Marine bacteria's mealtime dash is a swimming success

Denise Brehm
Civil and Environmental Engineering

Goldfish in an aquarium are able to dash after food flakes at mealtime, reaching them before they sink or are eaten by other fish. Researchers at MIT recently proved that marine bacteria, the smallest creatures in the ocean, behave in a similar fashion at mealtime, using their swimming skills to reach tiny food patches that appear randomly in the ocean blue.

The behavior of bacteria at these small scales could have global implications, possibly even impacting the oceans' health during climate change.

Scientists in the Department of Civil and Environmental Engineering demonstrated for the first time in lab experiments that the 2-micron-long, rod-shaped marine bacterium *P. haloplanktis* is able to take up nutrients before they undergo chemical changes. A paper published in the March 10 online edition of the Proceedings of the National Academy of Sciences describes the research.

"Our experiments have shown that marine bacteria are able to home in very rapidly on short-lived nutrient patches in the ocean," said Roman Stocker, the Doherty Assistant Professor of Ocean Utilization and lead author on the paper. "This suggests that *P. haloplanktis* performance is finely tuned to the oceanic nutrient landscape. If you are a bacterium, the ocean looks like a desert to you, where food mostly comes in small patches that are rare and ephemeral. When you encounter one, you want to use it rapidly."

The researchers were able to prove the behavior of *P. haloplanktis* by recreating a microcosm of the bacterium's ocean environment using new technology called microfluidics. Microfluidics consists of patterns of minute channels engraved in a clear rubber sheet engraved in a clear rubber sheet.

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Joseph Weizenbaum, professor emeritus of computer science, 85

Joseph Weizenbaum, professor emeritus at MIT, was a computer scientist who grew skeptical of artificial intelligence after authoring a program that many users felt they were speaking with an empathic psychologist, died March 5 in Berlin. He was 85.

Weizenbaum, who was Jewish, fled Nazi Germany with his parents and arrived in the United States in the mid-1930s. At the beginning of his career with computers, in the early 1950s, he worked on designing and building a digital computer at Wayne University in Detroit, Mich.

In 1956, Weizenbaum became a member of the General Electric team that designed and built the first computer systems in banking operations. Among his early technical contributions were the list processing system SLIP, which was an important developing language and cemented his role in the folklore of computer science research.

Weizenbaum was perhaps the first instance of what today is known as a chatterbot program. Specifically, the ELIZA program was designed as a patient and a psychotherapist by using a person's responses to shape the computer's replies. Weizenbaum was shocked to discover that many users were taking his program seriously and were opening their hearts to it. The shock prompted him to think philosophically about the implications of artificial intelligence, and, later, to become a critic of it.

Weizenbaum joined MIT's faculty in the 1960s. In 1976, he helped found the Computer Power and Human Reason, in which he dispelled ambivalence toward computer technology. "Computer Power and Human Reason" raised questions about the role of artificial intelligence, and spurred debate about the role of computer systems in decision-making for many years," said Eric Grimson, head of the Department of Electrical Engineering and Computer Science at MIT.

Weizenbaum's more recent book, "Kurs auf den Eisberg," dealt with the difficult role of the scientist in an immoral world.

OH SERIOUSLY...

The MIT Sea Grant College Program has selected two MIT faculty as recipients of the 2008 Doherty Fellowship in Ocean Utilization. Franz Hover, assistant professor in the Department of Mechanical Engineering, and Eric Alm, assistant professor with appointments in the Department of Biological Engineering and the Department of Civil and Environmental Engineering, will each receive a supplement in order of award of $25,000 per year for two years.

The Doherty Fellowship encourages promising, non tenure-track organization to undertake marine-related research that will further innovative uses of the ocean's resources. The area of research may address any aspect of marine use and management, whether social, political, environmental or technological.

Hover's research with autonomous underwater vehicles (AUVs) will focus on developing and demonstrating a manipulation system for unknown environments; Alm will be studying genetic engineering of marine bacteria.

The ITS, under the auspices of the U.S. Department of Transportation's Research and Innovative Technology Administration, advises the U.S. Secretary of Transportation on the study, development and implementation of "intelligent" transportation systems.

Alejandro N. Flores, a PhD student in the Department of Civil and Environmental Engineering, won the Outstanding Student Paper Award of the American Geophysical Union's Hydrology section.

The paper, co-authored with Professor Raffel Bras and Cees van der Gaag, is titled, "Modeling Uncertainty and Eddition in Soil Property Estimation: Restricted Pairing and Implications for Ensemble-Based Hillslope-Scale Soil Moisture and Temperature Estimation." Flores presented it at the AGU's meeting in December.

The MIT Undergraduate Society of Civil and Environmental Engineers (MUSE) has been named one of the 34 chosen as the inaugural class of fellows for the National Society of Professional Engineers. Jimmy Bartolotta, an MIT junior, has been named to the 2008 "ESPN The Magazine" Academic All-America First team in men's basketball.

The junior, who was named all-conference last year, is the first MIT player since 1980 to make the All-Conference team.

An MIT undergraduate and two graduate students in the Harvard-MIT program were recently named fellows of the MIT Technology Review, a program—which recognizes students who are immigrants or children of immigrants.

MIT undergraduate Sudhe Dalal, a junior in physics, and Mudassir Dalal, both in the Harvard-MIT program, have each received up to $16,000 a year for four years to support their academic and living expenses. Each award lasts two years.

Research by Moshe Ben-Avka, the Edmund K. Turner Professor of Civil and Environmental Engineering, and featured in an episode of The History Channel’s “Modern Marvels,” which aired Thursday, Feb. 8.

The episode, titled “Superhighways,” also featured a short interview with MIT alumnus Ramachandran Balakrishnan, PhD ’06 describing the traffic modeling program, MITSIM.

MITSIM simulates traffic the way the world really is. Drivers aim to get to their destinations as quickly as possible, each other, changing lanes, braking for the car in front slows down—and models the drivers’ responses in real time.

Fifteen percent of the voters who stayed home in the first primary will have access to the Internet can then cast their votes, pro- viding an instant tallying of results. One of the system is the use of the Iowa caucuses, in which supporters of candidates who fail to reach a certain threshold in the first round can then move on to their second choices, and so on, until a clear winner emerges.

A new computer software system developed by MIT researchers promises to make such ranking systems just as easy as traditional voting—and to give results that leave more people satisfied. The system is about to get its first major trial with the cable music network MTV.

Benjamin Mako Hill, while he was a graduate student in the MIT Media Lab’s Computing Culture group, created a system called Selectivity, which has been online as a free service since last fall and is about to unveil an upgraded version this spring.

With this software, any user can use the website (www.selectivity.org) and use a “Quickvote” in just a few seconds, and users anywhere who have access to the Internet can then cast their votes, providing an instant tallying of results. One of the system is the use of the Iowa caucuses, in which supporters of candidates who fail to reach a certain threshold in the first round can then move on to their second choices, and so on, until a clear winner emerges.

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A n MIT materials scientist’s research on sea snails has helped transform battery technology and may end the need for a rechargeable, biologically based battery that must be replaced if they get dunked in the tub.

Belcher’s eureka moment occurred 10 years ago, it arose from her long, delighted fascination with abalone, the sea snail, and from her willingness to ask a wide-open question: “What if?”

Holding up an abalone shell before a visitor, Belcher describes the moment when two threads—persistent interest and sudden insight—came together, forming the basis of her current research, which spans inorganic chemistry, materials chemistry, biochemistry, molecular biology and electrical engineering.

A seventh-generation Texan, Belcher began studying abalone when she entered the University of California, Santa Barbara, as a graduate student (abalone cling to California’s coastal rocks).

Intrigued since childhood by pearls and pearl-making mollusks, Belcher has been developing synthetic materials for 500 million years, “like the abalone does—but not be limited to one element? What material can we make so they fix themselves?”

“The abalone makes this amazing material out of a common mineral,” she says.

As a doctoral student at Santa Barbara, Belcher had an office with an ocean view. Working on her dissertation, she observed how the abalone produces both its rough outer shell and its opalescent inner simultaneously, she could see whales and dolphins in the Pacific.

On the wall opposite her desk hung a huge periodic table.

“If you’re a chemistry student and know organic chemistry, you understand the periodic table,” she says. “But if you ask the question of why, you look at the chart, and become amazed. It’s not there, it’s not there.”

“Seems so logical and easy. Shells had been self-assembling, manufacturing amazing materials for 500 million years,” Belcher says.

Belcher recalled she stood on her desk to get closer to the chart of 110 elements, and that she felt like running down the table. “It seemed so logical and easy. Shells had been self-assembling, manufacturing amazing materials for 500 million years,” she says.

Belcher received her PhD in 1997 and came to MIT in 2002. She won a MacArthur “Genius” award in 2004 and was named Researcher of the Year by Scientific American in 2006.

Her eureka moment has launched a new chapter in bioengi neering. It has led to the development of smart new nanomaterials, essential to advances in optics and electronics.

With MIT colleagues Paula Hammond, Bayer Professor of Chemical Engineering, and Yet-Ming Chiang, professor of materials science and engineering, Belcher grew the first biologically based, rechargeable battery—the one that can end short-lived cell phones.

Belcher’s MIT battery is comprised of a virus she and her colleagues engineered to latch itself to cobalt oxide. It does look like a clear film. Transparent, efficient, it could one day be poured onto the object it’s powering, like a coat of energizing paint.

Fabricating viral films, Belcher says, may provide new pathways for organizing molecules to help create electronic, optical and magnetic materials.

And in developing the ancient abalone’s clever clus for those new pathways. She keeps a cache of abalone shells on her MIT desk.

“It builds exquisite materials. It’s a very nice animal,” vegetat ion Belcher notes, offering a shell to a guest.

In her work at MIT is driven by a different question than the one she was researching on her desk, scanning the periodic table, abalone shell in hand.

“Back then, I asked, ‘What if? Wouldn’t it be interesting if?’” she says. “Now, the answer are more like, ‘What’s the most efficient, useful material we could make?’”

Ultra-tiny computer chips, fuel cells, “smart” nanocrystal sensors—anything is possible with hybrid materials, she says.

“For what if we could bond protein to other elements in the periodic table and grow new materials?” the say.

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Continued from Page 1

Hastings. “Second, MIT meets the full demonstrated financial need of all students we admit. Third, we award our aid based on need alone; MIT does not award any academic, athletic or other forms of merit scholarships.”

Building on this commitment, MIT will increase its financial aid budget to $574 million. MIT’s total financial aid budget is one of the largest at peer institutions. More than 22 percent of MIT undergraduates—has, on average, dropped by more than 15 percent when adjusted for inflation.

Hastings added.

In the past two years, the Institute took a leadership role in the national debate on financial aid when it became the first private university to depend on the environment; in algal blooms, for example, nutrient patches and glumes will be abundant, and some bacteria will be favored. Whenever is the case, nutrients get redistributed more rapidly, making the food web more productive and potentially affecting the rates at which carbon is removed from the ocean.

The National Science Foundation, the Department of Energy’s Genomes to Life Program, the Woods Hole Center for Ocean and Human Health, and the Gordon and Betty Moore Foundation funded this research.

material and sealed with a glass slide. The researchers injected bacteria and nutrients into the microchambers at specific locations and, using video-microscopy, recorded the bacteria as they foraged on two simulated food sources: a lyzing algal cell that creates a sudden explosion of dissolved nutrients and the small nutrient plume trailing behind particles that sink in the ocean.

The question of whether the bacteria could or couldn’t swim their way to the food in the test chamber has generated considerable interest in the scientific community over the past decade, because there’s a great deal riding on P. haloplanktis and its relatives’ ability to reach these nutrients and recycle them for other animals in the food web.

Scientists who study Earth’s carbon cycle know that accounting for all the organic matter in the marine food web is critical, including the nanobacteria in these tiny, discrete nutrient patches bacteria feed on. In fact, the carbon in those patches is so important that some scientists believe marine bacteria’s capacity to utilize it will determine if the oceans become a carbon sink or source during global warming.

Until 25 years ago, scientists weren’t really aware of the microbial loop, the processing of organic material among the smallest creatures in the ocean: bacteria, phytoplankton, nanozooplankton, viruses, etc. Now they know that the roughly one million bacteria per milliliter of ocean play a pivotal role in the microbial loop, by recycling that organic material, making it available to filter feeders like P. haloplanktis and other animals.

But quantifying the importance of bac teria in the microbial loop has been difficult, because creating a model that mimicks the environment wasn’t possible until recently.

“You can hope to study an organism’s behavior only in the context of its environment. The habitat of a bacterium, on the other hand, is determined by the pH, on the order of microns to millimeters,” said Stocker. “This has made the study of microbial behavior a formidable technical challenge to date. We have been able to create realistic environments in microchambers for studying marine bacteria in the lab by using microfluidic technology.”

P. haloplanktis is a rapid swimmer, propelling itself by a single rotating flagellum in bursts of speed up to 500 body lengths per second (the fastest land animal, the cheetah, travels at bursts of speed up to 30 body lengths per second). During experiments, Stocker and team observed that the bacteria would not only swim but also effectively to swim toward and follow their food sources. That directed movement in response to a chemical gradient (in this case, nutrients) is known as chemotaxis.

“IT will be important to see how widespread the use of rapid chemotaxis is in the ocean,” said Stocker. “We expect this to depend on the environment; in algal blooms, for example, nutrient patches and glumes will be abundant, and some bacteria will be favored. Whenever is the case, nutrients get redistributed more rapidly, making the food web more productive and potentially affecting the rates at which carbon is removed from the ocean.”

The National Science Foundation, the Department of Energy’s Genomes to Life Program, the Woods Hole Center for Ocean and Human Health, and the Gordon and Betty Moore Foundation funded this research.
Interview with the dean: Subra Suresh, School of Engineering

Over the course of the spring semester, Tech Talk will be bringing readers a series of interviews with each of MIT’s five school deans. The second in this series features Dean (DMSE) Subra Suresh, who took charge of the School of Engineering last summer. In the following interview with Greg Frost and David Chandler of the MIT News Office, Suresh outlines his hopes and dreams for the School of Engineering and the changing face of engineering.

Q. It’s admittedly early in your tenure, but can you give us a sense of your top short- and long-term goals?
A. The School of Engineering at MIT has been perceived both nationally and internationally as the leading engineering school. The long-term goal would be not only to maintain that lead in the face of ever-increasing competition, but also to enhance significantly the gap between us and peer institutions that compete with us. In the face of changing intellectual climate of engineering on a global scale, we must make sure that the next wave of engineering inventions and innovations—that by I mean the way engineering is taught in academic institutions for both graduate and undergraduate students—and the way engineering innovations impact industrial practice and society—nucleates here. For example, engineering science was a concept that started in MIT’s School of Engineering, and now it is followed all over the world. The goal is to provide opportunities that enhance excellence in education, research and innovation.

As a leading engineering school, I would say that we have not only an opportunity but also an obligation and a responsibility to lead the profession.

The pace of intellectual change in engineering has been very rapid, and multidisciplinary view of education and research has grown significantly within the past decade. Historically, engineering has been shielded from the significant implications of physics, chemistry and mathematics. But more recently biology has become an integral part of that part of that intellectual core. Economics, management and humanities, as well as communication skills, engineering ethics and teamwork have also become important flavors of that core. We must continue to ask if we are preparing our students the right way.

A faculty member at MIT has the opportunity to work across departmental boundaries within the school and across school boundaries within the Institute as far as multidisciplinary research is concerned. We must ensure that administrative and organizational barriers are minimized or eliminated to develop educational and interdisciplinary activities across schools. The time constant for organizational change in academia is much longer than the time constant for the evolution of a new intellectual discipline. One of the key things that we are focusing on is how to make the intra- and interschool organizational structures more nimble. For example, with respect to teaching, is there duplication of subjects? With respect to research, with respect to recruitment of junior faculty whose research interest may lie in more than one department, we want to make it easier to work effectively across organizational silos.

We know that there are growing numbers of faculty at MIT with more than one academic field of interest, and with activities that span more than one department. So this is going to be a very challenging task, but a very important task for us to examine and refine.

Given the blurring of disciplinary boundaries, we need to develop a system that continues to attract the best faculty and students. How do we continually improve our boot practices to mentor them, to nurture them, and to provide a supporting environment for their intellectual growth? This is also a strong focus of our strategic planning process.

Are there novel mechanisms through which we should be thinking about providing our students the opportunity for a broad education without necessarily sacrificing depth? In addition to well-established fields of specialization—as, for example, mechanical engineering, electrical engineering, computer science—should we explore the possibility of a broader engineering degree for those who would use it as a foundation to launch a career in a different field? What would be the intellectual content of such an MIT engineering degree? Would such a broad first degree in engineering enhance the appeal of science and engineering in society?

A second near-term and very important goal is to significantly increase the proportion of women and underrepresented minority groups in faculty and student ranks.

A third item is that individual faculty members at MIT in general, and at the School of Engineering in particular, have been extremely successful in engaging globally in educational and research activities. There are a few examples where MIT has centrally created opportunities for faculty and students. So one of the things we’ve started to do for the near term is to develop a strategic plan for the school, with respect to international and global engagement. We have also got the director of international programs for the school who is working very closely with the Institute committees to chart the course for international engagement in a coordinated manner.

The fourth major goal is to enhance opportunities to translate successes from scientific discoveries to practice so that the greatest benefits to society are realized as quickly as possible. MIT and the School of Engineering have done remarkably well in creating an ecosystem to translate fundamental research into practice. One recent initiative we have put in place involves internationalization of the best practices of the Deshpande Center. This is a program, known as i-Lab, International Innovation Initiative, that we launched several months ago. This is expected to create new opportunities for MIT faculty to translate research into practice on a global scale by bringing the best practices of the Deshpande Center in our international collaborations.

Q. Within the broad range of engineering disciplines, are there particular areas MIT needs to increase its emphasis? At the same time, are there areas that are important now but may be less so in coming years?
A. Broadly, there are areas within engineering that play a major role in interdisciplinary activities at the Institute. For example, the MIT Energy Initiative. In the latest round of seed funding, approximately 70 percent of the seed funding went to the School of Engineering—not by design, that’s just how it evolved. That’s important because we have a lot of strength in not only fundamental research but also in applying the fundamental research to practice, and energy and environmental sustain-
Subra Suresh, a former head of the Department of Materials Science and Engineering, this hopes and dreams for the School of Engineering and the changing face of engineering.

Bernard Gordon Program for Educational Leadership with a $20 million commitment for support from MIT alumnus Bernie Gordon over a 10-year period. And the purpose of the program is exactly that: to provide our undergraduate students an opportunity for much greater hands-on experience for learning through teamwork and for leadership training. In an increasingly virtual, software-controlled world, the real hardcore, hands-on experience in engineering should not be overlooked, and one of the purposes of this program is to provide much greater opportunities for our students to engage with the world and to learn by working with real systems and components. The challenge there is the scale. I mean, having a lab on campus is not that easy, but we want every undergraduate student to have that experience some day.

Q. As a follow-up question, is MIT doing this because it worries that incoming students aren’t as comfortable doing the kind of hands-on work as, say, previous generations of MIT students?

A. Great question. EECS has done this for their freshmen, but there are also other examples of this. About eight years ago, the Department of Aeronautics and Astronautics revamped its undergraduate curriculum. So they have a brand new graduate curriculum that combines learning with practical experience through experimentation, design and teamwork. The other example is in the Department of Materials Science and Engineering, where we built modern undergraduate teaching labs along the Infinite Corridor. In the sophomore year, we have a curriculum now where the students not only take lectures but also work in coordinator education. And we’ve meant creating new labs that did not exist and also required that we change our teaching assignments. Across many disciplines in the school, colleagues feel that such experiences are very important in undergraduate education.

There is a broad sentiment across the school that we cannot get away from the hands-on experience for engineering education. It requires a lot of resources, so I think it needs to be done carefully.

Q. Looking ahead, how important do you see engineering education being to a country’s competitiveness in an increasingly interconnected world?

A. This is going to be the century of technology, more so than the previous centuries. New institutions such as MIT will not only have many more career changes than their parents or grandparents did, but they are also likely to live and work abroad more frequently than the previous generations of engineers did. I believe that it is extremely important for MIT’s School of Engineering to help train outstanding engineers and global citizens whose technological prowess and leadership skills helps solve complex global problems. Such engineers, scientists, technologists and innovators will be the key to our country’s competitive edge in an increasingly interconnected global economy.

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On a ‘roll’: MIT researchers devise new cell-sorting system

Process could yield low-cost tool for diagnosing cancer, other diseases

David Chandler

MIT News Office

Capitalize on cells’ ability to roll along a surface, MIT researchers have developed a simple, inexpensive system to sort different kinds of cells—a process that could result in low-cost tools to test for diseases such as cancer, even in remote locations.

Rohit Karnik, an MIT assistant professor of mechanical engineering and lead author of a paper on the new finding appearing last week in the journal Nano Letters, said the cell-sorting method he pioneered is minimally invasive and highly innovative.

“It’s very dreamy,” he said. “Nobody has ever done anything like this before.”

The method relies on the way cells sometimes interact with a surface (such as the wall of a blood vessel) by rolling along it. In the new device, a surface is coated with lines of a material that interacts with the cells, making it sticky to specific types of cells. The sticky lines are oriented diagonally to the flow of cell-containing fluid passing over the surface, so as certain kinds of cells respond to the coating they are nudged to one side, allowing them to be separated out.

Cancer cells, for example, can be separated from normal cells by this method, which could ultimately lead to a simple, inexpensive system to sort different kinds of cells—a process that could result in low-cost tools to test for diseases such as cancer, even in remote locations.

Karnik said with the new system, “you can sort cells in a very simple way, without processing.”

Now that the basic principle has been harnessed in the lab, Karnik estimates it may take up to two years to develop into a standard device that could be used for laboratory research purposes. Because of the need for extensive testing, development of a device for clinical use could take between five and 10 years, he estimated.

The work was a collaboration between Karnik and six other researchers: MIT Institute Professor Robert Langer, Jeffrey Karp of the Harvard-MIT Division of Health Sciences and Technology, Seunggyo Hong, Ying Mei and Huazhan Zhang of MIT’s Department of Chemical Engineering, and Daniel Anderson of the Center for Cancer Research.

The work was funded by a grant from the National Institutes of Health.
A flair for computer repairs
IS&T’s Walk-In Help and Service Center in Building N42 han-
dles computer repairs, consulting and troubleshooting. With cross-
trained staff and a simplified pricing structure, this “front door” at 211 Massachusetts Ave. makes it easy for community members to get expert diagnosis and help. You don’t need to know whether your problem is a hardware malfunction, corrupted operating system, virus—or a combination of factors.

Call the Computing Help Desk at 617-253-1101 to talk to a consultant before bringing your computer to N42. Depending on the nature of the problem, this phone call may save you the trip. If not, you can make an appointment for an in-person consulta-
tion or a drop-off. There is no charge for the first 15 to 30 minutes you spend with a consultant. If the problem has not been resolved in that time, you can choose to leave your machine for repair. At this point, you will be charged $60 an hour for any soft-
ware repair or nonwarranty hardware repair plus the cost of any parts. There is no charge for work on hardware under warranty.

For more information, see http://web.mit.edu/ist/helpdesk.

MIT GeoWeb

MIT GeoWeb, a new interface to the MIT Geodata Repository, enables users to access Geographic Information Systems (GIS) data, once accessible only in ArcGIS, through a web-based browser interface.

The web interface lets users search, view and download GIS data and metadata from the MIT Geodata Repository, an international collection of GIS data maintained by MIT GIS Services, which is jointly sponsored by the MIT Libraries, IS&T and the Office of Educational Innovation and Technology. Users will find data in the MIT sys-
tem not freely available on the web or in Google Earth, and can download, manipu-
late and analyze data in whatever system they choose. MIT certificates are required for access. To learn more and see a video tutorial, go to http://web.mit.edu/geoweb.

Options for unwanted cell phones

Many options are available for reuse or disposal of cell phones that are old or that you no longer need. If your phone is from one of MIT’s preferred vendors—Sprint/ Nextel or Verizon Wireless—find out if anyone else in your department can use a cell phone from that vendor. If not, you can have your phone recycled. For a list of recycling sources, contact Angélica Milonas at milonas@mit.edu or John.Donnelly@jdonnelly.mit.edu.

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The MacVicar teachings awards were announced and celebrated at a gathering at Gray House on Friday evening. Gathered to celebrate were, from left, Dean for Undergraduate Education Nancy E. Hastings;Provost Raphael L. Reif; Sanjay E. Sarma, associated profess-
or of mechanical engineering; Tania Blake, professor of biology; President Susan Hockfield; Barton Zwiebach, professor of physics; Stephen James Tapsic, professor of literature; and W. Craig Carter, professor in the Department of Materials Science and Engineering.

As a young professor, Carl E. Wieman ’78 83 figured it would be easy to get his students as excited about physics as he was. He would just do the same old thing and students would see it with the same stir-
ing clarity he did.

“I didn’t work.”

“For many years, it was a frustrating puzzle to me” that students left the classroom as baffled—sometimes more baffled—than when they came in, said Wieman, a 2001 recipient of the Nobel Prize in Physics for his work on Bose-Einstein condensation.

As part of MacVicar Day 2008, an annu-
al MIT celebration of undergraduate educa-
tion, Wieman spoke March 7 about “Sci-
ce Education in the 21st Century: Using the Tools of Science to Teach Science.”

“ Hezbollah’s appearance at the University of British Columbia (http://www.cwvee.ubc.ca), that ‘enor-
mous global-scale issues’ such as global warming, require a scientifically literate popu-
lation. Yet science educators are fail-
ing to turn out students—aside from the
one percent who go on to scientific careers— incapable of “thinking about and using sci-
ence like a scientist,” he said.

Wieman’s undergraduate experience at MIT was unorthodox: he pursued his own research in Lester Wolf Professor Daniel Pritchard, now Cecil and Ida Green Profes-
osor of mechanical engineering; Tania Blake, professor of biology; President Susan Hockfield; Barton Zwiebach, professor of physics; Stephen James Tapsic, professor of literature; and W. Craig Carter, professor in the Department of Materials Science and Engineering.

that he realized that something was going wrong for undergraduate science students. At the same time that students who engaged in physics graduate programs were miracu-
ously transformed—from largely the same launching point as their nonscience class-
mates—into expert physicists.

“How did this happen?” Wieman started looking to the increasing body of class-
room-based studies; brain function investi-
gation and cognitive psychology research for an answer.

He found that a dismal retention rate— only 10 percent of students correctly recalled a nonobvious fact 15 minutes after they heard it in a lecture—was “exactly what you would expect,” he said. Because our short-term memory is very limited, it’s not surprising to brain researchers that students have only “a vague sense” of what a lecture was about immediately after it ended.

Within the context of brain research, the inability of students to change their mode of thinking from novice to expert also was not surprising, said Wieman. Becoming an expert changes the brain physically to include an organizational structure that allows retriev-
al and deployment of knowledge; simply deliv-
ering expert knowledge to students does not make them experts.

Wieman found that graduate students, by working with an expert tutor, learn by developing their own understanding. An expert individual tutor can have a large impact on even large lecture classes by focusing on motivation, he said. “The goal is to convince students that physics is impor-
tant and fascinating; probe where they are starting from, get them to actively process information you pose instead of imparting information; getting students to explain material to the professor and to each other, and allowing students to make mistakes and correct them on their own are all required in the determination of students’ knowledge and understanding,” he said.

Technology such as personal response clicks can enhance engagement and pro-
vide instant feedback on what students do. “It didn’t work,” he said. “They’ll probably get the same kind of puzzles and answers, but if you can make them care about that answer besides a rote version of something you pose: Is it obvious why someone might do something?”

Posing questions instead of imparting information; getting students to convince students that physics is important; and fascinating; probe where they are starting from, get them to actively process information you pose instead of imparting information; getting students to explain material to the professor and to each other, and allowing students to make mistakes and correct them on their own are all required in the determination of students’ knowledge and understanding,” he said.

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An artist’s rendering of the new David H. Koch Institute for Integrative Cancer Research at MIT, as it would be seen at dusk.

Groundbreaking research

MIT kicks off construction of the new Koch Institute

Anne Trafton
News Office

MIT broke ground on Friday for the new David H. Koch Institute for Integrative Cancer Research, a facility that its director, Tyler Jacks, said will usher in “the next generation in cancer research.”

The state-of-the-art institute, scheduled to open in December 2010, will house 25 laboratories occupied by MIT engineers, scientists and clinicians working together toward a common goal—creating better ways to detect, prevent and cure cancer.

“The challenges of cancer are immense, and the solution to the problem does not lie in a single field of study,” Jacks said during the groundbreaking luncheon. “Only by working together can we prevail.”

The institute will be largely funded by a $100 million donation from David H. Koch SB ’62, SM ’63. Koch, who was diagnosed with prostate cancer 16 years ago and given only a short time to live, said he became a “passionate crusader” for cancer research soon after beating the disease himself.

“This is not only an historic moment for MIT, but also for the nation’s very important cancer center program,” Jacks said. “What you are beginning today is a moment in my life I will always remember,” he said.

This occasion is one I have long waited for,” Koch said Friday. “The synergy between these two groups (scientists and engineers) will be very powerful and accelerate the development of cures. I’m very hopeful that by the time my children grow up, such cures will be available.”

Koch, who received a standing ovation after his remarks, said that having the cancer institute named for him is the greatest honor he has ever received. “This is a day I will always remember,” he said.

The new institute will be built on the corner of Main and Ames streets, across from the Broad and Whitehead institutes. That location puts it directly in the center of the science and engineering nexus that includes not only Broad and Whitehead but MIT’s departments of biological and chemical engineering, the Stata Center and Brain and Cognitive Sciences Complex, said MIT President Susan Hockfield.

The kind of ideas being developed here could revolutionize the way we detect cancer, the way we treat it, and the steps we take to prevent this disease altogether,” Hockfield said.

The Koch Institute will be equipped with the most sophisticated research tools currently available, including facilities for bioinformatics and computing, genomics, proteomics and flow cytometry, large-scale cell and animal facilities for genetic engineering and testing, advanced imaging equipment and nanomaterials characterization labs.

National Cancer Institute Director John Niederhuber said the new facility will set the “gold standard” for research on cancer and other diseases.

“This is not only an historic moment for MIT, but also for the nation’s very important cancer center program,” Niederhuber said. “What you are beginning today is a new era in how we approach and study the processes that lead to disease.”

The new institute will replace and build on the work of MIT’s Center for Cancer Research, which was established in 1974, shortly after the federal government declared a “war on cancer.” Hockfield said that much progress has been made since then, but more is needed.

“This is a moment to invest in a decisive change,” she said.

Several Cambridge city officials, including Mayor Domenic S. G. Mead break ground on the new David H. Koch Institute for Integrative Cancer Research.

Proponents detail research pursuits

Dozens of journalists from national and international publications attended a special media briefing Thursday, March 6, in which several MIT faculty members discussed research they will pursue at the new Koch Institute for Integrative Cancer Research.

“Cancer remains a devastating problem and a major health issue, and we at MIT want to do something about it,” Tyler Jacks, director of the Koch Institute, said in his opening remarks.

The daylong event at the Broad Institute featured discussions of topics such as why some cancer drugs fail, nanotechnology, cellular pathways in cancer cells and the immune system’s response to cancer.

Robert Weinberg, professor of biology, explained current theories of how cancer spreads through the body, a process known as metastasis. Researchers believe that metastasis, which causes 90 percent of cancer deaths, occurs when cancer cells regain the embryonic ability to move through the body.

Sangeeta Bhatia, associate professor of health sciences and technology and electrical engineering and computer science, described efforts to build nanoscale devices that could detect, monitor and treat cancer.

Institute Professor Robert Langer discussed his laboratory’s work on nanodevices, and Institute Professor Phillip Sharp described advances in RNA interference, which could be used to silence genes that cause cancer.

Other presenters were Frank Gertier, the Ross Scholar Professor of Biology; Michael Hamann, the Latham Family Career Development Assistant Professor of Biology; David Houmans, the Ludwig Professor of Biology; Angela Belcher, the Germeshausen Professor of Materials Science and Engineering and Biological Engineering; Michael Cima, the Sumitomo Electric Industries Professor of Engineering; Nancy Hopkins, the Amgen, Inc. Professor of Biology; Jacqueline Lees, professor of biology and associate director of the Koch Institute; Forest White, the Mitsui Career Development Assistant Professor of Biological Engineering; Michael Yaffe, associate professor biology and biological engineering; Scott Manalis, associate professor of biological and mechanical engineering, Paula Hammond, the Bayer Chair Professor of Chemical Engineering, Darrell Irvine, the Eugene Roll Career Development Professor in Tissue Engineering, and Dane Wittrup, the Carbon P. Dubbs Professor of Chemical Engineering and Bioengineering and associate director of the Koch Institute.

― Anne Trafton