a long way to go before being able to test this idea, but the hope is that if survival in the lung is influenced by phenazine — or some other electron-shuttling molecule or molecules — tampering with phenazine trafficking might be a potential way to make antibiotics more effective," said Newman, whose lab investigates how ancestral bacteria on the early Earth evolved the ability to metabolize minerals.

Newman and Dietrich looked at phenazines from an evolutionary perspective, and using RNA arrays to probe all of the small molecules' actions, they discovered that phenazines are not mere redox-active weapons but are molecules that activate the transcription factor SoxR.

In Escherichia coli and other closely related bacteria, SoxR regulates the response to superoxide stress and appears to be utilized to regulate a handful of genes that might be involved in the transport and modification of redox-active signals.

By manipulating phenazine activity in colonies of P. aeruginosa grown in the lab, the MIT scientists learned that these molecules create a smooth biofilm surface under which the colony can prosper in anaerobic bliss. The less phenazine available, the more wrinkled and less strong the colony surface becomes.

A thick biofilm also develops in the lungs of patients with CF infected with P. aeruginosa. Sealed under the biofilm are the pseudomonads that have adapted to the patients' lungs, developed antibiotic resistance and formed large anaerobic colonies.

Most people with CF die from a cascade of damaging lung infections. Pathogenic bacteria such as Staphylococcus aureus weaken the CF patient, but it is the onset of P. aeruginosa infection that signals a dangerous turn.

(Adapted from a news release issued by the American Society for Cell Biology)

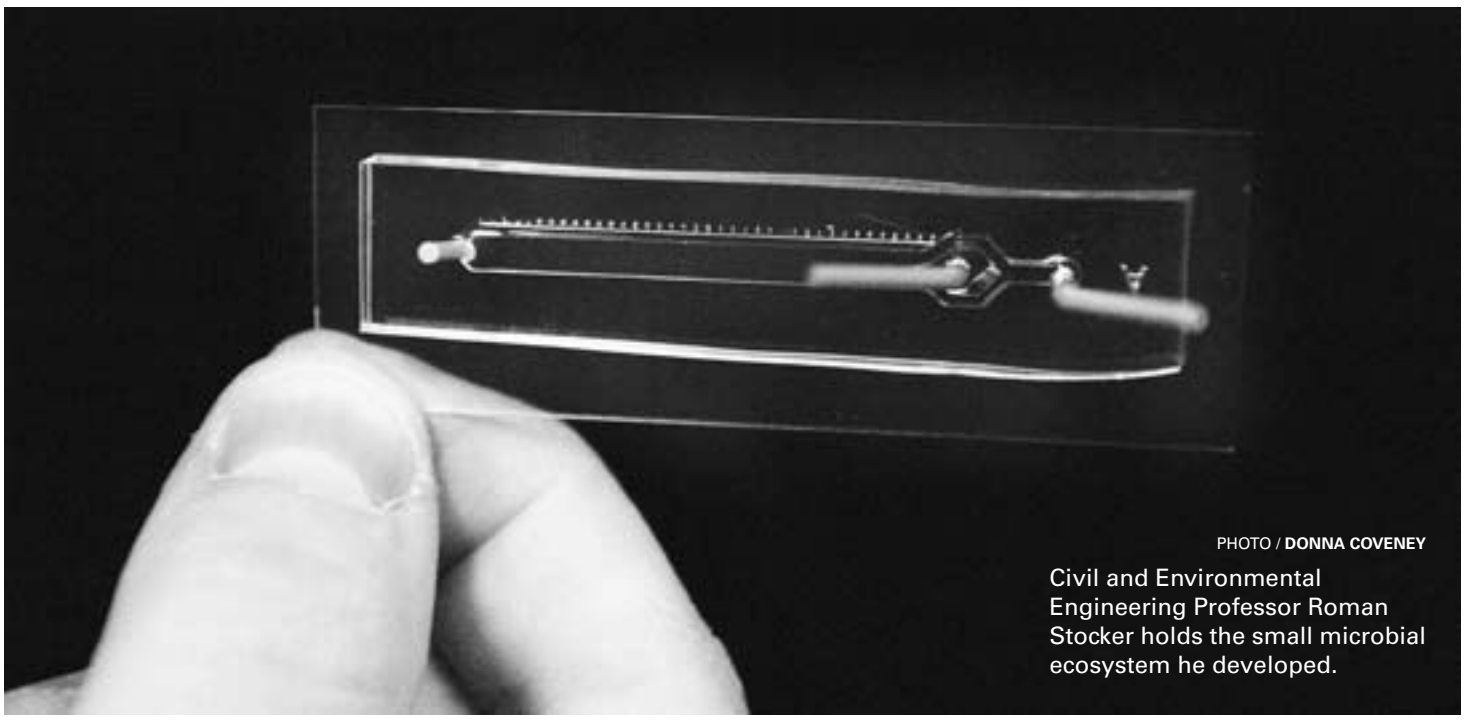


PHOTO / **DONNA COVENEY**

Civil and Environmental Engineering Professor Roman Stocker holds the small microbial ecosystem he developed.

A plankton-eat-plankton world

Tiny ecosystem may shed light on key ocean microbes and their role in influencing climate

Deborah Halber
Civil and Environmental Engineering

MIT researchers have created a microbial ecosystem smaller than a stick of gum that sheds new light on the plankton-eat-plankton world at the bottom of the aquatic food chain.

The work, reported in the January print issue of American Naturalist, may lead to better predictions of marine microbes' global-scale influence on climate.

Through photosynthesis and uptake of carbon compounds, diverse planktonic marine microorganisms — too small to be seen with the naked eye — help regulate carbon flux in the oceans. Carbon flux refers to the rate at which energy and carbon are transferred from lower to higher levels of the marine food web, and it may have implications for commercial fisheries and other ocean-dependent industries.

The MIT study is one of the first detailed explorations of how sea creatures so small — 500,000 can fit on the head of a pin — find food in an ocean-size environment.

Besides showing that microbes' swimming and foraging is much more sophisticated and complex than previously thought, the work also indicates that organic materials may move through the oceans' microbial food web at higher-than-expected rates, via a domino effect of resource patch formation and exploitation, said co-author Justin R. Seymour, postdoctoral fellow in the Department of Civil and Environmental Engineering (CEE).

Using the new technology of microfluidics, Seymour and colleagues Roman Stocker, the Doherty Assistant Professor of Ocean Utilization in CEE, and MIT mechanical engineering graduate student Marcos devised a clear plastic device about the size and shape of a microscope slide.

Depending on the organism being studied, nutrients or prey are injected with a syringe-based pump into the device's microfluidic channel, which is 45 mm long, 3 mm wide and 50 micrometers deep. "While relying on different swimming strategies, all three organisms exhibited behaviors which permitted efficient and rapid exploitation of resource patches," Stocker said. It took bacteria less than 30 seconds, for example, to congregate within a patch of organic nutrients.

This new laboratory tool creates a microhabitat where tiny sea creatures live, swim, assimilate chemicals and eat each other. It provides the first methodological, sub-millimeter scale examination of a food web that includes single-celled phytoplankton, bacteria and protozoan predators in action.

"Rather than simply floating in the ocean and passively taking up the chemicals required for growth, many microbes exhibit sophisticated behaviors as they forage in an environment where patches of nutrients and resources are few and far between," Seymour said.

Oceanographic ecological research has typically taken place at much larger scales because of the difficulty of measuring the behavioral responses of small populations of microorganisms in very small volumes of seawater.

"To understand how environmental fluctuations affect the ecology of populations, it is imperative to understand the foraging abilities and behavior of marine microbes at environmentally relevant scales," the authors wrote.

This work was supported by the National Science Foundation.

Water supplies could be strongly affected by climate change

Changes in rainfall can be amplified, up or down, in changes to aquifers

David Chandler
News Office

It's no simple matter to figure out how regional changes in precipitation, expected to result from global climate change, may affect water supplies. Now, a new analysis led by MIT researchers has found that the changes in groundwater may actually be much greater than the precipitation changes themselves.

For example, in places where annual rainfall may increase by 20 percent as a result of climate change, the groundwater might increase as much as 40 percent. Conversely, the analysis showed in some cases just a 20 percent decrease in rainfall could lead to a 70 percent decrease in the recharging of local aquifers — potentially devastating in semi-arid and arid regions.

But the exact effects depend on a complex mix of factors, the study found — including soil type, vegetation and the exact timing and duration of rainfall events — so detailed studies will be required for each local region in order to predict the possible range of outcomes.

The research was conducted by Gene-Hua Crystal Ng, a PhD candidate in MIT's Department of Civil and Environmental Engineering (CEE), along with King Bhumipol Professor Dennis McLaughlin and Bacardi Stockholm Water Foundations Professor Dara Entekhabi, both of CEE, and Bridget Scanlon, a senior researcher at the University of Texas. The results are being presented today at the American Geophysical Union's fall meeting.

The analysis combines computer modeling and natural chloride tracer data to determine how precipitation, soil properties, and vegetation affect the transport of water from the surface to the aquifers below. This analysis focused on a specific semi-arid region near Lubbock, Texas, in the southern High Plains.

Predictions of the kinds and magnitudes of precipitation changes that may occur as the planet warms are included in the reports by the Intergovernmental Panel on Climate Change (IPCC), and are expressed as ranges of possible outcomes. "Because there is so much uncertainty, we wanted to be able to bracket" the expected impact on water supplies under the diverse climate projections, Ng says.

"What we found was very interesting," Ng says. "It looks like the changes in recharge could be even greater than the changes in climate. For a given percentage change in precipitation, we're getting even greater changes in recharge rates."

Among the most important factors, the team found, is the timing and duration of the precipitation. For example, it makes a big difference whether it comes in a few large rainstorms or many smaller ones, and whether most of the rainfall occurs in winter or summer. "Changes in precipitation are often reported as annual changes, but what affects recharge is when the precipitation happens, and how it compares to the growing season," she says.

The team presented the results as a range of probabilities, quantifying as much as possible "what we do and don't know" about the future climate and land-surface conditions, Ng says. "For each prediction of climate change, we get a distribution of possible recharge values."

If most of the rain falls while plants are growing, much of the water may be absorbed by the vegetation and released back into the atmosphere through transpiration, so very little percolates down to the aquifer. Similarly, it makes a big difference whether an overall increase in rainfall comes in the form of harder rainfalls, or more frequent small rainfalls. More frequent small rainstorms may be mostly soaked up by plants, whereas a few more intense events may be more likely to saturate the soil and increase the recharging effect.

"It's tempting to say that a doubling of the precipitation will lead to a doubling of the recharge rate," Ng says, "but when you look at how it's going to impact a given area, it gets more and more complicated. The results were startling."

The work was funded by a grant from the National Science Foundation, as part of the Information Technology Research Program.

3-D: Looking at cell growth in three dimensions

Continued from **Page 5**

migrates individually but does not promote capillary formation.

The system is configured so that researchers can manipulate and study mechanical and biochemical factors that influence cell growth and migration, including stiffness of the gel scaffold, concentration of growth factors and other chemicals, and pressure gradients.

Two or three channels imprinted onto the plastic square contain either a normal cell growth medium or a chemical under study, such as growth factor. Cells growing in the scaffold between the channels are bathed in chemicals from the channels, and the effect of the chemicals can be evaluated based on various measures of cell function.

Kamm and his colleagues first described their microfluidic device in a January 2007 paper in Lab on a Chip. Vernella Vickerman, a graduate student in chemical engineering, and Seok Chung, a postdoctoral fellow in biological engineering, played critical roles in developing the device, Kamm said.

The research was funded by Draper Laboratory.

ALZHEIMER'S: New work shows promise

Continued from **Page 1**

Learning and Memory and who is also an investigator for the Howard Hughes Medical Institute. "Our findings provide insight into how neurons die in neurodegenerative diseases and offer a new therapeutic strategy for countering neuronal death."

Tsai's finding that HDAC1 is a molecular link between aberrant cell-cycle activity and DNA damage means that the enzyme could be a potential target for therapeutics against diseases and conditions involving neuronal death.

In mice genetically engineered to develop symptoms of Alzheimer's, Tsai and colleagues found that inactivating the HDAC1 enzyme led to DNA damage and cell death, while reinforcing its activity protected neurons.

Authors include collaborators from Harvard Medical School, University of Central Florida, the Broad Institute of MIT and Harvard, Massachusetts General Hospital and McLean Hospital.

This work is supported by the National Institutes of Health and the American Heart Association.

PHOTO / **DONNA COVENEY**

Li-Huei Tsai

Awards&Honors

Physics graduate student wins award at PANIC08

Georgia Karagiorgi, a graduate student in the Department of Physics, recently won the best poster award at the International Conference on Particles And Nuclei (PANIC08). The award, sponsored by the Elsevier journal Nuclear Physics A, honors young scientists.

Sloan students win first at CMU case competition

For the second year in a row, an MIT Sloan team consisting of Leaders for Manufacturing (LFM) and MBA students has won first place in Carnegie Mellon University's annual International Operations Case Competition. Members of this year's winning team included LFM '10s Chad Sailer, David Follette, Paul Witinski and Chris Lin, plus Michael Irwin, MBA '10.

This marks the fourth year that an MIT Sloan team, which has always included LFM students, has taken first place. Others won in 2000 (tied for first place), 2003 and 2007. Another team placed second in 2002.

Lecturer named APS fellow

Sekazi Mtingwa, a senior lecturer in the Concourse program at MIT, has been elected a fellow of the American Physical Society. The APS Fellowship Program was created to recognize members who have made advances in physics through original research and publication, or made significant innovative contributions in the application of physics to science and technology. According to the APS citation, Mtingwa was elected a fellow for his definitive treatment of intrabeam scattering, his contributions to the wakefield acceleration, and his early recognition of the fixed target physics potential of the next generation electron-positron collider.

Professors receive honorary doctorates

Rosalind Williams, the Bern Dibner Professor of the History of Science and Technology and Moshe Ben-Akiva, the Edmund K. Turner Professor of Civil and Environmental Engineering, were recently awarded honorary doctorates at KTH Royal Institute of Technology in Stockholm, Sweden.

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

Carnival Cruise Gift Certificates on sale NOW! The perfect gift to enjoy after the holiday rush! Starting at $418/for 2 guests. Sale ends 12/31/08. www.marciatraveldeals.com.

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

FOR RENT

Room for woman students in house in South Boston, a small studio $650. Included utilities, 617-268-0880. Red line access 10 feet away.

3 Questions

James Poterba on the recession

"3 Questions" is a new series from the MIT News Office that gives members of the community the opportunity to sound off on current events in their field of expertise. In this installment, James Poterba, the Mitsui Professor of Economics, discusses the current economic recession and how long it might last. In addition to serving as an MIT faculty member, Poterba is president and CEO of the National Bureau of Economic Research (NBER), a private group of leading economists that dates the start and end of economic downturns.

We want to hear your feedback and suggestions. Please contact the News Office at newsoffice@mit.edu, and be sure to write "3 Questions" in the subject line.

Q. NBER, the group you direct, announced earlier this month that the U.S. economy began contracting a year ago, in December 2007. That means it's already the third-longest recession since World War II, following two 16-month recessions in the 1970s and 1980s. Given that many of the leading economic indicators signal more weakness ahead, just how bad is this going to get?

A. Many signals suggest that the current recession is likely to be the longest and most severe in at least several decades. The NBER Business Cycle Dating Committee, which consists of seven economists who monitor economic indicators on an ongoing basis, identified the turning point as December 2007 — before the array of financial market shocks that have buffeted the U.S. and the world economy in 2008. The economy was in a period of declining economic activity when these shocks hit, and these shocks are virtually certain to prolong and deepen the period of economic weakness. The NBER does not make forecasts, but a number of private sector firms that do suggest that the U.S. unemployment rate, which was 6.7 percent in November, could rise to 9 percent in 2009. If those forecasts are realized, this would be the deepest recession since 1982-3, when the U.S. unemployment rate averaged more than 9.5 percent. The recession of the early 1980s was the deepest one in U.S. postwar history, and it was associated in part with the efforts by the Federal Reserve Board under Paul Volcker to wring inflationary pressures out of the U.S. economy.

Although a deep recession is a serious possibility, it is important to remember that government stimulus, implemented either through monetary policy or through fiscal policy, can have an important counter-balancing effect. The trajectory of economic activity during 2009 and 2010 is likely to depend in substantial part on the course of economic policy.

Q. Many Democrats have seized on NBER's announcement as more evidence of the need for Congress to approve a massive stimulus package — a new New Deal, of sorts. Yet presumably the U.S. would have to finance such spending with an equally massive expansion of debt. At what point do foreigners — who have dutifully loaned America trillions of dollars in recent years so that we could finance our consumption habits when times were good — say "enough's enough"? If they balk at lending us more, what then?

A. The short-run fiscal stimulus that began this year with the TARP program to rescue financial institutions, and that seems very likely to expand under the new administration in 2009, could push the measured federal budget deficit to close to one trillion dollars —about 6 percent of our GDP. While that is a dramatic change from recent years, when the federal deficit was less than $200 billion, it is not uncharted territory. The U.S. experienced similar-sized deficits for several years in the mid-1980s, and we begin this period with a lower ratio of government debt to GDP than many other large developed countries. The fact that the current financial crisis is global in nature has also led to a "flight to quality" in financial markets, and U.S. Treasury securities are viewed as the safest securities in the world. Thus at least for the moment, there does not seem to be much risk that foreign lenders will precipitously reduce their demand for U.S. government debt.

The auction of Treasury four-week notes on Dec. 9 provides some indication of the market's appetite for U.S. government securities. The Treasury securities sold at a zero interest rate — investors were prepared to lend to the federal government for four weeks in return only for a promise that they would get back their principal when the loan was due. Yields on long-term Treasury bonds are also currently low, even though market participants foresee substantial borrowing in the next few years.

One caution should be kept in mind when evaluating reports about the federal deficit, particularly the deficit connected with the TARP program to assist financial institutions. The federal government is making loans and providing subsidies to an array of firms, but it is in return collecting equity stakes or other securities issued by these firms. These claims have value, although it is difficult to judge that value today. The net cost to the federal government of rescuing financial institutions is likely to be substantially smaller than the gross cost of the loans, because the claims that the federal government now has on these firms may be sold at some future date. In some historical cases when the federal government stepped in to help troubled firms, and received an equity stake in return, the rescue operation netted a profit for the U.S. Treasury.

Q. What, if any, early signs should we be watching for to indicate that the worst has passed and the economy is rebounding?

A. I would look to the housing market. The financial crisis began with weakness in the housing market and a corresponding drop in the value of mortgages held by banks and many other financial institutions. The U.S. has been through a period of excessive leverage in which borrowing supported a wide range of investments, ranging from homes to exotic financial securities to consumer durables, and we are now witnessing a "deleveraging" in many markets. Because housing markets are very visible and construction employment is a major, but volatile, component of the aggregate employment, falling levels of housing inventory and stabilizing house prices may be "canaries in the coal mine" for stronger economic times.

GOOD ART *hunting*

MIT physics teacher tests art knowledge in hallway contest

Lisa Damtoft
Special to the News Office

Stroll down the sixth-floor hallway of the Kavli Institute for Astrophysics and Space Research in Building 37 and you'll see images of the Milky Way in molecular clouds, the Folded-port InfraRed Echellette spectrometer and simulations of cold dark matter caustics.

Walk a little farther, and you'll see a Rembrandt, a Hockney, a Picasso and many more reproductions by famous artists ranging from Giotto to Judd. This unexpected burst of art in an enclave of science and technology is the brainstorm of MIT physics professor and art lover Walter Lewin.

For six years, Lewin has used the board as a platform to run a weekly art quiz to pique curiosity and invite involvement by colleagues and students. Every Sunday, he posts a printout of an artwork; participants then use a little cardboard ballot box to submit their best guess as to who the artist is. The following weekend, Lewin posts the answer and starts the process all over again. At the end of each year, he awards art books to the three participants who got the most answers right.

A few years ago, Elizabeth Kubicki, an assistant in the Microsystems Technology Laboratories, was walking down the hall when the riotous gallery of thumbtacked images caught her eye.

Intrigued, she started playing the quiz, becoming a detective of sorts in the process. How could one figure out the creator of an unknown piece? First, she estimates the piece's time period, then turns to her art books and the web to determine the most important artists from that era. "I examine the art piece for specific elements significant to a particular artist — brush stroke, color, manner and favorite shapes," she said.

PHOTOS / **PATRICK GILLOOLY**

Elizabeth Kubicki, an assistant in the Microsystems Technology Laboratories, stands next to the art contest board near Professor Walter Lewin's office.

Not only has her participation in the quiz resulted in several sumptuous prizes — art books — from Lewin, but she also says she has learned profound lessons about the creative process.

"Art is a never-ending progress of inner expression," she says. "It's an inevitable journey from superior cave paintings at Lascaux from 32,000 years ago to the new dialectic of Mark Rothko's 'Orange and Yellow, 1956.'"

Lewin developed his passion for art as a child in his native Holland through his parents' art collection and visits to the Gemeente Museum in The Hague. While at MIT years later, he met renowned Dutch computer artist Peter Struycken.

"My parents had several of his works in their collection," Lewin said. "Peter and I became close friends. He made me 'see' art; before I knew him, I only 'looked' at art. I learned how to appreciate and evaluate the pioneering contributions in art."

Lewin collaborated with Struycken on the latter's art during the late 1970s; the physicist's increasing expertise in art history led to an invitation from the Beuymans Museum in Rotterdam to give the first Mondrian Lecture to a crowd of 900 in Amsterdam in 1979. He has even started an art collection of his own, now totaling about 125 pieces.

"Art is still pivotal in my life," says Lewin. "I can't even imagine what my life would be without it. An appreciation for art and, above all, knowledge of art enriches your life and broadens your horizons."

Kubicki agrees. "Art is mirroring our life, art is exercising our freedom and art is implementing our intellect."