It’s a ‘whisker’ wonderland

MIT researchers catch rats’ twirly whiskers in action

Rats use their whiskers in a way that is closely related to the human sense of touch. Just as humans move their fingertips across a surface to perceive shapes and textures, rats twitch their whiskers to achieve the same goal. Now, in a finding that could help further understanding of perception across species, MIT neuroscientists have used high-speed video to reveal rat whiskers in action and show the tiny movements that underlie the rat’s perception of its tactile environment.

Rats rely on whiskers to find their way in the dark, and they devote large areas of their brains to decoding the incoming signals, explains Christopher Moore, a member of the McGovern Institute for Brain Research at MIT and senior author of a study in the Feb. 28 issue of Neuron. Neuroscientists interested in perception have studied the whisker system intensively, but the information conveyed to the brain by whisker motions has remained a mystery—until now.

“Now that we can see what the rat’s whiskers are telling the brain, we can start to understand better how this amazing perceptual system works,” says Moore, who is also an assistant professor in MIT’s Department of Brain and Cognitive Sciences. “This understanding is relevant not only to the human sense of touch but to all forms of perception, because every sensory organ is an interface between the mind and the external world.”

What might a whisker-based sensation feel like? Imagine sweeping a stick across a picket fence. The frequency of vibrations depends on the spacing between the pickets, but the sensation in the hand is also affected by the length and flexibility of the stick and the speed of its movement.

Likewise, Moore reasoned, the whiskers’ movements and mechanical properties must influence the information that they relay to the brain. The whiskers are arranged in a pattern on the snout, with the shortest ones at the front. Experiments with isolated whiskers had demonstrated that, like harp strings, shorter whiskers are tuned to resonate at higher frequencies, creating a map of frequency information within the brain. But until now, no one had managed to see the detailed pattern of whisker movements in freely behaving animals.

Like the famous images MIT’s Harold “Doc” Edgerton made of bullets going through apples, the slow-motion version of these new movies provides the first glimpse of the micromotions that the whiskers transmit to the rat brain.

“We knew from watching rats’ behavior that there must be whisker micromotions that were too rapid to measure using available recording techniques,” explains Jason Ritt, a postdoctoral scientist in Moore’s lab and first author of the study. Ritt therefore spent several years developing a video system that captures whisker movements at a rate of 3,200 frames per second—100 times faster than the eye can follow.

Rats’ whiskers are extremely sensitive sensory organs that can produce up to 1 million movements per second. By bombarding the whiskers with tiny pellets of hydrogen gas, Moore’s lab and first author of the study. Ritt therefore spent several years developing a video system that captures whisker movements at a rate of 3,200 frames per second—100 times faster than the eye can follow.
MIT community mourns loss of senior Robert M. Wells, 22

Members of the MIT community are mourning the tragic death of Robert M. Wells, a senior in the Department of Management, Science and Engineering, Wells, 22, was originally from Ballston Spa, N.Y. Wells was found dead last weekend outside the Delta Upsilon (DU) fraternity house, which is on Beacon Street in Boston. Boston police are leading the investigation, and MIT authorities are cooperating fully.

“The sad news today is that the MIT community has experienced the loss of its 22nd undergraduate student this academic year,” said MIT President L. Rafael Reif in a message to the MIT community. “As all of us mourn the loss of Robert and the families of those MIT students who have died this year, I want to encourage all students here to make sure that they check in with each other, frequently, and to reach out to others if they are struggling.”

Robert M. Wells

Robert Mark Schuster, DUSP professor, 57

J. Mark Schuster, a professor of urban studies and planning, an expert on arts funding policies and the MIT Laboratory for Information and Decision Systems, passed away Friday, March 7, after a brief illness. He was 57.

“Robert Schuster helped develop the field of urban cultural policy and showed how it could be a vital part of the practice of city planning. He showed how to integrate the world of urban design and the world of government policy to achieve his assigned benefit of both,” said Lawrence Vale, professor and head of the Department of Urban Studies and Planning.

J. Francis Reintjes, 96

MIT Professor Emeritus J. Francis Reintjes, celebrated for his keen wit and unassuming but stalwart leadership in electrical engineering and computer science, passed away Feb. 21 after a brief illness. He was 96.

Born in Troy, N.Y., on Feb. 19, 1912, the son of George and Katherine (Lynch) Reintjes. Reintjes graduated from the state university of New York in 1934, received his bachelor’s and master’s degrees in electrical engineering from Rensselaer Polytechnic Institute in Troy, N.Y., and received his PhD in physics from MIT in 1947.

“Schuster is survived by his wife, Charlotte Harrison; a brother, Neil; and former wife, Devon Davidson. A memorial service at MIT is being planned. In lieu of flowers, donations can be made to First Night Boston, www.firstnight.org.”

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MacVicar Day being held on March 7

MacVicar Day 2008 will be held Friday, March 7, and to promote undergraduate teaching excellence, Nobe laureate Carl Wieman ‘73 will address the MIT community in a presentation that will be transformed into “Science Education in the 21st Century: Using the Tools of Science to Teach Science.”

The talk will be held in Kirsch Auditorium (32-129) from 2:30 p.m. to 5 p.m. on Friday. The 2008 MacVicar Faculty Fellow will be announced at a faculty reception hosted by President Susan Hockfield at Fresh Pond House following the afternoon program.

Institute Awards Convocation nominations now being accepted

Nominations are now being accepted for the 2008 Institute Awards Convocation in May. The IAC awards will honor students, faculty and staff who have made special contributions to the life of the MIT community. Descriptions of the awards can be found at web.mit.edu/iaa.

Nomination letters are due by Friday, March 14 5 p.m. For information, e-mail awards@mit.edu or call Fran Miles at 617-253-7546.

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A leg to stand on

David Chandler

In the United States, a typical prosthetics specialist who fits artificial legs for amputees might handle 15 to 20 such patients a year, fitting them with custom-built legs that cost upward of $8,000 apiece. Each patient then goes through a series of follow-up visits to make sure the new limb is properly fitted.

But in India, the Jaipur Foot Organization handles that many patients every day in each of its local centers. The charity is the world’s largest provider of prosthetics—and has worked with about a million patients since being founded in 1975.

The JFO, also known as Bhagwan Mahavir Viklang Sahyata Samiti, is based in Jaipur, a city of more than three million people that is the capital of Rajasthan in northern India. The artificial limbs they provide, based on a locally developed design, cost about $40, and the company has little time or funding for follow-up consultations, or for developing new methods.

A team of MIT students has been working on a new device that could greatly simplify the process of fitting these legs, producing a better fit while eliminating some steps in the process and reducing waste materials. The hand-powered system, which requires no external power, would also greatly simplify the fitting process and make it more accessible to where the present electricity-powered fitting system requires bringing along a bulky generator.

The first step in fitting a leg is to make a mold of the person’s stump to provide a precise fit. This is done by placing the stump into a container filled with tiny glass beads and covered with soft silicone rubber, and then creating a vacuum so that the beads seal tightly around the limb. This “negative” mold is filled with more glass beads (referred to as “sand”) to form a positive mold—an exact replica of the stump—and the socket of the prosthetic leg is made to fit that replica. Alternatively, the two steps can be done with plaster of paris instead of the sand—a process that doesn’t require electricity but does use heavy, non-reusable plaster.

The MIT system was designed under the auspices of the Dr. Lab in the Department of Mechanical Engineering. Mechanical engineering students Philip Garcia, Maria Luckyanova and Tessa Veenhuy, physics student Jessica Schirmer, and Dr. Lab instructor Konstantin Reddy have been working on the project—some of them for more than a year.

The new fitting system they devised uses a handcrank to produce the vacuum, eliminating the need for electric power. And the same device can be used to produce both the initial negative mold and the positive mold that replicates the shape of the stump.

Garcia, Luckyanova, Reddy and Schirmer spent two weeks at the Jaipur facility this January, thanks in part to a grant from MIT’s Public Service Center and a $57,000 award from last year’s IDEAS competition. They did one test run of a fitting, and the JFO personnel were very impressed.

“They were really pleased with the results,” Luckyanova says. They liked the fact that the new system produced less waste, required no electricity and seemed to produce a better fit that might lead to a longer-lasting prosthetic: “That’s because the plaster of paris in the traditional method shrinks slightly as it hardens, making the fit less exact.”

Lawrence project puts MIT on U.S. service honor roll

Sarah H. Wright

The Corporation for National and Community Service has named MIT to the President’s Higher Education Community Service Honor Roll for exemplary service efforts and service to disadvantaged youth. The Honor Roll recognizes colleges and universities that support service and the extent to which the school community to make a true difference in the lives of students, leaders and residents.

“We are honored to receive this recognition and will continue to work as a team with the Lawrence community to make a true difference in the lives of students, leaders and residents,” said Jonathan A..djangoproject, vice chancellor of Student Life.

Lawrence focuses on affordable housing development, community asset-building and youth pathways to career and education. Participants from MIT work with Lawrence community leaders and residents.

“We are honored to receive this recognition and will continue to work as a team with the Lawrence community to make a true difference in the lives of students, leaders and residents,” said Jonathan A._MODULES, vice chancellor of Student Life.

In Lawrence, the project called Lawrence and Region (LAR) has provided more than 20,000 combined service hours to Lawrence residents and organizations through the MIT@Lawrence partnership, according to Honor Roll materials.

In addition to the Department of Urban Studies and Planning, MIT@Lawrence collaborates with the Public Service Center, the Center for Real Estate, the MIT Media Lab, the MIT Sloan School and the Community Innovators Lab. Recently, the Center for Advanced Visual Studies, the Teacher Education Lab, the Special Program for Urban and Regional Studies and the MIT Museums have joined the partnership.

Lawrence and Region includes Lawrence CommunityWorks Inc, Groundwork Lawrence, Merrimack Valley Habitat for Humanity, Higher Education Resource Center, Arlington Community Trabajando and Lawrence Family Development Charter School. Honor Roll is now four years old, and it is the only U.S. program that recognizes the work of colleges and universities to engage students in service to communities.

Lawrence and Region (LAR) has been selected for the 2007-08 MIT@Lawrence project, which will focus on improving the quality of life for the community. The project is led by MIT@Lawrence director, Dr. John H. Bauer.

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In the World is a column that explores the ways people use technology—from the appropriately simple to the cutting edge—to help meet the needs of people in the developing world. If you know of a good example and would like to see it published, please e-mail tech@mit.edu.

Expert says big energy picture must balance security, sustainability and supply

Deborah Halber

News Office Correspondent

The world has no choice but to build more energy-producing plants—and find new sources of energy—but the build out process will not happen overnight, a government expert recently told an MIT audience.

“A worldwide boost in demand for energy, coupled with environmental concerns, will force a huge U.S. increase in the number of nuclear power plants—but it will take more than two decades to come to fruition, according to Carl O. Baurer, director of the U.S. Department of Energy’s National Energy Technology Laboratory (NETL).

Baurer’s Feb. 26 colloquium, “Energy Supply and Demand, Economics and Greenhouse Gas Management: Are They Related?” was sponsored by the MIT Energy Initiative. The discussion focused on the intertwined aspects of security, sustainability, supply and the environment in relation to the world’s energy production.

Baurer said blackouts in California, Texas and New England by 2016 are just some of the challenges facing decision makers as they tackle America’s energy future. “I happen to believe we’re right on the cusp of a huge energy build-out because we have no choice,” Baurer said.

But, he added, the lack of U.S. nuclear plant construction in recent decades has led engineers to turn to other fields, and construction companies are now looking at nuclear plants overseas.

In the U.S., the energy challenge, decision makers, he said, must juggle three “co-dependent” entities: the economic necessity for energy sources; energy supply and security; and the effect of solving climate change.

“Too often we divorce the climate and safety decision in policy that we can’t live with either,” Baurer said.

Coal, natural gas and oil use will remain largely unchanged in the United States over the next two decades, projections show, while the use of renewable energies is likely to increase by 40 percent to 90 percent of the total. Nuclear is the most consistent because old plants will shut down and new plants can’t be built fast enough to make a big dent in usage patterns by 2030.

And while the oil supply can be expected to increase by 25 percent in that time frame, worldwide energy demand is expected to leap 50 percent, further straining resources.

“Do we think the oil supply can grow by 50 percent? The challenge for increasing the oil supply is increasingly
Researchers at MIT Lincoln Laboratory have developed a portable sensor that can detect airborne pathogens such as anthrax and smallpox in less than three minutes. The new device, called PANTHER (for Pathogen Notification for TReatment Emergencies), represents a significant advance over any other sensor, said James Harper of Lincoln Lab's Biosensor and Immunoassay Technologies Group. Current sensors take at least 20 minutes to detect, handful-sized bacteria or viruses in the air, but the PANTHER sensors can do detection and identification in less than three minutes.

The technology has been licensed to Innovative Biosensors, Inc. (IBI) of Rockville, Md. In January, IBI began selling a product, BioFlash, that uses the PANTHER technology.

"There is a real need to detect a pathogen in the air, within three minutes, so you have time to take action before it's too late," said Harper, a principal scientist at the PSFC; and biological analysis and notification of antigen (PANTHER) technology.

"The device could be used in buildings, subways and other public areas, and can currently detect 24 pathogens, including ones. It could eventually be used on farms or in food-processing plants to test for contaminants or in food-borne pathogens. Another potential application is in medical diagnostics, where the technology could be used to test patient samples, giving rapid results without having to send samples to a laboratory. Instead of going to the doctor's office and waiting a few days for your test results, with CANARY you could get the results in just a minute or so," said Rider. The research on PANTHER was funded by the Department of Defense Threat Reduction Agency.

"B cells in the body are very fast and very sensitive," Rider said. "The CANARY concept uses an array of B cells, each specific to a particular bacterium or virus. The cells are engineered to emit photons of light when they detect their target pathogen. The device then displays a list of any pathogens found. CANARY is the only sensor that makes use of immune cells. Other available sensors are based on immunostains or PCR (polymerase chain reaction), which take much longer and/or are not as sensitive as the technology used by CANARY. Rider and colleagues first reported the success of CANARY (which stands for Cellular Analysis and Notification of Antigenic Risks and Yields) in the journal Science in 2000. Since then, they have been working to incorporate the technology into a portable device that could be used in a variety of settings where environmental threats might exist. The new device, PANTHER, takes the CANARY technology and combines it with an immunosensor that brings pathogens into contact with the detector cells. The prototype is about the size of a cubic foot in size, weighs 37 pounds and is well suited to building occupant applications. With minor modifications, it could also enhance biological detection capabilities for emergency responders. CANARY has been tested in rural and coastal environments as well as urban ones. It could eventually be used on farms or in food-processing plants to test for contamination by E. coli, salmonella or other food-borne pathogens.

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"The device would be more easily amplified and sequenced. They then use sequencing technology that is fast enough to analyze hundreds of millions of DNA base pairs in a week. Once the sequences of highly expressed mRNA are known, the researchers can compare them with DNA sequences in the database of bacterial genes and try to figure out which genes are key players and what their functions are.

The team found some surprising patterns of gene expression, DeLong said. For example, about half of the mRNA sequences found in microbial populations. The work could help microbial ecologists better understand what microbial lineages are most critical in regulating Earth's environment.

For several years, researchers have been trying to change that. "The new approach also has other potential applications, for example, one can now realistically consider using indigenous microbes as in situ biocides, as well as monitor the activities of human-associated microbial communities much more comprehensively," DeLong said.

The team's technique, which has already yielded a few surprising discoveries, is reported in the March 3 issue of the Proceedings of the National Academy of Sciences.

The work was facilitated by the Center for Microbial Oceanography: Research and Education (C-MORE), a National Science Foundation Science and Technology Center established in 2006 to employ novel approaches to microbial ocean life, most of which is not well understood.

The traditional way to study bacteria is to grow them in Petri dishes in a laboratory, but that yields limited information, and not all strains are suited to life in the lab. "The cast of characters we can grow in the lab is really small, and we want to get a picture of what's out there," said DeLong, who is research coordinator for C-MORE.

The MIT team gathers microbe samples from the waters off Hawaii, in a part of the ocean known as the North Pacific Gyre. Each liter of ocean water they collect contains 100 billion or more bacteria cells. For several years, researchers have been sequencing the DNA found in those bacteria, creating large databases of prevalent marine microbial genes found in the environment.

However, those DNA sequences alone cannot reveal which genes the bacteria are actually using in their day-to-day activities, or when they are expressing them.

"It's a lot of information, and it's hard to know where to start," said DeLong. "How do you know which genes are actually important in any given environmental context?"

To figure out which genes are expressed, DeLong and colleagues sequenced the messenger RNA (mRNA) produced by the cells living in complex microbial communities. mRNA carries instructions to the protein-building machinery of the cell, so it is a lot of mRNA corresponding to a particular gene, means that gene is highly expressed.

The new technique requires the researchers to convert bacterial mRNA to eukaryotic (non-bacterial) DNA, which can be more easily amplified and sequenced. They then use sequencing technology that is fast enough to analyze hundreds of millions of DNA base pairs in a week. Once the sequences of highly expressed mRNA are known, the researchers can compare them with DNA sequences in the database of bacterial genes and try to figure out which genes are key players and what their functions are.

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Grad student wins Lemelson-MIT Student Prize

Timothy Lu targets drug-resistant bacteria

MIT graduate student and synthetic biologist Timothy Lu is passionate about tackling problems that pose threats to human health. His current mission: to destroy pathogenic bacteria.

A discovery made by Lu, a 27-year-old MD candidate and PhD in the Harvard-MIT Division of Health Sciences and Technology, netted him the $30,000 Lemelson-MIT Student Prize on Feb. 27 and promises to combat bacterial infections by enhancing the effectiveness of antibiotics at killing bacteria. The discovery could also help in eradicating biofilm—bacterial layers that resist antimicrobial treatment and breed on surfaces such as those of medical, industrial and food processing equipment.

The $30,000 Lemelson-MIT Student Prize, annually given to an MIT senior or graduate student, reaches someone who has created or improved a product or process, applied a technology in a new way, redesigned a system or demonstrated remarkable inventiveness in other ways.

Lu's work focused on a subject matter that could have widespread impact. The Centers for Disease Control and Prevention estimates that the antibiotic-resistant bacteria MRSA or methicillin-resistant Staphylococcus aureus, causes approximately 84,000 infections and contributes to 18,000 deaths annually in the United States, through contact that occurs in a variety of locations, including schools, hospitals and homes. Bacteria can also infect food, including spinach and beef, and damage industrial equipment.

Fewer pharmaceutical companies are inventing new antibiotics, Lu explained, because they are expensive, prone to failure and require a long time to develop. According to the Tufts Center for the Study of Drug Development, the cost to develop a new drug is $930 million, a number that has increased by 60 percent since 1990. Every year, around 1.2 million antibiotics prescriptions are written with no antibiotics available, according to the Centers for Disease Control and Prevention estimates that the antibiotic-resistant bacteria contribute to 19,000 deaths annually in the United States, including schools, hospitals and homes. Bacteria can also infect food, including spinach and beef, and damage industrial equipment.

Medical devices infected by biofilms, such as replacement joints or pacemakers, often have to be removed surgically, prone to failure and require a long time to develop. According to the Tufts Center for the Study of Drug Development, the cost to develop a new drug is $930 million, a number that has increased by 60 percent since 1990. Every year, around 1.2 million antibiotics prescriptions are written with no antibiotics available, according to the Centers for Disease Control and Prevention estimates that the antibiotic-resistant bacteria contribute to 19,000 deaths annually in the United States, including schools, hospitals and homes. Bacteria can also infect food, including spinach and beef, and damage industrial equipment.

"While working at a hospital as part of a graduate course, I saw many patients who contracted new infections due to already-compromised immune systems or equipment that is extremely difficult to keep sterile," Lu recalled. "Being infected by difficult-to-eradicate bacteria is a traumatic experience for patients and a serious public health issue that needs attention. I thought that there had to be a solution for these infections."

Penetrating biofilms

Lu also applied his work with bacteriophage to create a new technique for reducing harmful biofilms, which are slimy layers of bacteria that develop on the surfaces of medical, industrial and food processing equipment and are difficult to penetrate and remove. Current treatment methods to penetrate biofilms can involve peptides or enzymes, which must be administered systematically and are costly. Medical devices infected by biofilms, such as replacement hip joints or pacemakers, often have to be removed surgically.

Lu invented enzymatically active bacteriophage that directly target the infection site, where they can simultaneously penetrate the biofilm’s protective slime layer and kill the bacteria underneath. "I inherited my interest in invention and entrepreneurship from my father," Lu said. "It was very inspiring to see the amount of effort my father and his team put into their work and their joy and elation when they achieved success."

And others see Lu’s future potential beyond his groundbreaking discovery.

"Tim is one of the young stars in the emerging field of synthetic biology," said Collins, his adviser. "I am confident he will develop into a leading clinical investigator and innovator."

MIT graduate student and synthetic biologist Timothy Lu recently won the Institute’s $30,000 Lemelson-MIT Student Prize for his work on the use of bacteriophage to fight antibiotic-resistant bacteria.

Inherited inventiveness

Born in Stanford, Calif., and raised in Yorktown Heights, N.Y., and in Taiwan, Lu credits his inventiveness to his father, Nicky, an engineer and entrepreneur who helped develop modern semiconductor memories with IBM and the integrated circuits industry in Taiwan. Lu recalls spending time at his father’s office during his formative years, where he reviewed plans and designs for new integrated circuits.

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In tests, Lu’s platform proved greater than 99.997 percent effective at destroying biofilms—a significant improvement over current treatment options.

The ultimate goal is to develop a sustainable source of antibacterial therapies that are effective and easy to produce at low cost, and will last us through the 21st century," Lu said.

According to Lu, his engineered enzymatically active bacteriophage could be initially applied in food processing settings to kill foodborne bacteria, such as Escherichia coli (E. coli) that contaminate spinach and cause severe illness when ingested. In line with these hopes, there is evidence that U.S. regulatory authorities are warming up to the therapeutic use of bacteriophage. For example, in 2006, the U.S. Food and Drug Administration approved the first U.S. treatment for Listeria contamination of processed meats using natural bacteriophage.

"Lu added that enzymatically active bacteriophage could also benefit industry by being used to treat infected pipes and reduce corrosion.

The Lemelson-MIT Student Prize also named two other finalists for the award. Lu's work focused on a subject matter that could have widespread impact. The Centers for Disease Control and Prevention estimates that the antibiotic-resistant bacteria MRSA or methicillin-resistant Staphylococcus aureus, causes approximately 84,000 infections and contributes to 18,000 deaths annually in the United States, through contact that occurs in a variety of locations, including schools, hospitals and homes. Bacteria can also infect food, including spinach and beef, and damage industrial equipment.

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"Lu added that enzymatically active bacteriophage could also benefit industry by being used to treat infected pipes and reduce corrosion.
NASA has selected a proposal by an MIT-led team to develop plans for an array of radio telescopes on the far side of the moon. This choice was based on its robustness, because the long wavelengths of the radio waves it will detect don’t require particularly accurate placement and alignment of the individual components. In addition, it doesn’t matter if a few of the hundreds of antennas fail, and their performance would not be affected by the ever-present lunar dust.

The new lunar telescopes would add greatly to the capabilities of a low-frequency radio telescope array now under construction in Western Australia, one of the most radio-quiet areas on Earth. This array, which also involves MIT researchers, will be limited to the upper reaches of the low-frequency radio spectrum, and thus will only be able to penetrate into a portion of the cosmic Dark Ages.

The new observations could test current theories about how the universe formed and evolved into its present state.

According to prevailing theory, this unobserved span of time in the universe’s infancy includes a period when dark matter—an unknown component of the universe that accounts for a majority of all matter—collapsed from a uniform soup of particles into clumps that formed the scaffolding for all the structures that emerged later, from stars and black holes to entire galaxies. All astronomical observations made so far only reveal the results of that whole formation process—except the cosmic background radiation, which only shows the raw material before the process began. The whole generation and birth of all the kinds of objects seen in space today, began. The whole gestation and birth of matter—collapsed from a uniform soup of particles into clumps that formed the scaffolding for all the structures that emerged later, from stars and black holes to entire galaxies. All astronomical observations made so far only reveal the results of that whole formation process—except the cosmic background radiation, which only shows the raw material before the process began.

The only place that is totally shielded from both light and radio interference is the far side of the moon, which always faces away from the Earth and therefore is never exposed to terrestrial radio transmissions. Besides being the highest priority scientifically for a telescope on the moon, this low-frequency radio telescope array will be one of the easiest to build, Hewitt says. That’s because the long wavelengths of the radio waves it will detect don’t require particularly accurate placement and alignment of the individual components. In addition, it doesn’t matter if a few of the hundreds of antennas fail, and their performance would not be affected by the ever-present lunar dust.

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Penny wise

Another MIT physicist, Papadopulo Fellow Jeff Gore, has been sought after as a science consultant. Gore, a biophysicist who studies the evolution of cooperative behavior among ants, has no relation to his research interest in ants—specifically, the species of ants that carry goods and that can get rid of the penny.

Gore, for example, reasoned that if ants could carry a penny, they would carry it to a central location. He then calculated what would happen if ants were to carry pennies to the center of a city. He found that if each ant carried the same amount of money, the city would become a single-minded object. The ants would then divide the money among themselves, and each ant would carry the same amount of money.

Gore then calculated how long it would take for the ants to carry the money to the center of the city. He found that it would take about 80 years for the ants to carry the money to the center of the city. He also calculated how much money the ants would carry in the process, and he found that the ants would carry about $10 billion per year.

In related news, the MIT Portugal Program last month launched a new virtual website that will enable users inside and outside the program to learn about its latest initiatives, education and research, events and successes. Features include a new online application form for the Advanced Studies and PhD programs offered, a resource area where users can access all of MIT's OpenCourseWare, and a newly designed website (www.mitportugal.org).

The site, which also includes a new brand identity for the program, is a single point of entry to the Portuguese program. "MIT is already known and respected throughout this region and the world," he said. "And MIT has opportunities to become even more significant in the global economy."
ARTS

FINDING art

New web site sheds light on works both seen and unseen

Sarah H. Wright
News Office

The List Visual Arts Center has just made MIT's public art collection more accessible to the public with a new web site, http://listart.mit.edu. Inspired by MIT's OpenCourseWare program, the new List site, launched Feb. 19, is designed to offer people who may not be able to visit campus a chance to see its art collection and to use List Center materials, according to List Director Jane Farver.

"Education is a major part of the List Center mission, and the staff wants the collection and center brochures, press materials and lectures to be widely available. We are grateful to the Institute of Museum and Library Services for making the new web site's interactive map of MIT's public art collection possible. The site has just begun, and we'll continue to devote time and resources to improving it," Farver said.

Named in 2006 as one of America's 10 Best Campus Art Collections by the Public Art Review, the MIT collection includes works by the world's most prominent artists—Pablo Picasso, Auguste Rodin, Alexander Calder—placed amid buildings by such notable architects as Alvar Aalto, Frank Gehry and I.M. Pei.

But locating these works on MIT's campus presented a problem: Some are outside and some inside buildings; some works are large; some are small enough to escape notice.

List's solution is a web site that tracks arts events, displays images from current exhibitions and has, as its innovative centerpiece, an interactive, searchable campus map of MIT's public art collection.

The map looks like the usual MIT campus map, but it's rich with arts information. Click on "search for," and a list offers names of artists and architects whose work is in the Institute collection and on public view. Click on a name—say, painter Jennifer Bartlett—and a yellow dot pulses in NW30, where her work, "Overhill Road, Shawnee Mission," hangs.

Other search functions include clickable thumbnail photos of artwork and buildings and additional windows containing biographical information on artists and architects.

In the future, site users will be able to download streaming audio of the List Center's archive of lectures, artist talks and other educational programs, Farver noted.