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TechTalk

SERVING THE MIT COMMUNITY

A MATERIAL FOR ALL SEASONS

MIT teams finding many uses for graphene, the newest form of carbon

David Chandler
News Office

In a blown-up image from a scanning tunneling microscope, it looks just like an endless sheet of chicken wire: a simple flat sheet made up of a lattice of hexagons. But this nanoscopic material called graphene, first generally acknowledged to exist just five years ago, turns out to have a variety of unique, and potentially very useful, characteristics — ones several MIT researchers are actively trying to better understand and turn into real-world applications.

Graphene, a form of the element carbon that is just a single atom thick, had been identified as a theoretical possibility as early as 1947. Even as Institute Professor Mildred Dresselhaus, her physicist husband Gene, and others were working in the 1960s with multiple layers of graphene, many scientists were saying that such an ultra-thin sheet of matter could never be found or even made. "It was very controversial; there were many people who were skeptical," about the research, she says.

Now that it has been found, with widely publicized results published in 2004 by researchers at the University of Manchester, UK, "the topic has exploded," she says. Researchers are focusing on how to harness its properties, and how to produce it in sufficient quantity for extensive research and eventually for commercial applications. MIT has become a major center of work on this hot topic, with several different research groups pursuing various aspects — including physical, chemical, electronic and engineering — of the novel material.

While many universities and commercial laboratories are pursuing research on graphene's basic

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PHOTO / **DONNA COVENEY**

Flower show

Like many members of the MIT community, these tulips basked in the sunshine during the recent spate of unseasonably warm weather.

Physics tackles a complex problem: how to diversify

Anne Trafton
News Office

MIT's Department of Physics is renowned as one of the best in the country. However, it lags behind other schools in its diversity — a trait the department is determined to change.

Led by department head Edmund Bertschinger, several initiatives are underway to diversify the physics faculty, which now has six women and one underrepresented minority. The figures are higher among the student population, but there is much work to be done, says Bertschinger.

In March, Bertschinger presented a plan to the physics faculty to draw more women and underrepresented minorities to MIT. Casting a wider net will help the department attract a higher level of academic talent, among both faculty and students, and ensure that MIT maintains its excellence, he says.

"If you restrict the applicant pool for any position, you may be excluding a star candidate," he says. "There are extremely talented underrepresented minorities and women in physics that we can strive to recruit."

Small but growing

Some progress has already been made. Two years ago, the physics department had the smallest percentage of women faculty of any MIT department — at slightly more than 5 percent. Since then, the department has hired two women and has an offer out to a third, which would bring the total to seven.

Janet Conrad, a particle physicist who arrived at MIT last year from Columbia University, says she's accustomed to being the only woman in a group of physicists, but believes gender-balanced groups are more productive. Throughout her career, she has noticed that as more women join a research group, "women become comfortable in the group. The more women faculty you have, the more you will get."

This holds true at MIT: Four of the department's six female faculty members are clustered in the Laboratory for Nuclear Science: Conrad, June Matthews, Gabriella Sciolla and Jocelyn Monroe, a Pappalardo fellow

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Task Force assessing ideas on efficiencies, expenses

Anne Trafton
News Office

MIT's Institute-wide Planning Task Force, created to explore ways to maximize efficiency and reduce Institute expenses, has gathered more than 1,000 ideas from members of the MIT community. The group is now evaluating the ideas and thoughts generated during group discussions and is working toward preliminary recommendations in June.

Members of the MIT community can read the ideas in the online "Idea Bank" at http://ideabank-dev.mit.edu/, which features charts summarizing the categories of submissions. Many of the ideas fall into the broad themes of automation, simplification and sharing of resources.

Among the most popular ideas are reducing paper usage, which accounted for 46 percent of all submissions related to administrative processes, and improving efficiency of heating and cooling, which made up 26 percent of suggestions related to space usage.

"This is an opportunity for the entire MIT community to build a better, more efficient MIT," said Vice President for Finance Israel Ruiz, who is helping to coordinate the Task Force. "In that context, we will need to work together in the best MIT spirit in order to provide the simplest, fewest and most flexible solutions that meet our unique needs."

Vice Chancellor and Dean for Graduate Education Steven R. Lerman and Associate Provost Martin A. Schmidt are also coordinating the Task Force, which was set up in response to the decline in revenues as a result of the global economic crisis. The committee is charged with helping to reduce MIT's expenses by $50 million to $100 million over the next two to three years, starting with the 2011 fiscal year. These reductions follow an initial $50 million reduction underway for FY 2010.

Several efficiency-enhancing projects are now in the works, including streamlining business travel processes. A pilot phase to test the plan, which will provide credit cards for travel and establish an electronic expense reporting system, is planned to launch as early as July.

In addition, the Office of the Vice President for Finance and Information Services & Technology are collaborating to automate the processing of 50,000 requests for payment per year. The new process is targeted for adoption this fall.

The Task Force has categorized ideas from the community into nine areas, corresponding to Task Force working groups: Administrative Processes, Education, Human Resources and Benefits, Information Technology, Procurement, Research Enhancement, Revenue Enhancement, Space and Student Life.

The working groups have begun assessing which high-level strategies would be most feasible to adopt, and estimating the degree of savings that would result. They are also identifying incremental improvements and changes that, taken together, could also offer significant savings for the Institute.

"We are considering ways in which the Institute can take maximal advantage of shared research facilities, and are also looking at the different teaching models, as well as looking at opportunities to automate and simplify existing processes — for example, electronic invoicing, electronic pay stubs, graduate student admissions, and faculty and staff searches," said Ruiz.

Searching for roots of compassion

In MIT visit, Dalai Lama calls for ethics in a secular age

David Chandler
News Office

Tenzin Gyatso, the 14th Dalai Lama, exhorted a packed audience at Kresge Auditorium on Thursday, April 30, to work toward a more compassionate world, emphasizing that a loving and ethical life can be based on any religion, or on no religion.

In his second visit to MIT, the Dalai Lama dedicated a new center created in his name: The Dalai Lama Center for Ethics and Transformative Values, which is part of the Office of Religious Life at MIT. The center, which will partner with members of the MIT community to explore spiritual, ethical and religious questions, will be directed by MIT's Buddhist chaplain, Tenzin Priyadarshi.

"Open heartedness, compassion — it's a capacity from birth," the Dalai Lama said in his address. "It must be possible to increase that." He said all humans have an innate, biologically based level of compassion, but it is limited. However, there is also a higher level — an "infinite, unbounded tendency toward compassion." This comes from a "biological seed," he said, but "there's potential to increase that," just as knowledge can be increased by education.

If people have no religious belief, the Dalai Lama said, those people's ethical and compassionate feelings are "not coming from a religious idea, but simply by nature." Most people today, he said, are not very serious about religion, even if they visit a church, mosque or temple occasionally. "The majority of the 6 billion people [on the planet], I think, you can count as non-believers. We must find ways and means for promotion of these values" of ethics and compassion among these non-believers, he said.

He said that some people see secularism as "rejection of all religions, some say secularism means respect for all religions." He added that, "I expect [it is] not a rejection of religion. There is no reason to reject all religions." All of the major religions teach "forgiveness, tolerance, respect — no one would argue these are bad."

"I say secularism means respect all religions equally — no preferences [for] this religion, that religion. I'm Buddhist: from my perspective Buddhism is best, but that does not mean Buddhism is best for everyone." It is best, "for my practice, my tradition, that's all. I respect, genuinely respect, Christianity, Islam, Judaism … I really respect all religions, secularly. I also respect non-religious people."

The Dalai Lama spoke for about 45 minutes before taking questions from the audience. When asked by an audience member how he should respond if his job required him to work on weapons, the Dalai Lama replied that "our aim should be to demilitarize the world, hopefully later this century." Until that is achieved, he said, such personal decisions will be difficult to make, but he emphasized that violence doesn't come from weapons but from their users. "So I usually call for inner disarmament," he said. "Inner disarmament is easy to achieve. External, difficult."

Before his appearance at Kresge, on Wednesday the Dalai Lama took part in a tree-planting ceremony outside Simmons Hall, and then viewed a sand mandala that has been created there over the past week. He also made an appearance at Harvard, and addressed a gathering on Saturday at Gillette Stadium in Foxborough, Mass.

Chaplain Tenzin Priyadarshi said that the Dalai Lama Center faces an important task, given the "unprecedented crisis" in the world's economy today. "The world is in need of clarity and hope." The economic recession has been accompanied by "a recession in hope and values," and it is important to address these needs, he said.

Commenting on the creation of the new center, Chaplain to the Institute Robert Randolph said that "people will look back on this day as the beginning of something really important for the MIT community. We need to find ways for our students to have access to the best of contemporary thinking" on issues of ethics. "This is an exciting moment."

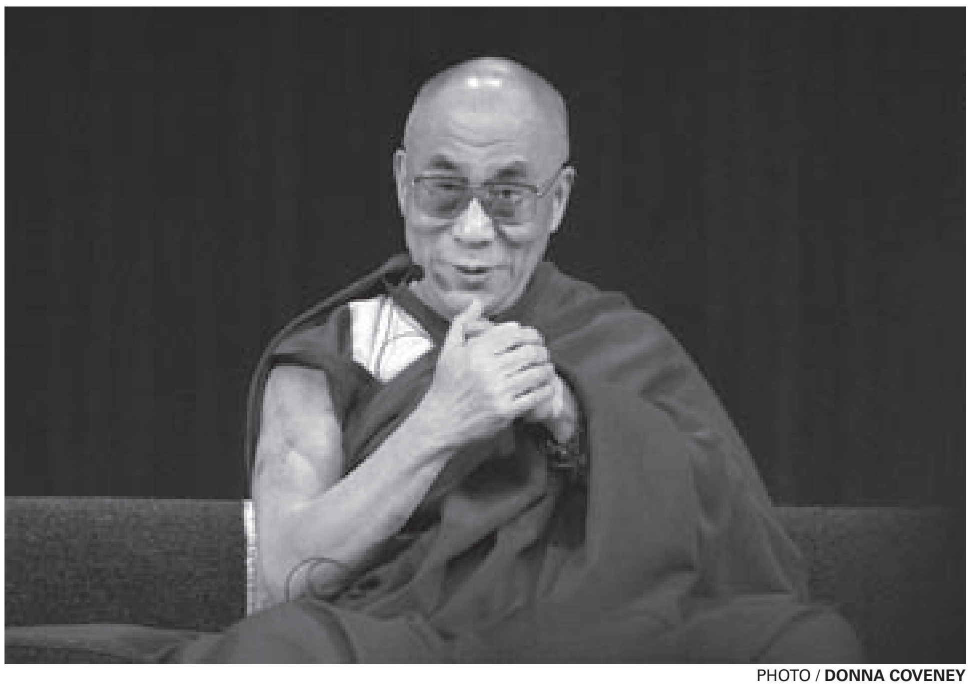

PHOTO / **DONNA COVENEY**

Tenzin Gyatso, the 14th Dalai Lama, addresses the crowd at MIT's Kresge Auditorium on Thursday, April 30.

News in brief

Sloan's Lo to discuss quantitative analysis and the current financial crisis in Sigma Xi lecture

Andrew Lo, the Harris & Harris Group Professor of Finance at the MIT Sloan School of Management, will deliver the 2009 Sigma Xi lecture titled, "Models vs. Mania: The Role of Quantitative Analysis Research in the Current Financial Crisis," at 8:30 p.m. on Thursday, May 7, in the MIT Faculty Club, E52, 50 Memorial Drive.

Lo, who also directs the MIT Laboratory for Financial Engineering, received his PhD in 1984 from Harvard University and taught at the University of Pennsylvania's Wharton School before coming to MIT in 1988. His research interests in the areas of financial engineering and risk management include pricing of financial assets, options and other derivative securities; non-linear models of stock and bond returns; and hedge fund risk transparency. Most recently, his studies have extended to neurobiological models of individual risk preferences in financial markets.

Sigma Xi was founded in 1886 as an analogue to Phi Beta Kappa in the fields of science and engineering research. Its 100,000 members are affiliated with 500 chapters and clubs throughout the world. The MIT chapter is the organization's largest and annually elects new members from the undergraduate and graduate student bodies and the Institute's faculty and research staff.

The annual lecture, which is open to the public, will be preceded by the Sigma Xi dinner for new initiates of the society. Those wishing to attend the dinner at 6:30 p.m., immediately preceding Lo's lecture, should contact Professor Linn Hobbs at 617-253-6970 or hobbs@mit.edu.

Bike awareness event planned for May 13

MIT's Office of Parking and Transportation will hold a bike awareness event from 11 a.m. to 2 p.m. on Wednesday, May 13, outside the Stratton Student Center. Join in and learn how to commute to work safely by bike. Register your bike during the event and get a free T-shirt with your bike permit.

Check out the brand new bike repair station outside the student center, where cyclists can make quick repairs to their equipment. Refreshments and a bike tour around campus will also be available. Vendors scheduled to attend include: Cambridge Bike Shop, Pietzo, Charles River TMA, Parking and Transportation Office, MIT Police, EHS Office, DAPER and the WG Transportation Committee.

This event is being held in conjunction with Bay State Bike Week 2009 and the MassCommuter Challenge, which is encouraging people to cycle to work or school at least once during the week of May 11-17. Better yet, sign up to commute by bike all week. Details and registration are available at: http://baystatebikeweek.kintera.org/faf/home/default.asp?ievent=300139.

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Editor
Greg Frost

Photojournalist
Donna Coveney

Production
Patrick Gillooly

News Office Staff

Writer ... David Chandler
Assistant Director/Photojournalist ... Donna Coveney
Administrative Assistant II ... Patti Foley
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Energy Secretary Chu to speak May 12 at MIT

Nobel laureate to deliver Compton Lecture

Nobel Laureate and U.S. Energy Secretary Steven Chu will visit MIT on May 12 and deliver the Compton Lecture.

Chu, who won the Nobel Prize in physics in 1997 for his work on the cooling and trapping of atoms with laser light, is the first Nobel laureate to serve in a U.S. cabinet position. Until his DoE appointment he was a professor of physics at the University of California, Berkeley, and director of the Lawrence Berkeley National Laboratory.

Chu comes from a family of scholars, and his father, Ju Chin Chu, earned his doctorate in chemical engineering from MIT in 1946.

Chu will deliver the Compton Lecture in room 10-250 (Huntington Hall) at 4 p.m. on Tuesday, May 12. He will be introduced by MIT President Susan Hockfield. The lecture series, named in honor of Karl Taylor Compton, MIT's ninth president, began in 1957 and aims to give the MIT community direct contact with the important ideas of our times and with people who have contributed much to modern thought.

The Karl Taylor Compton lecture series is sponsored by the MIT president in conjunction with the Provost's Office.

MIT senior wins on Jeopardy!

Jiaqi "Jean" Cui, an MIT senior from Garden City, N.Y., has won at least two episodes of the popular TV quiz show "Jeopardy!"

In her first appearance, which originally aired on Thursday, April 30, Cui played against Larry Sullivan, an assistant high school principal from Fairfield, Conn., and Liz Murphy, a foreign services officer originally from Scranton, Pa. Murphy came into the game as a five-time returning champion who had won more than $121,000.

Going into the episode's final question, Cui was leading with $14,500, Sullivan had $14,200 and Murphy had $9,100. Although all three contestants failed to provide the correct final answer, Cui's skillful wagering left her with $599 — enough to secure her a repeat appearance.

In the following night's episode, Cui competed against Andrew Swan, an eighth-grade English teacher from Watertown, Mass., and Toni Vitanza, a flight attendant from Clemson, S.C. As the Final Jeopardy round began, Cui, with $7,192, was trailing Swan and Vitanza, who had $13,600 and $12,000, respectively. Cui put nearly all of her winnings on the line and correctly answered the final question, giving her a come-from-behind win as her opponents failed to come up with the right answer.

PHOTO COURTESY OF 'JEOPARDY!' PRODUCTIONS INC.

MIT senior Jiaqi 'Jean' Cui poses with Jeopardy! host Alex Trebek. Cui has won at least twice on the quiz show.

Cui will be off the air until May 18 as Jeopardy! hosts its annual two-week college championship. Having signed a non-disclosure agreement, Cui cannot discuss her performance until after each episode airs.

Community Spring Break event canceled

In light of ongoing concerns about the H1N1 influenza ("swine flu") virus, the Spring Break event originally scheduled for today in Killian Court has been canceled.

The Institute is closely monitoring H1N1 flu developments. For updates and resources, including a set of FAQs, please visit the MIT Medical web site at http://medweb.mit.edu and the MIT Emergency homepage at http://emergency.mit.net.

MIT chemist Nocera, alumna named to Time 100 list

Time magazine named MIT professor Daniel Nocera among its 100 most influential people for 2009, adding the chemist to a list that included Michelle and Barack Obama, U.S. Sen. Ted Kennedy, Energy Secretary Steven Chu and more.

Nocera, the Henry Dreyfus Professor of Energy and professor of chemistry in the Department of Chemistry, was noted by the magazine for his work "making hydrogen fuel from water, taking his cue from plants' photosynthetic ability to split water using sunlight."

Alumna Robin Chase GM '86, co-founder of Zipcar, the car-sharing service, also made the Time 100 list.

MIT project wins Franklin R. Buchanan prize

The MIT project Visualizing Cultures, which was created in 2002 to explore the potential of the Internet for developing innovative image-driven scholarship and learning, was awarded this year's Franklin R. Buchanan prize by the Association for Asian Studies. The prize is awarded annually to recognize an outstanding curriculum publication on Asia designed for any educational level, elementary through university. The project can be viewed at http://visualizingcultures.mit.edu.

MISTI awards fellowships for 2009

Five MIT students have received a 2009 Anthony Sun Fellowship Award to pursue international internships this summer through the MIT International Science and Technology Initiatives (MISTI).

Department of Electrical Engineering and Computer Science senior Scot Frank will continue his pioneering work on a low-cost solar cooker in western China. Physics senior Charles Agoos will work with a China Educational Technology Initiative (CETI) team to help expand OpenCourseWare programs in Taiwan and Fuzhou, China.

A sophomore in architecture, Katelyn Snyder, will work on historical preservation in the Old City of Acre (Akko), Israel.

Chris Moses, a brain and cognitive sciences junior and president of STeLA, the Science and Technology Leadership Association, will join a research team at the RIKEN Brain Science Institute in Japan.

A graduate student in comparative media studies, Madeline Clare Elish, will explore the intersection of art, science and technology at the Medialab-Prado in Madrid, Spain.

MISTI Director Suzanne Berger, the Raphael Dorman and Helen Starbuck Professor of Political Science, presented the awards on April 29 at an annual gala honoring the more than 360 MIT students who will intern in nine countries this year through MISTI.

Berger also acknowledged the European Club for its contribution to MISTI internships in Europe, and she thanked Josep Maria Cervera of the Barcelona Chamber of Commerce for its founding sponsorship of the MIT-Spain Program.

MIT Energy Initiative Director Ernest Moniz, the Cecil and Ida Green Distinguished Professor of Physics and Engineering Systems, discussed the importance of international experience and the global response to climate change in his keynote address.

Obituaries

Kenneth Vincent Donaghey, MIT plumber, 77

Kenneth Vincent Donaghey, who worked as a plumber at MIT for more than three decades, died on April 24 after a long illness. He was 77.

Donaghey was born in Winchester and served in the U.S. Air Force during the Korean War. He began working at MIT in the mid-1960s; he retired in 1996 and moved to Florida.

His son, Kenneth A. Donaghey, is a house manager for MIT's Department of Housing; another son, Tim Donaghey, worked as a carpenter in the MIT Department of Facilities for several years. The elder Donaghey was also the uncle of Larry Donaghey, the assistant director of labor relations in facilities, and of Philip Donaghey, a plumber in facilities.

Donaghey was a member of St. Timothy's Catholic Community Church in Lady Lake, Fla., and the American Legion. He enjoyed playing golf, making stained glass lamps and windows, and spending time with his children and grandchildren. He is survived by his wife, Elizabeth C. Donaghey, of The Villages, Fla.; six sons and a daughter; and 17 grandchildren.

A memorial service will be held on May 6 at 10 a.m. at St. Mary's Catholic Church in Winchester. Burial with military honors was at the Florida National Cemetery in Bushnell, Fla.

Robots on a recycling rampage

Student projects compete in annual event

More than 150 robots, in a wide variety of sizes, shapes and capabilities, will battle it out on May 6 and 7 in a contest to see which can collect the most soda cans and simulated bales of trash and return then to a recycling facility — actually a milk crate in the corner — all in under a minute. The robots will be competing head-to-head in a series of elimination matches, and the top eight finishers will get trophies or T-shirts.

The matchups are the culmination of 2.007, a required class for sophomores in mechanical engineering, and it's an MIT tradition that goes back more than two decades. The popular contest has spawned a host of imitators over the years, including the very popular FIRST competition for teams of high school students.

The students, who each build their own robots individually from identical kits of components, will not have their grades for the class affected by the contest outcome, nor will they win any prizes beyond the trophies and shirts — except, of course, the all-important bragging rights.

The competition, called "Sweeping the Nation," takes place on a square playing field two meters on a side. It is divided in half by a line of cinderblocks painted to resemble buildings, with narrow alleys between them. There is also a "tunnel" in that row, which rotates at random intervals and directions, so robots that start on opposite sides can cross into the opponent's side by passing through the tunnel, or by being built narrow enough to go through the alleys, or by climbing over the buildings.

Points are awarded for collecting a crushed soda can and returning it to a narrow slot (the "recycling bin"). There are more points for picking up an intact can and crushing it before returning it. Points are also awarded for taking the "bales" to a designated spot, more points for stacking them up, and even more for grabbing one from the opponent's side and returning it to one's own stack.

In short, the many possible strategies contribute to very different robots, and students are encouraged to use their creativity. In addition to the provided components in the kits, students can add decorative elements to their 'bots, and that's where they often unleash their imaginations.

A preliminary elimination round will take place Wednesday evening, followed by the finals Thursday evening, starting at 7 p.m., at the Johnson Athletic Center's ice rink. The event will also be shown live by webcast and on MIT's cable TV.

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.

Tumors targeted using tiny gold particles

Gold nanorods could detect, treat cancer

Anne Trafton
News Office

It has long been known that heat is an effective weapon against tumor cells. However, it's difficult to heat patients' tumors without damaging nearby tissues.

Now, MIT researchers have developed tiny gold particles that can home in on tumors, and then, by absorbing energy from near-infrared light and emitting it as heat, destroy tumors with minimal side effects.

Such particles, known as gold nanorods, could diagnose as well as treat tumors, says MIT graduate student Geoffrey von Maltzahn, who developed the tumor-homing particles with Sangeeta Bhatia, professor in the Harvard-MIT Division of Health Sciences and Technology (HST) and in the Department of Electrical Engineering and Computer Science, a member of the David H. Koch Institute for Integrative Cancer Research at MIT and a Howard Hughes Medical Institute Investigator.

Von Maltzahn and Bhatia describe their gold nanorods in two papers recently published in Cancer Research and Advanced Materials. In March, von Maltzahn won the Lemelson-MIT Student Prize, in part for his work with the nanorods.

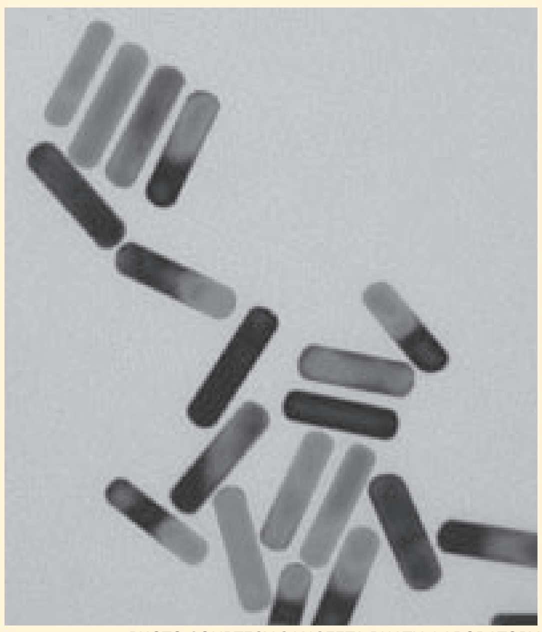


PHOTO COURTESY SANGEETA BHATIA LABORATORY

MIT researchers developed these gold nanorods that absorb energy from near-infrared light and emit it as heat, destroying cancer cells.

Cancer affects about seven million people worldwide, and that number is projected to grow to 15 million by 2020. Most of those patients are treated with chemotherapy and/or radiation, which are often effective but can have debilitating side effects because it's difficult to target tumor tissue.

With chemotherapy treatment, 99 percent of drugs administered typically don't reach the tumor, said von Maltzahn. In contrast, the gold nanorods can specifically focus heat on tumors.

"This class of particles provides the most efficient method of specifically depositing energy in tumors," he said.

Wiping out tumors

Gold nanoparticles can absorb different frequencies of light, depending on their shape. Rod-shaped particles, such as those used by von Maltzahn and Bhatia, absorb light at near-infrared frequency; this light heats the rods but passes harmlessly through human tissue.

In a study reported in the team's Cancer Research paper, tumors in mice that received an intravenous injection of nanorods plus near-infrared laser treatment disappeared within 15 days. Those mice survived for three months with no evidence of reoccurrence, until the end of the study, while mice that received no treatment or only the nanorods or laser, did not.

Once the nanorods are injected, they disperse uniformly throughout the bloodstream. Bhatia's team developed a polymer coating for the particles that allows them to survive in the bloodstream longer than any other gold nanoparticles (the half-life is greater than 17 hours).

In designing the particles, the researchers took advantage of the fact that blood vessels located near tumors have tiny pores just large enough for the nanorods to enter. Nanorods accumulate in the tumors, and within three days, the liver and spleen clear any that don't reach the tumor.

During a single exposure to a near-infrared laser, the nanorods heat up to 70 degree Celsius, hot enough to kill tumor cells. Additionally, heating them to a lower temperature weakens tumor cells enough to enhance the effectiveness of existing chemotherapy treatments, raising the possibility of using the nanorods as a supplement to those treatments.

The nanorods could also be used to kill tumor cells left behind after surgery. The nanorods can be more than 1,000 times more precise than a surgeon's scalpel, says von Maltzahn, so they could potentially remove residual cells the surgeon can't get.

Detection agents

The nanorods' homing abilities also make them a promising tool for diagnosing tumors. After the particles are injected, they can be imaged using a technique known as Raman scattering. Any tissue that lights up, other than the liver or spleen, could harbor an invasive tumor.

In the Advanced Materials paper, the researchers showed they could enhance the nanorods' imaging abilities by adding molecules that absorb near-infrared light to their surface. Because of this surface-enhanced Raman scattering, very low concentrations of nanorods — to only a few parts per trillion in water — can be detected.

Another advantage of the nanorods is that by coating them with different types of light-scattering molecules, they can be designed to simultaneously gather multiple types of information — not only whether there is a tumor, but whether it is at risk of invading other tissues, whether it's a primary or secondary tumor, or where it originated.

Bhatia and von Maltzahn are looking into commercializing the technology. Before the gold nanorods can be used in humans, they must undergo clinical trials and be approved by the FDA, which von Maltzahn says will be a multi-year process.

Other authors of the Advanced Materials paper are Andrea Centrone, postdoctoral associate in chemical engineering; Renuka Ramanathan, undergraduate in biological engineering; Alan Hatton, the Ralph Landau Professor of Chemical Engineering; and Michael Sailor and Ji-Ho Park of the University of California at San Diego.

Park and Sailor are also authors of the Cancer Research paper, along with Amit Agrawal, former postdoctoral associate in HST; and Nanda Kishor Bandaru and Sarit Das of the Indian Institute of Technology Madras.

The research was funded by the National Institutes of Health, the Whitaker Foundation and the National Science Foundation. Nanopartz Inc. supplied gold nanoparticles, gold nanowires and the precursor gold nanorods used in this work.

GRAPHENE: MIT teams finding ways to make atom-thick graphene commercially viable

Continued from **Page 1**

properties or on potential applications, MIT is unusual in having faculty members involved in so many different aspects of graphene research and working collaboratively on these projects, says Tomas Palacios, an assistant professor of electrical engineering and computer science and a leader of one of MIT's research groups exploring graphene's possible electronic applications.

A successor to silicon?

Its unique electrical characteristics could make graphene the successor to silicon in a whole new generation of microchips, surmounting basic physical constraints limiting the further development of ever-smaller, ever-faster silicon chips.

But that's only one of the material's potential applications. Because of its single-atom thickness, pure graphene is transparent, and can be used to make transparent electrodes for light-based applications such as light-emitting diodes (LEDs) or improved solar cells. The potential solar cell applications are now being studied by some MIT researchers including Associate Professor of Electrical Engineering Vladimir Bulovic and Associate Dean of Engineering for Research Karen Gleason.

Graphene could also substitute for copper to make the electrical connections between computer chips and other electronic devices, providing much lower resistance and thus generating less heat. And it also has potential uses in quantum-based electronic devices that could enable a new generation of computation and processing.

"The field is really in its infancy," says Michael Strano, associate professor of chemical engineering, who has been investigating the chemical properties of graphene. "I don't think there's any other material like this."

The mobility of electrons in graphene — a measure of how easily electrons can flow within it — is by far the highest of any known material. So is its strength, which is, pound for pound, 200 times that of steel. Yet like its cousin diamond, it is a remarkably simple material, composed of nothing but carbon atoms arranged in a simple, regular pattern.

"It's the most extreme material you can think of," says Palacios. "For many years, people thought it was an impossible material that couldn't exist in nature, but people have been studying it from a theoretical point of view for more than 60 years."

Palacios and his team just last month published new results showing that graphene can be used to make frequency multipliers that could enable much faster computer chips and communications devices.

Once obscure, now red-hot

As early as 1981, a review article on graphene by the Dresselhauses, as well as numerous peer-reviewed papers on the subject, described the electrical and mechanical properties of graphene layers. "We weren't exactly looking for single isolated layers at that time," says Mildred Dresselhaus; rather, they were working with graphene layers sandwiched between layers containing other molecules.

"These materials obviously had different properties, different from anything else," Dresselhaus says. "That's what excited us."

When she started working in 1961 on the properties of carbon and its many forms of atomic arrangements, it was not a popular subject for research, Dresselhaus recalls. "There were probably 10 people in the world" doing such research in the 1960s, she says. "Now there are thousands." At the American Physical Society annual meeting last month, she says, there were more sessions devoted to graphene and related carbon research than any other subject. "This is by far the most popular topic" in physics today, she says.

Another team studying graphene at MIT is led by Pablo Jarillo-Herrero, an assistant professor of physics, who is studying its basic physical properties and using graphene's unique behavior as a way to study fundamental quantum-mechanical effects. For example, in graphene, electrons behave as if they were massless particles propagating according to the laws of relativistic quantum mechanics, a behavior that is normally reserved to particles traveling near the speed of light in accelerators or in the cosmos. Such behavior is at the heart of the ultra-high mobilities exhibited by graphene devices.

Jarillo-Herrero says that because the material is so new and its fundamental properties still being discovered, "we have some applications in mind, but many totally new ones will for sure come up as we continue doing research."

Scaling up production

Carbon atoms have a propensity to bind very strongly to each other, as well as to other kinds of atoms. The molecular bonds they form are easy to make and very hard to break. That's what gives carbon molecules and crystals their unrivaled strength.

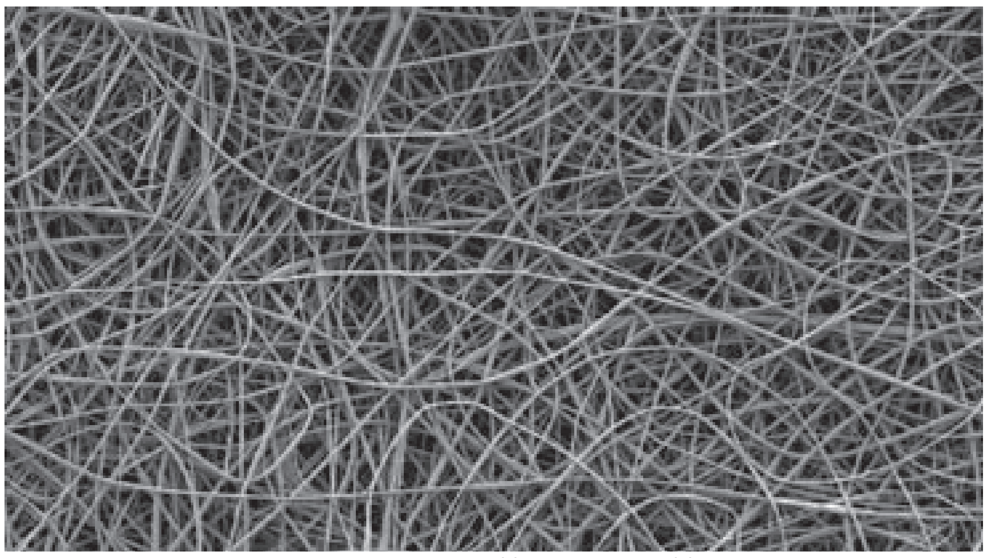
Graphite, the material of ordinary pencil lead, is essentially a jumbled mass of tiny scraps of graphene. The trick that enabled the first demonstrations of the existence of graphene as a real separate material came when researchers at the University of Manchester applied sticky tape to a block of graphite and then carefully peeled off tiny fragments of graphene and placed them on the smooth surface of another material.

That method is sufficient for scientific research. "For the physicists, that's all they need," says Strano. "They don't care if they go to a lot of effort to make five tiny pieces, they can study those for years." But when it comes to possible commercial applications, it's essential to find ways of producing the material in greater quantities.

One of the MIT research teams, led by Jing Kong, the ITT Career Development Associate Professor of Electrical Engineering, is working on developing such methods. In preliminary work, they have created sheets of graphene by chemical vapor deposition, a technique that could be used to make larger quantities of graphene.

Kong's method uses equipment that is "very compatible to conventional semiconductor processing." The method "is quite straightforward, and not too expensive," she says, which could help to enable commercial applications. For specialized functions such as computer chips, further research will be needed to improve the quality and uniformity of the graphene sheets, she says, but for other applications such as solar-cell electrodes, the existing process allows the researchers to start the investigation.

Dresselhaus is a bit more cautious about making graphene sheets suitable for commercial applications for the next generation of electronics. "Incorporating them into something useful for society is already underway, but to provide the next generation of semiconductor electronics, that's really a decade away," she says. The widespread excitement about graphene "is well-deserved," she says. "It has very exceptional properties, and it's simple. It's strong, it's light, and it's relatively inexpensive. I've always liked it."



PHOTOS / (L) DONNA COVENEY; (R) COURTESY OF GREGORY RUTLEDGE

LEFT: Gregory Rutledge. RIGHT: A scanning electron micrograph of an electrospun nonwoven mat of poly(styrene-co-dimethylsiloxane) fibers, showing the porous, nonwoven structure of the mat.

Spinning at the nanoscale

Electrospun fibers could be used for protective clothing, wearable power and more

Anne Trafton
News Office

In his office, MIT Professor of Chemical Engineering Gregory Rutledge keeps a small piece of fabric that at first glance resembles a Kleenex. This tissue-like material, softer than silk, is composed of fibers that are a thousand times thinner than a human hair and holds promise for a wide range of applications including protective clothing, drug delivery and tissue engineering.

Such materials are produced by electrospinning, a technique that has taken off in the past 10 years, though the original technology was patented more than a century ago. In Rutledge's lab, researchers are exploring new ways to create electrospun fibers, often incorporating materials that add novel features such as the ability to kill bacteria.

"We're still in the Wild West mode of discovery," says Rutledge. "People are hypothesizing almost anything and giving it a try. We're still trying to figure out which ones are the payoff applications."

Rutledge has been one of the pioneers of electrospinning nanofibers since the nanotechnology boom of the late 1990s. Though he describes the actual electrospinning process as almost "a mundane thing," he and his colleagues have demonstrated a number of ways to create electrospun membranes with new and useful traits.

Electrospinning, the most general way to make a continuous polymer nanofiber, uses an electrical charge to draw the fiber from a liquid polymer. As a jet of charged fluid polymer sprays out the bottom of a nozzle, an electric field forces the stream to whip back and forth, stretching the fiber lengthwise so its diameter shrinks from 100 microns to as little as 10 nanometers.

The fiber forms a thin membrane as it hits the surface below the nozzle. These electrospun membranes have a unique combination of stretchiness and strength, and are easy to handle, making them suitable for a wide range of applications. Because the membranes are very porous (they contain 85 percent open space), they are already used as HEPA (high efficiency particle accumulation) filters, found in vacuum cleaners and military tanks.

In the past few years, Rutledge's team has produced several textiles that incorporate functional materials into the electrospun membranes. One major focus is designing textiles that can protect against toxic agents, both biological and chemical, by adding protective compounds to the polymer.

One such material, described in the journal Polymer last year, incorporates chlorhexidine, which can kill most bacteria. Rutledge's team is also working with oximes, a class of organic compounds that can break down organophosphates, chemicals that are the basis of many pesticides, insecticides and nerve gases. Materials such as these, developed in collaboration with Alan Hatton, the Ralph Landau Professor of Chemical Engineering, could be used to coat medical devices or create protective clothing for soldiers.

Rutledge and Paula Hammond, the Bayer Professor of Chemical Engineering, recently reported in the journal Advanced Materials a material embedded with titanium oxide, which can break down a variety of industrial chemicals, including organic compounds like phenols and allyl alcohol.

The fibers hold promise for development of new breathable, waterproof materials. Four years ago, Rutledge and Randy Hill of Dow Corning created an electrospun sheet that is extremely water-repellent. Such a material, described in the journal Langmuir, has the potential to become a cheaper alternative to GoreTex, which is made of Teflon — a more expensive starting material than the polymers used to make electrospun fibers. More recently, working with MIT professors Karen Gleason, Robert Cohen, Gareth McKinley and Michael Rubner, Rutledge's group has demonstrated a variety of ways to render breathable electrospun fabrics water- and oil-repellent.

Rutledge is now working on electrospun fibers made of block copolymers that self-assemble into a collection of concentric cylinders within the fiber. Such fibers, made possible by a co-axial version of electrospinning technology that the group reported in 2004, could be used to impart color to fabrics without dye, or to create "wearable power" by combining electrodes and electrolytes into individual fibers.

"There are a lot of ways one can imaginatively think to use some of this stuff," says Rutledge.

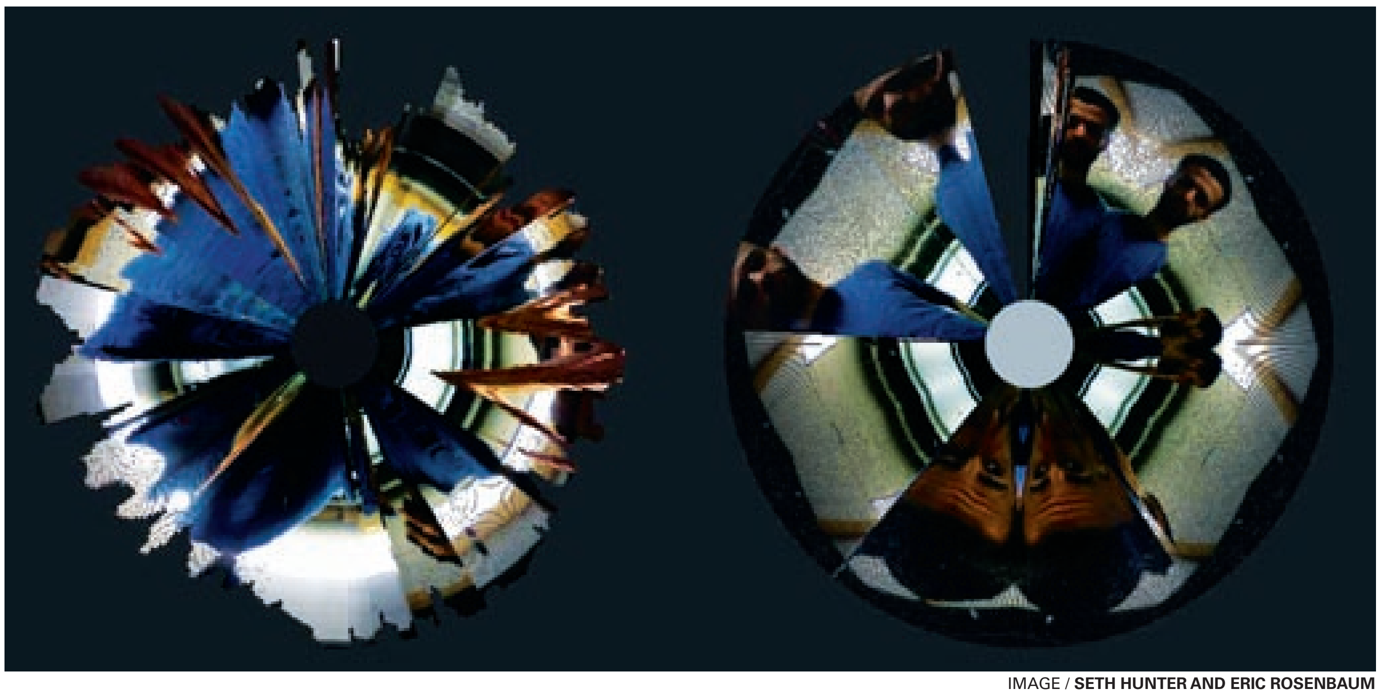


IMAGE / SETH HUNTER AND ERIC ROSENBAUM

Processing time

Teams of programmers gathered May 2 for 'ProcessingTime,' a coding jam and competition organized by Assistant Professor of Digital Media Nick Montfort as part of the Boston Cyberarts Festival. Participants were invited to use Processing, a programming language for visual design that was created at MIT Media Lab, to create aesthetically pleasing displays of time. Shown above is a screenshot of 'Motion Clock, Stillness Clock,' the winning entry by graduate students Seth Hunter and Eric Rosenbaum.

Investigating a sometimes-faulty protein's role in brain links

Picower study could lead to treatments for autism, more

Deborah Halber
Picower Institute

Researchers at MIT's Picower Institute for Learning and Memory have shed light on how a protein implicated in cognitive disorders maintains and regulates brain cell structures that are key to learning and memory.

The work could lead to new treatments for autism, mental retardation and Fragile X syndrome, which researchers believe are tied to abnormalities in synapses, the junctures through which neurons communicate.

"Increase in the size of synapses and memory formation are closely linked," said Mariko Hayashi, a Picower Institute research affiliate and co-author a new study about the work that appeared in a recent issue of the journal Cell. "Synapses get larger when we learn something and smaller when we forget something or unused connections are pruned. This happens in infants' growing brains and in learning and memory during adulthood. "

The study shows how two proteins — named Shank and Homer — work together to form a structural platform that allows other critical proteins to link to it like Legos, changing the active neurons' synapses.

Getting the message

When one neuron sends a signal to another neuron through chemical messages called neurotransmitters, receptors on the target membrane receive the signal. Shank and Homer help the receiving neuron get the message by interacting with a phalanx of receptors — a kind of central switchboard for synaptic transmissions — called the postsynaptic density (PSD).

Researchers hope that elucidating the little-understood structure and composition of the PSD will shed light on synaptic plasticity, the brain's ability to change, learn and remember.

Researchers are particularly interested in Shank because the protein is disrupted in a small proportion of autistic individuals.

"If a protein is missing or not working correctly, then the network structure is not formed the way it's supposed to be and cognitive problems occur. A striking example is in some cases of autism spectrum disorder, Shank has a mutation," Hayashi said. "Potentially, we may be able to manipulate the function of Shank in the brain and cure the disease."

Homer and Shank, the MIT researchers found, latch onto each other to form a solid structure other proteins can bind to. This helps explain how PSDs and spines get bigger when learning and memory occur, and could lead to new therapies that boost the size and integrity of these tiny complexes.

Specifically, Hayashi and colleagues from RIKEN Brain Science Institute, Brookhaven National Laboratory, University of Milano and New York University found that Homer forms a dumbbell-shaped structure that binds to two Shank molecules at each end. "We showed through electron microscope analysis that these two proteins form a mesh-like matrix structure," Hayashi said.

During brain development and learning and memory, "it is highly likely that Homer and Shank assemble or disassemble to change the shape of the PSD," Hayashi said.

This helps explain how the size of synapses and the number of receptors increase when learning and memory occur, and could lead to new therapies that control the size and integrity of the PSD.

This work was supported by RIKEN, the National Institutes of Health and Japan's Ministry of Education, Science and Culture.

3 Questions: Jeffrey Hoffman, on fixing the Hubble telescope

"3 Questions" gives members of the community the opportunity to sound off on current events in their field of expertise. Jeffrey Hoffman, professor of the practice in MIT's Department of Aeronautics and Astronautics, is a former space shuttle astronaut whose five flights included the first Hubble Space Telescope servicing mission in 1993. He offered his thoughts on what the next repair crew can expect during the fifth and final Hubble servicing mission set for launch on May 11, and on NASA's future.

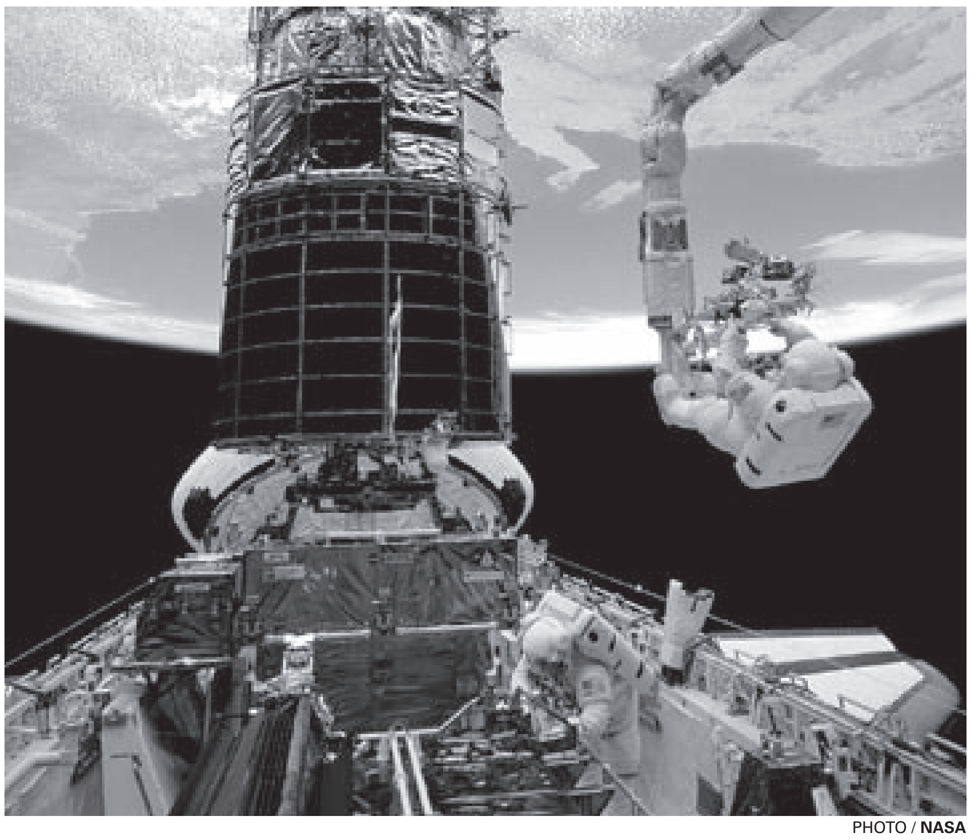


PHOTO / **NASA**

Jeffrey Hoffman, inside the shuttle payload bay, assists F. Story Musgrave, on the robotic arm, during the Hubble telescope's first servicing mission in 1993.

Q. What's the most difficult aspect of doing hands-on repairs in orbit on a giant, delicate instrument like the Hubble?

A. I treat it much the way I treat working on a car or any other type of home repair. The number one thing is, don't hurt yourself, and that kind of gets lost in the weeds sometimes, but the number one thing in human spaceflight is safety. Number two, don't break anything that isn't already broken. That happens sometimes during home repairs, and you curse and yell, but you can afford the time; you can't afford the time when you're up in space. And then finally, you've got to fix the problem. And that is sometimes easy: Most things on Hubble were designed for easy access for space-suited astronauts. But there have been plenty of tasks that we've had to deal with that were never originally contemplated, and so you need skill at using a spacesuit and particularly fine manipulation with big bulky spacesuit gloves, and also an understanding of the tools you have, and the ability to come up with innovative solutions when problems occur.

Q. After all the months of training and simulations you went through, was there anything when you got out there that surprised you?

A. Oh yes, absolutely. We were of course expecting to be surprised. Every time NASA had visited a satellite before Hubble, there had always been surprises — usually due to something being out of configuration compared to the drawings. Now the Hubble project did an extraordinary job of configuration control, so things were the way they were supposed to be, but not everything worked the way it was supposed to. Particularly, the first day, after we successfully replaced the gyroscopes, the door wouldn't close. That was probably our biggest problem, and that could have destroyed the telescope had we not been able to get that door closed. It was warped, and we had to figure out a special way to use a tool — it was just something that had never been envisaged before, we had never trained for it. It was always assumed that we would just close the handle and the door would close. It didn't work.

We had a solar array that didn't roll up and we had to leave in orbit. We had an electronics box that we knew in advance we were going to have to replace; it was not designed for EVA [extravehicular activity] replacement, and there were all these tiny little 2 millimeter screws, which we were told were captive screws, but in fact in zero-g they weren't. So they started floating all over the place, and we had to grab them and chase them all around, and it was a mess. That was right at the limit of what we were capable of doing in a spacesuit.

Q. What are your thoughts about the impending end of the shuttle program at the end of next year, and the possibility of extending it beyond that?

A. The shuttle is an extraordinarily capable vehicle. It's been very good to me, and I've done some extraordinary things with it. It was built under difficult circumstances, and so its design was compromised. It's far from a perfect vehicle.

The shuttle was designed specifically for low-Earth orbit, just to go up a few hundred miles and back. The shuttle itself is getting old, so the bottom line is I think it's time for a new vehicle. The shuttle was never as easy to maintain and refly as was originally imagined, despite the fact that it's extraordinarily capable once it's up in space. It's a more dangerous vehicle than it should be. We know that. It has no escape system, it's sitting on the side of the stack rather than on top where well-behaved human-carrying modules should be. It's very capable, but it's not as robust as it could be.

Even at the beginning of the shuttle program, we were still dreaming about going back to the moon, and even farther, and the shuttle was never designed to do that. And we now have a new direction in the space program where we would like to do that. I hope that direction is continued by this administration. And so one way or another we need a new vehicle.

I think the tragedy is that we as a country, as an agency, waited until the imminent retirement of the shuttle to start designing and building a new vehicle. We've had several false starts over the last 20 years, and wasted billions of dollars, but that's the way it is, and here we are.

So I think it's the right decision to retire the shuttle. And given the fact that it's going to be retired I don't see any justification for keeping it flying for just a few more years. Yeah, so we have a gap in U.S. space capability. The only thing we need a spaceship for during the next few years is to get up to the space station, but the Russians will do that for us, and maybe even Elon Musk [founder of SpaceX, which is building the privately-funded Falcon 9 rocket] will do that for us. In fact, I'd love to see private industry take over maintaining the low-Earth orbit infrastructure. If private industry could support that on the basis of tourist travel and however else they can make money, then NASA could buy their services at the marginal cost of doing business instead of maintaining the whole infrastructure. I mean, NASA spends a third of its budget just supporting a transportation infrastructure, and if that could be obtained from the private sector, NASA would save a lot of money, which could be used for exploration, which is what I think NASA's real goal should be in the future, not running a transportation system.

MISTI seeks proposals for seed grants

MIT International Science and Technology Initiatives (MISTI) has launched a call for proposals for its second round of Global Seed Funds grants. The program provides funds to MIT faculty and researchers to support early stage international projects and research collaboration. Applicants are encouraged to involve MIT students — both undergraduate and graduate — in their projects.

MISTI Global Seed Funds include a general fund for projects anywhere in the world and several country funds. The award may be used to cover travel, meeting and workshop costs to facilitate international projects and collaboration. The deadline for applications is Sept. 14, 2009.

In the inaugural grant round, 27 projects out of 104 applicants were awarded a total of $457,000 in funding.

For more details and to apply, please visit http://mit.edu/misti/faculty/.

Italian students' group in quake relief drive

MITaly, the Italian student association at MIT, has begun raising money to support reconstruction at the University of L'Aquila, which was severely damaged during the earthquake that hit Italy's Abruzzo region in April.

Money raised will go toward laboratory equipment and physical reconstruction of buildings at the university and its engineering school. For more information on the fundraising initiative, please visit http://web.mit.edu/mitaly/www/mensetmanus-fund2009.html.

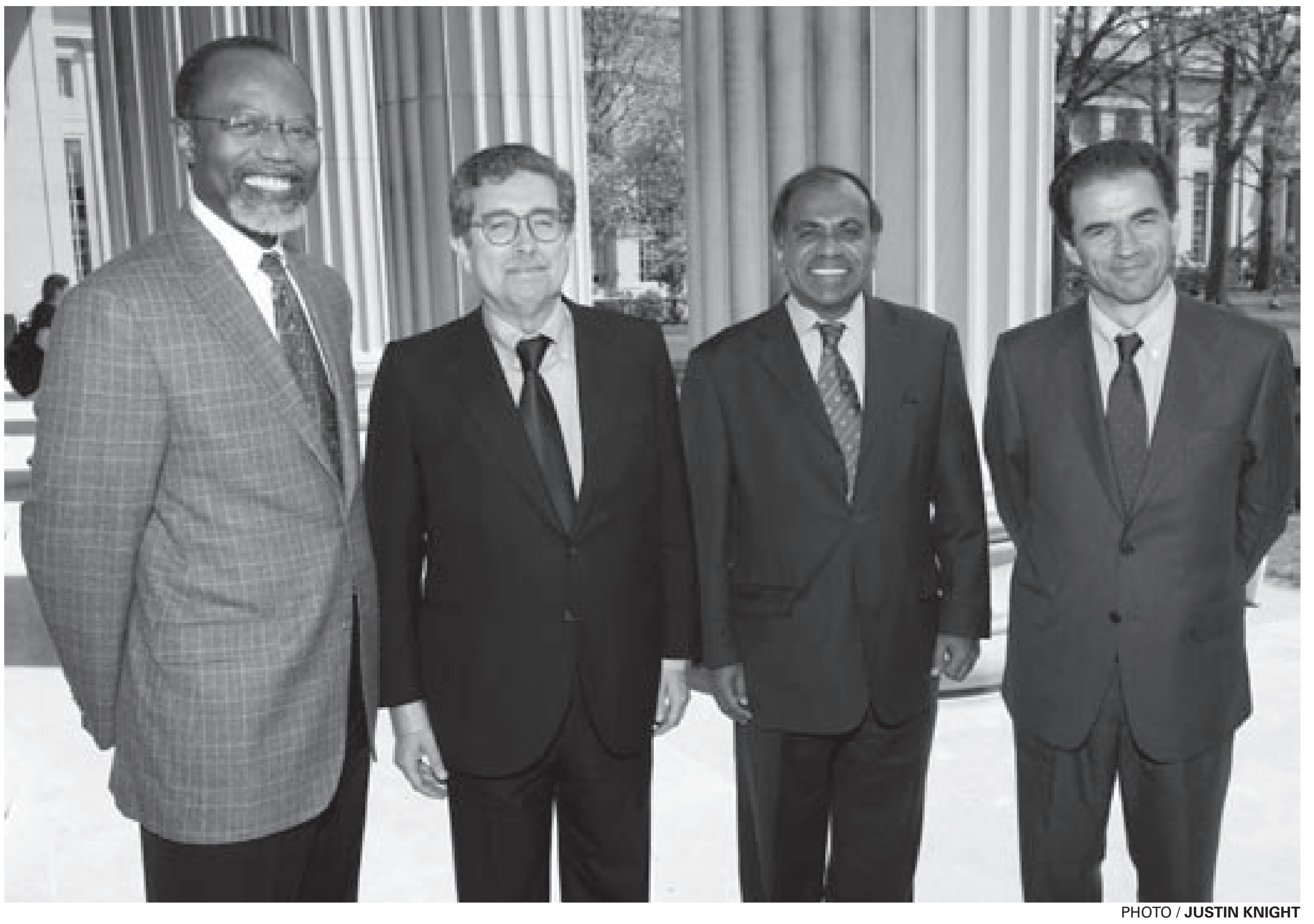


PHOTO / **JUSTIN KNIGHT**

Strengthening ties

MIT hosted a visit last week by Portuguese government officials to discuss the future of the MIT-Portugal Program. From left: Chancellor Phillip Clay; José Mariano Gago, Portugal's minister of science, technology and higher education; Dean Subra Suresh, School of Engineering; and Manuel Heitor, Portuguese secretary of state for science, technology and higher education.

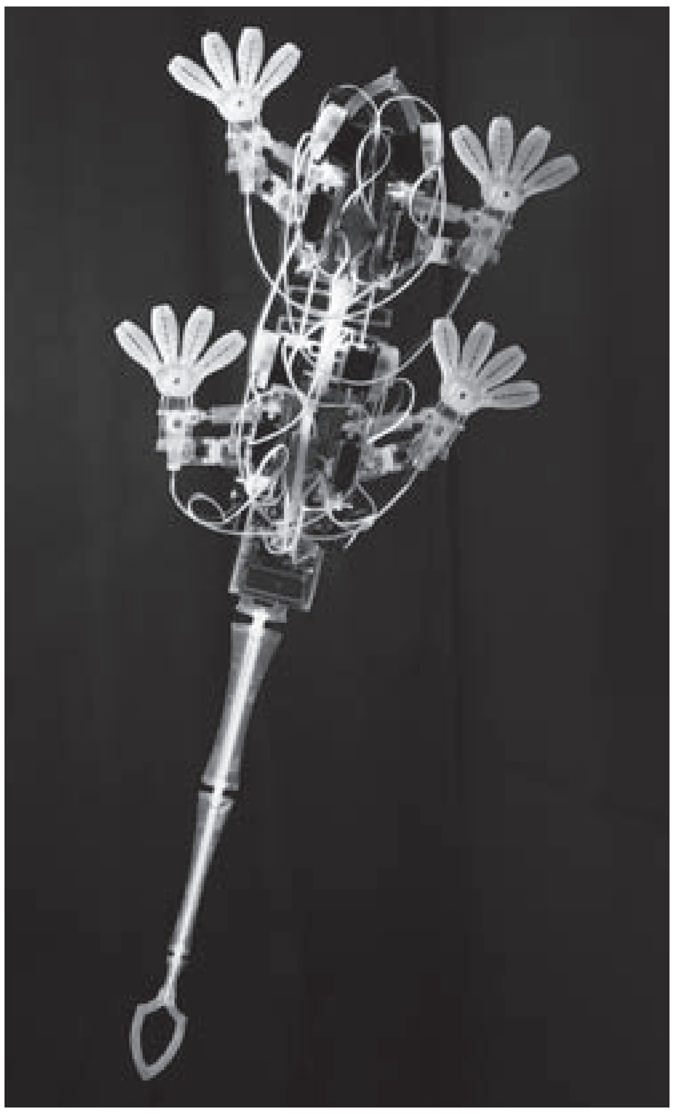


PHOTO / SANGBAE KIM AND MARK CUTKOSKY

One project that received MITEI seed funds involves developing remote-controlled robots that can walk along deep-sea oil pipes and drilling facilities, performing critical inspection and maintenance tasks. Key to the design is a foot inspired by that of the gecko, which can stick to and traverse all kinds of surfaces.

MITEI awards third round of seed grants

Nancy Stauffer
MIT Energy Initiative

The MIT Energy Initiative's third round of seed grants for energy research will support innovative work on solar power, nuclear power, fuel cells, biofuels, and more. Several projects are inspired by natural systems such as gecko feet and bacterial antennas.

Total funding in this round of seed grants exceeded $1.5 million. Thirteen projects received grants ranging from $60,000 to $150,000 and lasting from one to two years, while two additional projects were awarded smaller, shorter-term "planning grants."

"We were especially pleased to see that more than half the awards in this round went to junior faculty," said MITEI Director Ernest Moniz. "And as in the previous rounds, many of the awardees are new to energy-related research."

A few examples will demonstrate the creativity and diversity of the funded research. In one project, Sangbae Kim, who joins the mechanical engineering faculty in May 2009, aims to develop remote-controlled robots that can perform monitoring and maintenance of deep-sea oil pipes and drilling facilities — tasks critical for safe and environmentally appropriate operation. The robot must walk along underwater pipes for inspection and then stop to perform maintenance, so the researchers are designing a foot inspired by the remarkable adhesion system that enables geckos to adhere to and traverse all kinds of surfaces.

In another biology-related project, Professor William Green and Assistant Professor Kristala Jones Prather, both of chemical engineering, are using computational and experimental methods to identify biofuel molecules that promise significant performance advantages in engines over conventional fossil fuels and can be made in high yields using metabolic engineering.

Assistant Professor Alfredo Alexander-Katz of materials science and engineering is also looking to nature for help in designing high-performance photovoltaic devices. His work focuses on the light-harvesting antennas of photosynthetic green bacteria, which have the ability to harvest essentially every photon that they encounter. Understanding how these natural systems self-assemble will help researchers design novel artificial systems that can harvest light with high efficiency.

Other solar-related projects focus on solar concentrators. For example, Associate Professor Marc Baldo of electrical engineering and computer science is working to improve the "luminescent solar concentrator," a device in which glass or plastic is coated with dyes that absorb light and then re-emit it for collection by solar cells attached at the edges. Such devices work well with diffuse light but have weak absorption of sunlight in the infrared — a shortcoming that the researchers will address by incorporating rare earth ions into the glass or plastic substrate.

To speed the development of hydrogen fuel cells, Sylvia Ceyer, the John C. Sheehan Professor of Chemistry, is investigating alternatives to the commonly used platinum catalyst, which is expensive and readily poisoned by common fuel contaminants. One candidate is a novel, less-expensive alloy that may do the job of the platinum — catalyzing reactions that form water on the electrodes.

A project led by Assistant Professor Marilyne Andersen of architecture focuses on innovative window systems that can reduce the need for energy-consuming lighting, heating, and cooling but are rarely implemented, in part because predicting their performance in a given space is difficult. Andersen is developing new metrics that will generate realistic estimates of their energy-saving potential as well as other benefits such as visual and thermal comfort, health, and productivity.

Funding for the new grants comes from MITEI's founding and sustaining members (see http://web.mit.edu/mitei/about/members.html), supplemented by the Chesonis Family Foundation, other private donors and MITEI. For a complete listing of the new seed grants, go to http://web.mit.edu/mitei/news/spotlights/recipients-04-09.html.

To date, MITEI's seed fund program has supported more than 50 early-stage research proposals plus ignition and planning grants. "We expect to see high-impact results from this program over the next several years, providing the foundation for future major MIT energy research efforts," said Robert Armstrong, deputy director of MITEI.

PHYSICS: Dept. tackling a complex problem

Continued from **Page 1**

who will become an assistant professor this fall.

Conrad credits Peter Fisher, head of the Particle Physics Division, and Richard Milner, head of the Laboratory for Nuclear Science, for working to make women feel welcome in particle physics.

"There are times when the female postdocs and faculty outnumber the males on the fifth floor (of Building 26)," she says. "One recent evening, the fifth floor was inhabited by all women except for Professor Bruno Coppi. He burst into my office and said, 'Look how MIT has changed! It's marvelous to see this!'"

> *Our students — both undergrad and grad — are great ambassadors for our program.*
>
> **Janet Conrad**
> **physics professor**

Part of the recent success stems from a new directive for faculty search committees to come up with lists of star female and minority candidates. The department is also offering funding to bring promising underrepresented candidates to MIT to give talks before they apply, so they can build relationships with faculty here.

Attracting more female graduate students is also a top priority, says Bertschinger. While 30 percent of the department's undergraduate physics majors are women, MIT lags comparable universities in its number of female physics graduate students. As of 2007, only 13.7 percent of MIT's physics graduate students were female, much fewer than at Harvard (37.3 percent), Columbia (35.8 percent) and Caltech (22.8 percent).

Bertschinger wants MIT to start outcompeting those schools for the top women candidates. After female students are admitted, at least one female faculty member contacts each student, and current women graduate students also reach out to each admitted student, inviting them to MIT for dinners and other events.

"Our students — both undergrad and grad — are great ambassadors for our program," says Conrad.

The department also recently added a third month of paid maternity leave for graduate students, after students requested the move.

These efforts appear to be having some impact already, as 25 percent of new physics PhD students who entered MIT last fall are female.

Building connections

While the numbers of women have been growing, progress has been lagging for minority faculty and graduate students. But several new efforts are underway to boost the number of underrepresented minorities (defined as African Americans, Mexican Americans, Puerto Rican Americans and Native Americans).

> *If you cut off large groups of people because they don't feel comfortable — not because they can't do the work — then you're losing out on an opportunity.*
>
> **Eric Hudson**
> **associate professor of physics**

In February, the department took its largest-ever contingent to the annual joint conference of the National Society of Black Physicists and National Society of Hispanic Physicists, part of an ongoing effort to recruit more minority graduate students.

Underrepresented minorities make up about 16 percent of MIT's undergraduate physics majors, similar to the Institute's overall percentage of minority undergraduates, but only 3 percent of MIT's physics graduate students are minorities.

One way to elevate those numbers is to build relationships with historically black colleges, in hopes of creating a pipeline of talented physics graduates from those schools to MIT. When such relationships are established, faculty and program directors from those schools will be more likely to encourage their best students to come to MIT, says Tali Figueroa, assistant professor of physics.

"We have to prove to people with good students that their students will have a good experience and come out of MIT even stronger and better than they came in," says Figueroa, a Puerto Rican American who is the department's only minority faculty member.

Bertschinger is also encouraging faculty who travel to large universities to give talks to stay an extra day to give another talk at a nearby black college (for example, faculty visiting the University of Maryland could also give a talk at nearby Morgan State).

The department, in conjunction with the School of Science, is also thinking about setting up a post-baccalaureate program for minority students to spend a year at MIT taking classes and/or doing research before formally applying to graduate school. Such a program would be especially beneficial for students from smaller schools who might be intimidated by the thought of coming to a large research institution such as MIT, says Bertschinger.

Another way to make connections with more minority students is through MIT's MSRP program, which brings minority undergraduates to the Institute every summer to do research (similar to a summer UROP). In recent years the physics department has had few students in the program, but a Florida A&M student who came last year was very successful and plans to apply to MIT for graduate school. At least three physics students plan to attend this summer.

Associate professor of physics Eric Hudson helps to organize MSRP and recently won an MIT Excellence Award in Diversity and Inclusion for that work, as well as for his mentoring of minority physics students and for helping to organize the annual Converge weekend, which brings minority undergraduates to MIT to learn about the Institute before applying to grad school.

Events such as MSRP and Converge can help the entire Institute fulfill its educational mission by drawing talent from the entire population, according to Hudson.

"The goal of MIT is to bring the absolute best people here to work to learn about the world," Hudson says. "If you cut off large groups of people because they don't feel comfortable — not because they can't do the work — then you're losing out on an opportunity."

The MIT News Office will publish the 2009 Institute Awards issue in print (MIT Tech Talk) and online on June 3 this year. The annual special section lists winners of annual awards, by department, along with photographs where available.

Complete information on how to submit awards is available at http://web.mit.edu/newsoffice/awards.html, but please note that the deadline is 5 p.m. on Friday, May 22, in order to be included in the awards issue.

Natural inspiration

Neri Oxman strives to bring architecture to life

David Chandler
News Office

When you look at MIT graduate student Neri Oxman's work, it's not hard to believe that she started out as a pre-med student before deciding to switch to architecture. Everything she builds or designs looks organic, as if it had grown like some alien life-form instead of having been crafted by human hands and imagination.

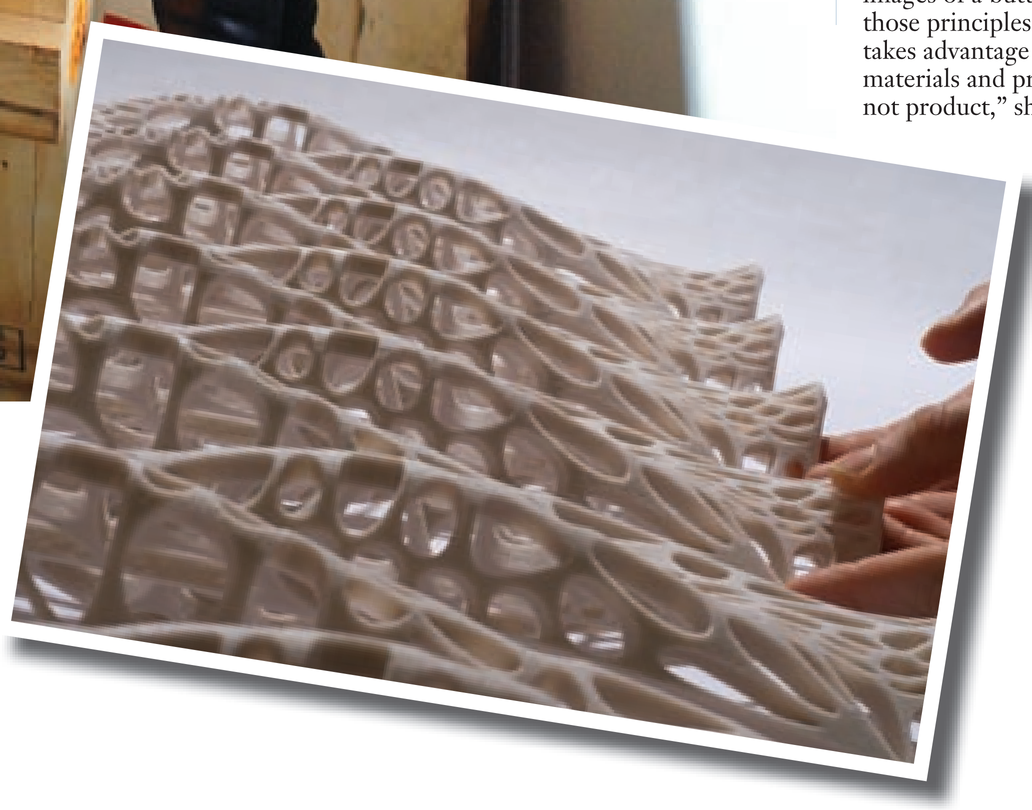
And that's precisely what she's trying to do: create art and architecture that draws from the way nature works. That approach has already earned several of her works a place in the permanent collection of the Museum of Modern Art in New York — and she has received several major awards.

Oxman, 33, was born and raised in Israel, where her parents are both architects and her grandparents engineers. She still has a year to go toward her PhD from the Media Lab, but her work is already turning heads. "She's pushing the boundaries of the possible, and in the process creating some very beautiful and thought-provoking objects," says her thesis advisor, William Mitchell, the Alexander W. Dreyfoos (1954) Professor of Architecture and Media Arts and Sciences.

Oxman's creations combine hard-nosed engineering with artistic vision. Working with W. Craig Carter, the Eugene Bell Professor of Materials Science and Engineering and a Margaret MacVicar Faculty Fellow, she has produced a new version of the 3-D printers used for rapid prototyping, called FAB.REcology, which has the unique ability to "print" objects whose texture and resilience vary from one portion of the object to the next. That enabled the production, for example, of a one-third-scale prototype for a molded chaise longue, which she is seen holding at left. The model is made of resin and has a filigreed structure that — at its full size — would be strong enough to support a person's weight, combined with sections flexible enough to nestle the body in comfort.

That chair's design, she says, drew inspiration from the internal structure of bones and other biological forms.

Her work aims to use computational tools to produce "performance-based design," she says, in which, as occurs in nature, "the organization of the structure is directly linked to the forces that are applied to that structure." To achieve that, she studies natural materials like the cellular structure of a bone, or microscopic images of a butterfly wing, and translates those principles into construction that takes advantage of the flexibility of modern materials and processes. "It's about process, not product," she says.



PHOTOS / **(A) DONNA COVENEY, (R) MIKEY SIEGEL**

ABOVE: Neri Oxman poses in her studio with a model of a molded chaise longue that drew inspiration from the internal structure of bones and other biological forms.

RIGHT: 'Monocoque,' a 3-D printed polymer resin composite, that is part of the Museum of Modern Art's permanent collection.