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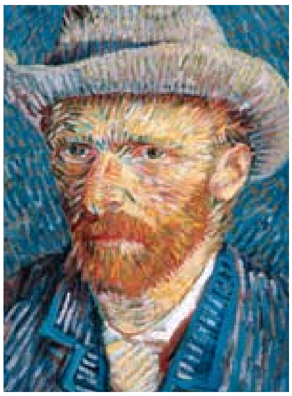
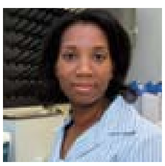
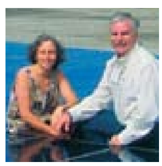
David Gothard


Van Gogh Museum

Cover and left: *Self-Portrait in a Gray Felt Hat: Three Quarters to the Left,* September 1887–October 1887. Courtesy The Van Gogh Museum.

DEPARTMENTS





RESEARCH SHOWCASE

Insect cyborgs, new materials for solar panels, a tool for recycling coal fly ash, a better bird-tracking system, and a new treatment for brain tumors were among the 71 projects spotlighted at the 2007 Engineering Research Showcase, Sept. 11.

The event, organized by the College of Engineering's Office of Research and Graduate Studies, highlighted the innovative work of undergraduates, graduate students, and postdoctoral researchers in the college.

"The research featured in the showcase addresses some of society's most pressing problems," said W. Kent Fuchs, the Joseph Silbert Dean of Engineering, in welcoming visitors to the event. "The far-reaching impact of this work will help improve human health, uncover sources of sustainable energy, and improve communications around the world."

Craig Weinman, a materials science and engineering Ph.D. candidate, won first prize in the poster competition for his work with Christopher Ober, the Francis Bard Professor of Materials Engineering, on environmentally friendly boat paint. Coatings currently used on marine vessels to prevent the growth of barnacles, algae, and other organisms contain toxic metals.

Robert Emro

Biological and environmental engineering major Laura Autumn Floyd '09 explains how she investigated creating different kinds of acetaminophen at the 2007 Engineering Research Showcase, Sept. 11 in the Duffield Hall atrium. Floyd worked with Lara Estroff, assistant professor of materials science and engineering, and was funded by an Intel-sponsored Engineering Learning Initiatives grant.

Weinman and Ober are creating a nontoxic coating that consists of two layers of synthetic rubber: a special outer layer that inhibits the growth of organisms, supported by a durable layer made from a material also used in shoe soles.

Speaking at the awards ceremony, Cornell's newly appointed vice provost for research, Robert A. Buhrman, related the difficulty researchers often have in describing their work to nonscientists.

"But no matter how hard or easy it is to inform people about what it is that you do, it is research and scholarship that really define Cornell to the world, and it is you graduate students and postdocs who are the key instruments that create that research," said Buhrman, who is the John Edson Sweet Professor of Engineering in the School of Applied and Engineering Physics. "It turns out that you are really good at what you do. That shows through so well here."

Sharath K. Bhagavatula '08 won the Undergraduate Prize for his work with mechanical and aerospace engineering Assistant Professor Brian Kirby on electrokinetic phenomena in hydrophobic microsystems. Their goal is to develop an understanding of how fluids interact with various substrates in a microfluidic environment, which could improve biomedical devices.

For the first time this year, the showcase featured short oral presentations by graduate students on their research. Topics included a biosensor for the infectious parasite *Cryptosporidium*, a potential treatment for osteoporosis, and an improved rechargeable battery.

Second prize in the poster competition went to Ph.D. student Marleen Kamperman for her work with materials science and engineering Professor Ulrich Wiesner on porous nonoxide ceramics.

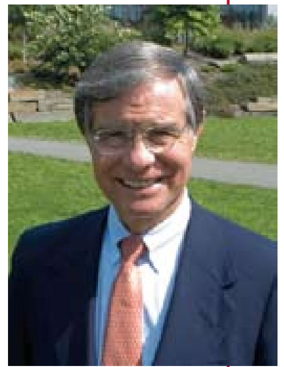
Designing an electronically assisted walker won third prize for an interdisciplinary team of graduate students and undergraduates from biological, biomedical, and mechanical engineering. Biomedical engineering master's degree students Sheryl Lau and Philip Wang worked with Suneth Attygale '07, mechanical engineering senior Homer Chiang and biomedical engineering senior lecturer David Lipson.

Judges represented the event's corporate sponsors: Simon Yeung, Dow Chemical Co.; Hui Li, Spansion Inc.; John Spoonhower, M.S. '75, Ph.D. '77, Kodak Co.; Don Bott, Xerox Corp.; Alison McKay, Becton, Dickinson and Co.; and Barbara Merritt, Lockheed Martin Corp. Intel also sponsored the event.

—Robert Emro

GIFT FOR THE FUTURE

Provided



Trustee David Croll '70

A major gift from Trustee David Croll '70 CE will help support research on energy and its environmental impacts—a strategic focus of the College of Engineering. Croll has pledged $5 million for the establishment of the Croll Professorship of Sustainable Energy Systems and related programmatic funds.

"Both education and research will benefit from this wonderful gift from the Croll family," said W. Kent Fuchs, the Joseph Silbert Dean of Engineering. "Their gift to Cornell's sustainable energy systems initiative will enable us to recruit a senior faculty leader in this area of strategic importance."

The Croll Professor will work closely with the new Cornell Center for a Sustainable Future. In its infancy but growing quickly, the center will bring together researchers across campus to address issues related to energy, the environment, global warming, and poverty. Interim Associate Director Sidney Leibovich, who oversees both the center's and the college's focus on energy, is leading the search for the Croll Professor.

"This is the first major investment allowing the college to implement its plans to focus on energy and the environment," said Leibovich, the Samuel B. Eckert Professor of Mechanical Engineering. "Resources are required to attract new faculty and to equip their laboratories: the overall investment needed is large, but alumni are rising to the challenge and helping us both financially and with sound advice."

At least 20 percent of the college's faculty members are working on some aspect of energy research, according to Leibovich, but they are often unaware of each other's work. "We realized that the collective impact on this colossally large and complex problem could be made much greater by fostering communication and interaction, and that this would best be facilitated by a senior faculty member globally recognized in the area of energy-environment interaction," he said. "We want Cornell to be the place people everywhere look to first to learn the state of the art on these questions."

—Lauren Gold, Cornell Chronicle and Robert Emro

NO DUES DUE

Attention engineering alumni: you are now a member of the College of Engineering Alumni Association. The CEAA Board of Directors voted unanimously in April to eliminate membership dues, making all alumni members.

Most alumni are happy with the change, according CEAA President Jaclyn Spear '74 EE, and many have asked how they can be more involved with the association. "The majority of the responses from the CEAA membership have been positive and many have asked how they can find new ways to connect and contribute to the College of Engineering," she said. "With this change it has become apparent that CEAA is evolving as an organization and we need to consider how we will better engage alumni."

A letter to dues-paying members in September explained that the change was necessitated by declining membership. Dues-paying members dropped 18 percent, from 1,410 to 1,156, over the last 12 years. An analysis by the board revealed that the expenses of postage, materials, and staff time spent to manage paid membership amounted to over 40 percent of annual dues.

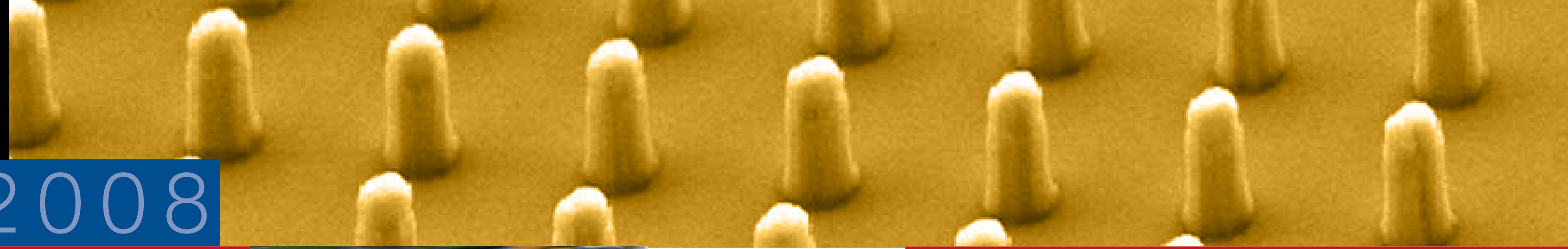
W. Kent Fuchs, the Joseph Silbert Dean of Engineering, has agreed to supplement the CEAA budget with money from the Cornell Fund for Engineering, which consists of unrestricted contributions made by alumni and friends each year. By using resources previously dedicated to marketing, soliciting, and administering dues to raise additional gifts for the fund, Tim Dougherty, assistant dean for Alumni Affairs and Development in Engineering, said the college can more than make up for the revenue that would have come from dues.

The accumulated dues payments of the association's 328 Lifetime Members will be used to fund the CEAA awards given each spring at the CEAA Engineering Conference. These include the Undergraduate Student Organization Award, Best Team Award, Undergraduate Research Award, and the Academic Achievement Award for non-tenure track staff and lecturers. The complete list of the CEAA lifetime members is at www.engineering.cornell.edu/lifetime-members.

"I would like to express a special thank-you to past paying members; especially lifetime members who have made the CEAA Awards Program possible," said Spear.

Spear said the change will help the CEAA better fulfill its mission: to engage alumni in the life of the college. The focus of the December board meeting will be a strategic discussion of alumni participation and what activities and programs CEAA and the college could offer.

—Robert Emro



TORONTO SHOOTOUT

Courtesy of University of Toronto Formula Racing Team

David Porter driving Cornell's FSAE race car at the Toronto Shootout. As in professional racing, the Cornell FSAE team displays its many corporate sponsors.

For the second year in a row, Cornell's Formula SAE team has won the University of Toronto Shootout, a race for student-built and -driven race cars.

The competition tests both driving skill and a car's acceleration and maneuverability as a team of four drivers negotiates an irregular course of about one kilometer at the Mosport International Raceway in Bowmanville, about 60 miles east of Toronto, at speeds averaging around 45 mph. The regional competition drew 15 teams from the United States and Canada. Second place went to a team from the University of Michigan.

Cornell drivers David Porter '08, Mike Rooks '07, and Erik Shewan '08 drove the course in 54.17, 54.47, and 56.2 seconds, respectively, to come out with the best average time and win the race, which is determined by the three best times of four drivers. Jason Smart '09 was the fourth driver, making good time but losing points for hitting a traffic cone. The course is an oval track on which cones are used to create a sort of slalom on the straightaways. Porter also won best single time, beating the closest competitor by only three one-thousandths of a second.

The Cornell students triumphed in a car that was not in top form. The car was the same one the team drove in the International Formula SAE competition last May, and it was "acting up," Porter reported. The team improved performance by replacing the electronic control module but still had to run the car without its supercharger, which greatly reduced acceleration.

The Cornell FSAE team consists of about 45 graduate and undergraduate students, 34 of whom traveled to the Toronto Shootout. The team is currently in the design and testing phase for a new car to enter in the spring FSAE competition. Al George, the J.F. Carr Professor of Mechanical Engineering, and Brad Anton, associate professor of chemical and biomolecular engineering, are faculty advisers.

The team returned from Canada with a prize of $150 and four Goodyear tires, which will be used during the development and testing of the new car.

—Bill Steele, Cornell Chronicle

MEETING THE CHALLENGE

Dave Ahl '60 B.E.E. '61

Team Cornell at the DARPA Urban Challenge in Victorville, Calif. Kneeling, from left: Adam Shapiro '09; staff member Mike Kurdziel, an RIT graduate student; Isaac Miller, Ph.D. candidate; Aaron Nathan '07; Sergei Lupashin '06. Standing: Frank-Robert Kline '09; Jason Catlin '08; Tony Tether, director of the DARPA Urban Challenge; Noah Zych '06, M.Eng. '07; Pete Moran '06; Brian Schimpf '07; Professor Mark Campbell; and an unidentified DARPA official. Not shown: faculty advisers Professors Dan Huttenlocher and Ephrahim Garcia.

A car driven by artificial intelligence that can navigate city streets, obey traffic laws, pass, merge, and avoid other vehicles, reroute around blocked streets and, above all, not hit anything, sounds almost impossible. But six university-affiliated teams, including one from Cornell, met such rigorous standards at the 2007 DARPA Urban Challenge, Nov. 3, in Victorville, Calif.

Team Cornell's "Skynet," a converted Chevy Tahoe named for the AI in the Terminator movies, was one of only 11 vehicles out 35 initial entries selected for the final test, where cars carried out three simulated military-supply missions in an urban setting. Five of those were eliminated during the first mission.

All six remaining cars performed amazingly, completing about 55 miles on city streets, merging with and passing each other as well as cars driven by actual people. But in the end, said Mark Campbell, associate professor of mechanical and aerospace engineering and one of the team's faculty advisers, it came down to time. "Our first mission ran quite well, but we had some throttle problems, which slowed us down the last two missions," he explained.

Carnegie Mellon, Stanford, and Virginia Tech universities took first, second, and third place, with prize money of $2 million, $1 million, and $500,000. DARPA did not rank the remaining teams. Other finishers were the Massachusetts Institute of Technology and a University of Pennsylvania–Lehigh University partnership.

Campbell considered the Cornell team's achievement outstanding, noting that most other teams worked closely with well-financed industrial partners and had substantial faculty and senior researcher technical leadership.

"We took the view that we were advisers, not team leaders," said Dan Huttenlocher, the John P. and Rilla Neafsey Professor of Computing, Information Science, and Business. "This is one of the reasons I love being a faculty member at Cornell. We have students who are willing to take something like this on and drag faculty members into it."

—Bill Steele, Cornell Chronicle

IGERT FELLOWS

Provided

IGERT funded students: Brian Bryce ECE, Darren Southworth PHYS, Robert Rodriguez MSE, Jonathan Alden AEP, Rebecca Cantrell CBE, Brandon Aldinger CCB.

Two National Science Foundation grants totaling more than $6 million will support Cornell science and engineering graduate students for the next five years.

The Cornell Center for Materials Research received $2.9 million from NSF's Integrative Graduate Education and Research Traineeship program to teach the next generation of scientists and engineers to better collaborate across disciplines.

The CCMR's IGERT fellows will take weeks-long "modules" related to the broad field of nanoscale surfaces and interfaces, taught by faculty members in such different fields as chemistry and physics. They also will take short courses on such skills as public speaking, writing science papers, and ethical issues.

"The modules will give students an introduction to how other people talk and think about the field," said CCMR director Melissa Hines, who wrote the NSF grant and enlisted about 24 faculty members as co-principal investigators. "Students will still get a firm grounding in their core discipline, while the IGERT program will give them an introduction into nanoscale interfaces as well."

The study of nanoscale interfaces and surfaces naturally draws on many different scientific disciplines. Industry and research are icreasingly concerned with the field, because of its relationship to the fundamental behavior of many materials.

The first six CCMR IGERT fellows are at Cornell now, with six more per year expected for a total of 30. To supplement their education in core subject areas, they will participate in interdisciplinary research projects under two faculty members from different fields.

The IGERT grant supports the university's goal of increasing diversity on campus, particularly in science and engineering, by funding a staff recruiter who will develop relationships with such colleges as the University of Puerto Rico and Tuskegee University.

Cornell's Nanobiotechnology Center will receive $3.2 million from IGERT to support fellows designing and testing flexible electronics for next-generation biomedical devices—from biologically compliant neural implants to wireless drug delivery.

Called the FlexEBio research grant, the program will focus on: biosensors; the material-biology interface; and flexible implantable electronics for medical monitoring, diagnostics, and therapeutics.

The broad research area of flexible electronics has been developing over the past decade, said Christopher Ober, the F.N. Bard Professor of Materials Engineering and principal investigator. Using methods similar to inkjet printing, it has produced flexible displays and flat-panel lighting, as well as circuitry printed onto flat, plastic substrates.

FlexEBio IGERT fellows will combine these potentially low-cost methods with biomedical applications.

"Over the next decade, I think Cornell has the opportunity to have an enormous impact in the biomedical area of flexible electronics, and this work will spill into other areas as well," said Ober.

The IGERT funding will bring up to 40 fellows to Cornell and program partners SUNY Binghamton and the University of Albany/Wadsworth Center. Each will work on team research projects at one of these core institutions. Existing partnerships will allow students at Lincoln University, Howard University, and Clark Atlanta University to participate in the Cornell-based team research efforts, called Team Focus Projects. Some students will also work overseas at such partner institutions as Seoul National University in Korea and Cambridge University in the United Kingdom.

IGERT fellows will take courses in areas where materials science, biology, and other disciplines converge, and students from other institutions will participate in the courses through such distance-learning technologies as video conferencing.

—Anne Ju, Cornell Chronicle

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NASA

Nicole Monahan '11 experiences microgravity while M.Eng. student Qing Liu '07 ME commands the robotic arm to move to get data on its power performance.

weightless wonder

Cornell students test new robotic arm in NASA's "Vomit Comet"

As NASA's "weightless wonder," a modified McDonnell Douglas C-9, approaches the top of its arc, there's a slight rumble before the engines grow quiet. Then, as the fliers begin their descent into zero gravity, their bodies rise into the air, and time seems to slow down.

By Kenny Berkowitz

"You get a tingling in your stomach, like you're about to slide down a roller coaster," says Master's of Engineering student Tim Ulm '07 ME, back in Ithaca after flying 32 parabolas in NASA's Reduced Gravity Student Flight Opportunities Program. "Then in an instant, once your body starts to lift off the floor, there's an initial rush, and everything changes. The tingling fades, all sensation fades, and once your body recognizes that you're floating, you feel completely free. Once you realize you're not going to spontaneously combust, all the anxiety drifts away, and you want to embrace that feeling, play with it. But everything comes at you so quickly, until you suddenly remember you're supposed to be focusing on the experiment. So you pull yourself back, ignore how it feels, and remind yourself to press the right buttons on the laptop."

It's the beginning of Study Week, and with the sound of machines whirring all around their basement laboratory, the members of Cornell's Microgravity Research Team huddle around a pair of tables. The four fliers—Ulm, Mark Amato '07 ECE, and Qing Liu '07 ME, all Master of Engineering students, and Nicole Monahan '10—and their eight teammates have just come back from Houston, where they successfully tested their gyroscope-driven robotic arm in zero gravity, and though they all need to catch up before finals, the mood around the table is spirited and the conversation is about riding the "Vomit Comet."

"At first, I was very worried that I would, well, do what the name of the plane suggests," says Liu, who is co-leading the 2007–08 team with Monahan. "For the first two zero-gravity parabolas, I felt really nauseous, like I was going to be sick. You really do feel disoriented in zero gravity, because there's no real sense of up or down. But then, on the third parabola, I remembered this book I'd read about some kids in space. They get over their nausea by thinking of their feet as being down, no matter what their orientation. So that's what I did, and I was completely fine for the rest of the flight. And it became this very stimulating, perspective-altering experience that I couldn't have gotten any other way."

Now in its third year, the student-run project began with a plan to design a space telescope that would use gyroscopes to power its movements. From there, the project shifted direction, trying instead to design a prosthetic human arm to be used here on Earth; but after a disappointing first year, the second team decided to begin its work from scratch, changing direction again to concentrate on building a robotic arm that could operate effectively in space.

The three projects all share a common center in mechanical engineering, which most of the teammates are currently studying. For years, aerospace engineers have used control-moment gyroscopes (CMG) to orient their spacecraft, and in theory, a motor driven by scissored pairs of CMGs could be used just as easily on a smaller scale, providing a low-energy, high-efficiency control mechanism for a robotic arm to move objects from one place to another.

As part of their outreach work, the team has been traveling to elementary schools around the county, where they explain the project with the help of a rotating bicycle wheel, a Sit 'n Spin, and a little Newtonian physics. One at a time, the children stand on the Sit 'n Spin while tilting the bike wheel from side to side. When the wheel spins clockwise, the Sit 'n Spin turns counter-clockwise; when the wheel is tilted to rotate counter-clockwise, the Sit 'n Spin responds by turning clockwise.

"Zero gravity was fine, but being in 2G was pretty tough. On Earth, I weigh about 175. . . but when we hit 2Gs, I weighed about 350 pounds. "

NASA

M.Eng. students Tim Ulm '07 ME and Mark Amato '07 ECE get used to weightlessness in preparation for their experiment.

Though the movements seem counter-intuitive, they serve as a quick demonstration of the conservation of angular momentum. At its simplest level, the wheel represents a gyroscope spinning freely on its axis. When it's connected to the Sit 'n Spin, the two behave as a pair of counter-rotating discs, transferring angular momentum from one to the other. Like the wheel-and-turntable combination, the team's robotic arm requires very little power to move even relatively heavy objects; in the frictionless environment of space, the robotic arm's hauling potential is even greater. Cornell's arm is motored by three pairs of CMGs, one at each joint, that generate a constant, easily controlled gyroscopic torque; because the pairs are scissored, the angular momentum of the tilting CMGs always points along the joint's axis of rotation, changing the joint's spin speed as they tilt but requiring virtually no input power to maintain that motion.

According to team calculations, a gyroscope-powered arm could be as much as 90 percent more efficient than the more familiar flywheel-driven arms that could be used onboard the international space station. If the team's numbers are accurate, there would be more than enough reason to begin manufacturing the arms commercially, and in the short term, say a decade from now, they might be used to assemble a spacecraft from component parts or perform repairs on a broken satellite. In the long term, still decades away, the technology might be adapted to power environmentally friendly factories on our own planet, using a fraction of the energy used by contemporary manufacturing.

NASA

(left) Amato, Monahan, Liu, and Michael Stocke ’07 explain their experiment to NASA officials to verify they have followed safety procedures, have working equipment, and have prepared appropriate operational guidelines. (center) A NASA medical officer assesses Amato’s flight readiness. (right) Students receive flight training.

That’s what brought Cornell’s MRT to Houston, and the purpose of attending NASA’s Microgravity University was to put that theory to the test in zero gravity, where conditions are dramatically different from anything they could find here on the ground. “Power is in very short supply in space,” says Mason Peck, assistant professor of mechanical and aerospace engineering and faculty adviser to the MRT. “NASA simply can’t launch a space station intact. They have to send it in pieces, and in-orbit construction is a task that could be done by robots, and probably will be. With this technology, you can move extremely fast without using a whole lot of power.

“Imagine a robotic arm with a set of spacecraft components floating nearby,” he continues. “The arm picks up one component, moves it into place, then reaches for the next, and the next. Using gyroscopes to conserve momentum and energy makes a lot of sense, but nobody else has really tried to exploit this technology the way we’re doing. No one would propose driving a robotic arm this way, and I think that’s what really keeps this team going.”

After pursuing a Ph.D. in medieval literature, and even teaching English at Roosevelt University, Peck returned to the University of Texas for a bachelor’s degree in aerospace engineering. He followed it with an engineering Ph.D. from UCLA, seven years as a systems engineer at Hughes Space and Communications, three years as a fellow at Honeywell Defense and Space Systems, and several patents for his work in spacecraft dynamics.

Since arriving at Cornell in 2004, Peck has taught courses in dynamics, control, and systems engineering. He’s been given the Robert and Vann Cowie Teaching Award, and made a name for himself as a visionary behind the “starship on a chip,” a nano-fabricated device so tiny that it could be propelled through the farthest reaches of space by magnetic forces. (It doesn’t hurt that Peck’s father is a science-fiction novelist.)

The bulk of his research revolves around spacecraft dynamics and control-moment gyroscopes, and as a sideline to the work of his research group, Peck spends an hour or two a week with the MRT, working to develop an effectively hands-off approach. “If you give a student team too much autonomy, they’ll just get lost,” says Peck. “If you give them too little autonomy, they’ll never develop the independence they need. The challenge here is to find that sweet spot, because if you give them just enough direction to get them to the next problem, the results are completely theirs. It can be awkward at times, because I can’t really afford to be completely dependable, can I? For better or worse, the members of the team know they can’t rely on me to provide a solution and they can’t just look up the answer on Google. They’ve got to get used to the idea of solving problems on their own, because that’s what these student teams are really about: problem solving.”

For the members of the MRT, which won the 2007 Cornell Engineering Alumni Association’s Student Project Team of the Year Award, the lessons hit home. “From Professor Peck, I learned to always consider alternatives,” says Amato, who survived 31 parabolas before losing his lunch on the Vomit Comet’s last dive. “When we ask him questions, more often than not he tries to point us toward finding our own conclusions. Of course, they’re generally the conclusions he’s already reached, but he expects us to find the answer ourselves. It’s like giving us the keys to the car and letting us drive.”

After applying to NASA, working for two semesters on the arm, fine-tuning their design, and testing all their components in their lab, the 2006–07 MRT flew to Houston, where they joined student teams from 33 other colleges. But as soon as they tried to retest everything on-site—and impressed NASA engineers with their project’s vast potential for injury—their power failed, and they quickly realized their work was far from finished.

Under the leadership of Josh Kennedy, M.Eng. ’07, and Michael Stocke, M.Eng. ’07, the team restored the power supply with a quick shopping trip to the mall, covered up the arm’s exposed gears with Tupperware, and padded its sharp edges with duct tape. Then, after planning all along to control the robotic automatically, they learned the last piece of bad news: In the interest of safety, NASA’s flight crew needed them to provide an in-flight human controller to keep the one-foot-tall, 63-pound arm from colliding with fliers.

“That was definitely a wrench in our overall plan, but they felt we wouldn’t be able to react if someone was flying toward the arm,” says Liu. “So we decided to use a spare

NASA

Monahan experiences weightlessness during parabolic maneuver.

Ulm and Amato operate the experimental robotic arm.

Liu somersaults in zero gravity with the help of a NASA spotter.

MRT TEAM 2006–07

Mark Amato
Diego Asturias
Michele Carpenter
Keith Corrigan
Josh Kennedy
Todd Levin
Qing Liu
Nicole Monahan
Michael Stocke
Tim Ulm

NASA

Ulm operates the experiment while Amato records the motion of the arm on video.

laptop and made some last-minute adjustments to use the computer keys to control the arm. Granted, it was only four keys, but it took some getting used to, because when you're weightless, direction doesn't feel very intuitive."

For the first flight, Amato and Ulm solved the challenge by strapping themselves to the laptop, and then to the floor of the plane. For the second, Liu and Monahan alternated between controlling the robotic arm, videoing the experiment, and turning somersaults in zero gravity, all under the watchful eye of space shuttle astronaut and Cornell alum Don Thomas, M.S. '80 MSE, Ph.D. '82, who'd come along for the ride.

Both flights followed the same plan, with 30 seconds of zero gravity followed closely by 30 seconds of hypergravity, repeated 30 times, with one Martian parabola (one-third of Earth's gravity) and one lunar parabola (one-sixth of Earth's gravity) thrown in for a little change of pace. For Monahan, who describes the experience as "kind of like swimming at the bottom of a pool," the flight was gentler than expected, but for her three teammates, the hardest part came at the bottom of each parabola, as the plane climbed steeply from 0G to 2G.

"Zero gravity was fine, but being in 2G was pretty tough," says Amato, who responded to yet another crisis by reprogramming the arm's data acquisition module in flight. "On Earth, I weigh about 175, and I have a thin frame. But when we hit 2Gs, I weighed about 350 pounds. I thought I'd be able to hold myself up just using my abs and my trapezius. Instead, it was like wearing weights on every part of my body, and it turned out my head was a lot heavier than I thought."

The team had come to Houston with high hopes of outperforming the international space station's Canada Arm 2. Even with the problems in collecting data, and even after all the ad hoc engineering that took place on site, they made their point: The gyroscopic drive used significantly less power than that of a conventional flywheel drive.

"We proved that you could effectively use control-moment gyroscopes to actuate a robotic arm in a zero-gravity environment," says Ulm. "Being able to put together a project like this in less than a year is a testament to the power of the ideas behind it. We may have missed some of the data, but just proving the functionality of the ideas is groundbreaking for a project team like ours."

With the fall semester underway, a new team has formed around Liu and Monahan, with plans to either refine the existing design or begin all over again. Instead of three pairs of gyroscopes, the 2008 model will use four or five, and instead of using the laptop, it will be driven by a haptic controller attached to the arm of one of the fliers. The next prototype promises to be considerably lighter and more agile than the first, and if this year's team is invited to return to Houston, they expect to be even more successful.

"It was an awesome experience," says Monahan, who hopes to someday become an astronaut. "We built it, we actually got to test it in zero gravity, and we came back with usable data. We weren't always sure it was going to work, but in the end, it really did. Plus, the fact that we could actually do it as students is really cool."

"Looking back, my memories are of floating around in zero gravity," adds Amato. "The whole thing went by so fast, but that's really what stays with you: the feeling."

By Michael Gillis

University Photo

Making It Real

Keeping today's students on the path to a better world

The path to a career in engineering used to begin in the backyard or the garage.

"Most of my friends bought some old, beat-up car and rebuilt it many times and made it work," recalls Shefford Baker, associate professor of materials science and engineering at Cornell University's College of Engineering. "That wasn't very sophisticated engineering, but it was hands-on, applied engineering."

Students pursuing an engineering degree today are more likely to have reached the top level in a video game than souped up a Chevy. Upon arrival at Cornell they are thrown head-first into a demanding and intense education. Their days are filled with technical coursework and methodology that has been short on practical application in the first few years. Without experiences like tinkering with cars, radios, or ailing home appliances, many fail to see the relevance.

Cornell Engineering is changing that by helping students see how math, science, programming, and communication all fit together in a career that can help solve the world's problems. Changes to the college's curriculum are already under way. The reason is simple: Students need to understand how their steady diet of technical course work applies to the real world.

"Helping beginning students to understand the tools, scope, and impact of engineering is important because modern students have spent a lot less time engaged in activities that one would traditionally think of as engineering before they get to college," Baker says.

The opportunity for curriculum improvements was identified by the college's Committee on Curriculum Transformation in 2005. That panel issued a report detailing which components of the curriculum needed attention and the importance of providing the necessary breadth of engineering's core concepts while maintaining a balance with technical instruction.

Their report was handed off the following year to the Curriculum Task Force, assembled by W. Kent Fuchs, the Joseph Silbert Dean of Engineering, with instructions to suggest changes to the common curriculum.

The task force searched for a formula to better align engineering with math, chemistry, physics, and computing. Easier said than done, since what has been done so far seems to be working well for faculty and students.

First-year blues

One of the key points identified by the Curriculum Task Force is the difficulty first-year engineering students face in absorbing so much technical information without tangible, real-world context.

"Traditional engineering curricula consist primarily of isolated technical courses created for the purpose of imparting detailed skills, and they provide little opportunity to understand the breadth and depth of engineering careers," reads the panel's November 2006 report. "Because students don't have a clear idea what engineering disciplines are like, they are ill equipped to select a major—or even to decide whether engineering is right for them.

That challenge, compounded by a heavy load of technical classes, can be daunting.

In fact, it's during the first year that the college sees its highest rate of attrition among engineering students, says Lisa Schneider, director of the college's Engineering Learning Initiatives. And although Cornell fares better than many other schools, Schneider adds that the first year, and even first two years, can prove intimidating and inflexible.

"You don't want to turn students off," she says.

That problem is even more pronounced for female students, she adds.

"If they don't see the relevancy, even if they're getting A's, they'll leave and go to a different college, a different major," she says. "You've got some bright students here, so you want to make sure you're engaging them so they can see the path."

In addition, students feel pressured to decide quickly. "We want students to be free to choose any engineering major to the end of the second semester," Baker says, but added that maintaining flexibility in the curriculum is a challenge.

Chemical engineering, for example, calls for commitment by the second semester. "You start closing doors fairly quickly," Baker says.

Completing all the required courses in time to choose a major doesn't leave much room to explore other classes. "You can take one elective freshman year," says John Harris '12, "but it's hard."

The college recognizes the demand for more flexibility, and educators are working to build in more options.

"Many students want to take courses in management, leadership, finance, and related areas," says David Gries, associate dean for undergraduate programs at the College of Engineering. "Few Cornell engineering students these days go into the job market and spend the rest of their life simply doing technical engineering. They may start new companies or run large corporations. Typically they become leaders in their professional and personal lives, so it is important for students to have the flexibility they need to take these courses.

"The difficulty, of course, is in providing that flexibility," says Gries "while also providing the depth that they need."

But while faculty and educators explore more flexibility in the curriculum, some positive change is already in motion.

Who needs math?

Engineering students, that's who. The problem is, by the time students are in the thick of their undergraduate years, many have forgotten the math they learned in the first few years.

"It's a very common refrain among engineering professors that students often seem to have forgotten all the math they ever learned," Baker says.

The importance of math was not lost on the Curriculum Task Force.

According to the report, research indicates there are significant benefits when "math skills are applied immediately and constantly in science and engineering courses ... in terms of comprehension, retention, and fluency in problem solving."

That research led the committee to offer up one of it first recommendations to better integrate math and engineering in the first year.

Working with the math department, the faculty implemented an important change in Math 191, the first engineering calculus class.

"We replaced one of the two recitations in Math 191 with a collaborative-learning session," Gries explains. "Students work in groups to solve engineering problems, using the mathematical concepts being learned in the course. The problems are developed by engineering faculty. This replacement has two goals: One, get students working with each other; and, two, provide motivation for the mathematical concepts being learned."

That kind of interaction is invaluable, Schneider says.

"Ideally, they'll learn the math better because they're engaging in something they're interested in," she says. "They came here to study engineering. They can see right off the bat that what they're learning in math is applicable to engineering."

Baker adds that the math department's support of the effort, which included assistance with the integration, helped move the process along.

"The math department really got on board with that very early," he says.

Classes in Math 191 now consist of two or three instructor-led sessions and two steered by TAs. They incorporate collaborative workshops in which students apply calculus to real engineering problems.

"It's not just math. They do relate to other subjects, like physics," says Lyssa Lincoln '12. "So I can see the benefit of that."

Based on the success of changes to Math 191, Gries says the college is planning to extend the concept to Math 192.

Do you compute?

Another task force recommendation in the mix is a boost in the number of computing credits required, up from four to five.

"Computing is ubiquitous these days, and it is important for engineers to have knowledge of more than one language and programming environment," Gries says. "The previous one-course, 4-credit requirement tried to do this, but there wasn't enough time in that course."

Now students must take a 4-credit course in programming fundamentals in either MATLAB or Java, as well as a 1-credit course in the other language.

"It's a good idea, because they used to combine Java and MATLAB in one semester" says Laura Hyde '12. "I don't have any computer background, so this way I get to do one and then do the other."

> "Many students want to take courses in management, leadership, finance, and related areas."

The task force's 2006 report spells out how significant computing skills are today to the contemporary student.

"Students should be able to write computer programs to solve engineering problems as a matter of course, as routinely as they use a computer to write papers or access the Internet," the report reads. "Further, students need experience in the use of different programming languages and environments. At the moment, these objectives are not reached for all engineering students."

A working knowledge of programming is an asset for engineers, Baker says.

"Just as you need math, you need to understand how computer programs are written and work," he says, adding that once a student is fluent in one programming language, that skill can be applied more effectively to solving engineering problems in other programming languages.

The right chemistry

The third change to the curriculum is the elimination of Chemistry 211, Chemistry for the Applied Sciences, a decision made in conjunction with the chemistry department.

"(Chemistry 211) was more of a terminal, survey course, for students who would be taking only one course in chemistry," Gries says. "It was felt that it was better to teach the students fewer topics but go more in-depth in them. So, the students now take Chem 209, which has the same content as Chem 207. When this change was made, the chemistry department suggested having a separate course for engineers, Chem 209, and using 207 only for non-engineers. The engineering version, Chem 209, can rely more on mathematics because all incoming engineering students have had the equivalent of high school calculus."

"The exams are much better because it's much more math-based," says Arianne Babina '12. "We don't have to write up lab reports like the other class. Ours are more based on our calculations and results."

Baker says the change allows students to dig a little deeper, as opposed to outlining the basics.

"If you're skimming over the tops of the trees, you don't really get much of an appreciation of the details and structure," Baker says.

Change is in the air

As the curriculum evolves, faculty and educators recognize they need to complement those changes by evaluating other components of the undergraduate experience.

That experience, they know, will play an important role in the careers graduates choose after leaving Cornell.

"Employers are looking at student GPAs, and they really want the top students, but also, for the most part, they know that a student who has successfully gone through the curriculum at Cornell is going to be a pretty good student," Schneider says. "So they're looking at what other things (students) are bringing to the table. Do they have good communication skills, teamwork skills; (are they) a good person to have on the team?"

The engineers of the 21st century do need to be more aware of the world around them, as well as possess skills that may not have been emphasized in the past.

One report, *The Engineer of 2020: Visions of Engineering in the New Century,* published in 2004 by the National Academy of Engineering, details how engineering is evolving.

"Given the uncertain and changing character of the world in which 2020 engineers will work, engineers will need something that cannot be described in a single word," the report states. "It involves dynamism, agility, resilience, and flexibility. Not only will technology change quickly, the social-political-economic world in which engineers work will change continuously. In this context it will not be this or that particular knowledge that engineers will need but rather the ability to learn new things quickly and the ability to apply knowledge to new problems and new contexts."

University Photo

Among suggestions from the task force to enhance the undergraduate experience and better equip students to compete globally is providing more opportunities to study off campus.

"We will be encouraging our undergrads to spend time abroad—spending a semester at a university, doing an internship, or doing it through co-op," Gries says. "In engineering, and indeed many other fields, the work is done on a global scale, and having an experience abroad, experiencing firsthand another culture, can change one's perspective tremendously. We are steadily developing relationships with universities in other countries, and it is now easy for students, depending on their major, to study in India, Mexico, Germany, Hong Kong, and Singapore. We have two programs with Ecole Centrale Paris."

Heather Hunter '09 CE attended a civil engineering summer camp at the Indian Institute of Technology in Kanpur this year. "This was an incredible trip, I did things I never expected, like morning exercises every day with a general from the army, meeting the president of India, and singing a song in Telugu on stage," she says. "I learned a ton not just about civil engineering, but about India, its history, languages, politics, music, and movies. I also learned a lot about myself."

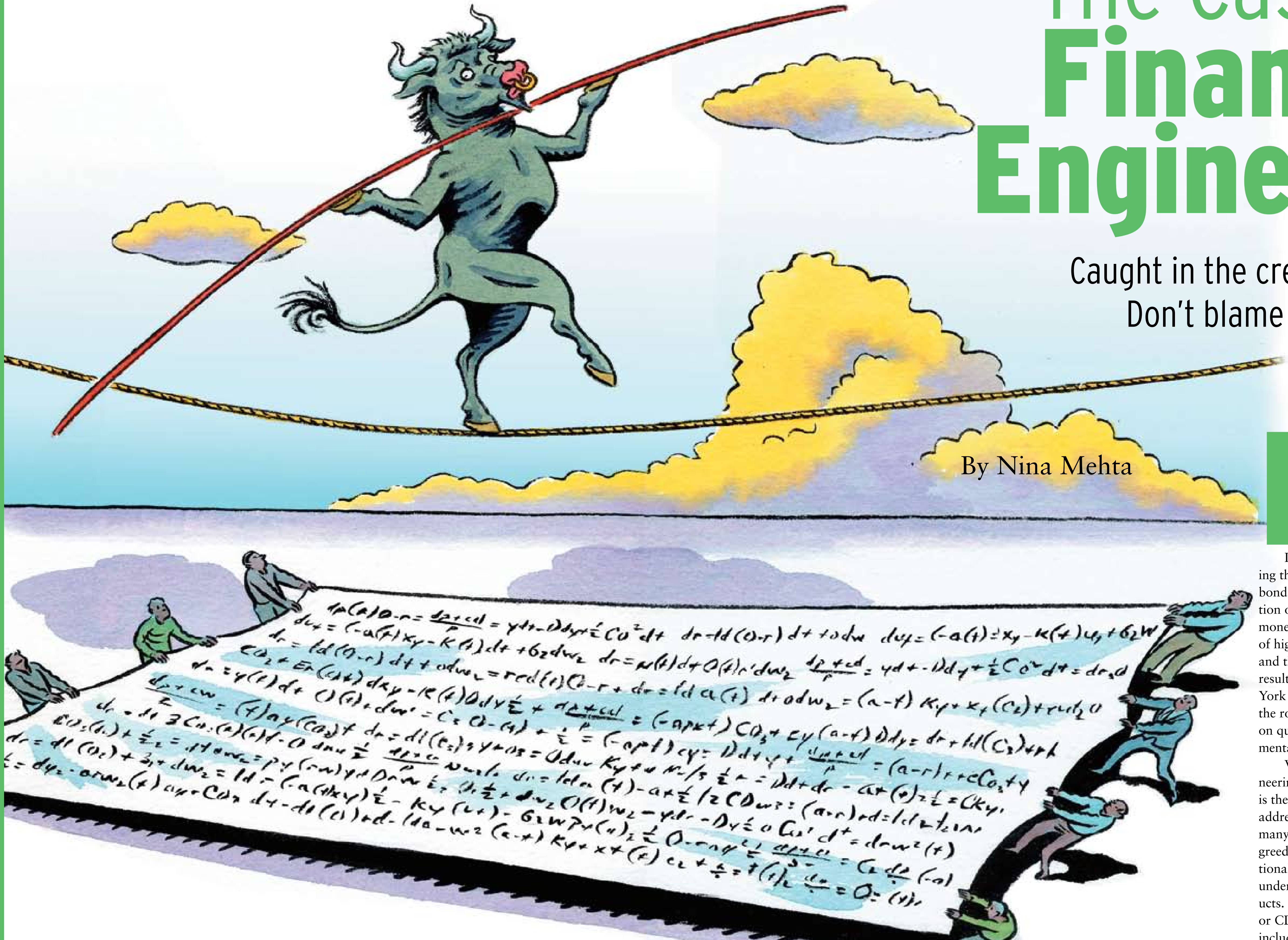
But, like other changes to the curriculum, providing more experiences like Heather's will need some fine tuning over time. As Baker points out, coordinating a student's course load with education abroad can be complicated.

"We would love to have students study abroad, but we have a very demanding curriculum, and at pretty high levels," he says, adding that sending a student abroad can encroach on some of the critical class time on campus.

Nonetheless, Baker says Cornell students still have an upper hand.

"There are some things the real world cares about that Cornell is good at and I think is better at now," Baker says. "Cornell students are able to work anywhere in the world."

Illustration by David Gothard



The Case for Financial Engineering

Caught in the credit crunch? Don't blame quants.

By Nina Mehta

Every so often, the markets stumble badly and the blame game starts.

In 1987, portfolio insurance was fingered for the massive selloff on October 19—now known as Black Monday—that resulted in a 23 percent plunge in the Dow Jones Industrial Average.

In August 1998, Russia defaulted on its bonds, throwing the traditional pricing relationships between government bonds from various countries out of whack. The combination of bad assumptions and leverage—using borrowed money to jack up profit opportunities—led to the implosion of high-profile hedge fund Long-Term Capital Management and the threat of a wider collapse of financial markets. That resulted in a $3.5-billion bailout orchestrated by the New York Federal Reserve Bank. The common scapegoat, after the routs of both 1987 and 1998, was overconfident reliance on quantitative, computer-driven models—one of the fundamental applications of financial engineering.

With the recent subprime mortgage crisis, financial engineering is once again taking some heat. Financial engineering is the use of mathematical and engineering methodologies to address financial problems. In the current search for culprits, many experts and the media have pointed not only to a greedy mortgage industry, but also to the failure by institutional investors and credit-rating organizations to properly understand the risks buried in complex credit-related products. Chief among these are collateralized debt obligations or CDOs—pools of securities often backed by mortgages, including more risky subprime loans, which are sliced into products based on their riskiness and sold to investors. Given the complexity of these products, some industry watchers see the subprime meltdown as a sign of financial innovation gone awry—making it nearly impossible for individuals and companies to appropriately analyze their risks. In their view, the spreading subprime disaster is the stepchild of complex financial products and misperceived risks.

So should financial engineering take the rap? No, says Victoria Averbukh M.S./Ph.D. '97 OR a former Deutsche Bank strategist in mortgage-backed securities who now directs the School of Operations Research and Information Engineering's Financial Engineering program in Manhattan. "Events of the summer may suggest that more diligent understanding of securities pricing and risks is needed, but even that's debatable," she observes. In her view, what's needed is greater vigilance about the risks that are bought in a financial world that has grown increasingly complex.

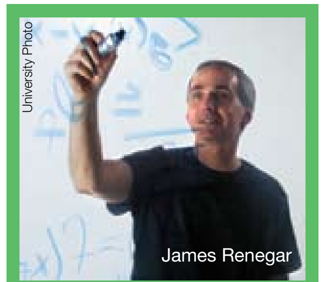
What's not debatable is that financial engineering has unleashed tremendous innovation over the last few decades. This innovation encompasses the evolution of financial derivatives—contracts whose values are based on an underlying instrument like a stock or bond—into new products that enable companies and institutions to hedge risks that once made their future less certain, to complex securitizations such as CDOs. Many say that the tools of financial engineering, like any other set of tools, require an eyes-wide-open approach. "Anecdotal evidence suggests that a lot of the big subprime CDO holders did not have adequate credit models or chose to rely on third-party models without a complete understanding of the risks in those products," Averbukh says. "Wall Street will always want better profit margins, but the industry needs to tap more deeply into financial engineering in response to growing complexities."

Robert Jarrow, a professor of finance and economics in the Johnson School of Management who started Cornell's official financial engineering program in 1995 with mathematician David Heath (they launched an informal program in the early 1990s), agrees that financial products and the models undergirding them aren't to blame. Ditto financial engineering.

"They're very complex instruments," Jarrow says about subprime mortgages and the CDOs issued against them. "Better and more thoughtful modeling would have alleviated—and perhaps even made impossible to happen—the subprime crisis." In his view, the meltdown shows the need for better knowledge and people in financial engineering, not a paring back of their presence. He views the subprime crisis "as a cry, a manifestation of the need for better modeling." Not enough good quantitative modeling was done in advance of the crisis, he says.

Evolving Discipline

At Cornell, and at other schools with financial engineering or quantitative finance programs, the subprime crisis comes at an interesting moment. Unlike in 1998, financial engineering is now a full-fledged discipline. In 1998, Cornell's financial engineering concentration—a joint program between ORIE and the Johnson School—was entering its fourth year. Carnegie Mellon, another early bird in this area, had launched its program in 1993, the same year MIT launched a financial engineering track for its MBA degree. Now there are dozens of financial engineering graduate programs globally.



University Photo

James Renegar

. . . it's now apparent that even to sell many products, financial firms "need individuals with a thorough understanding of the underlying mathematics." —*James Renegar*

In the years since the first of these programs got rolling, financial engineering has changed. Jarrow notes that in the early 1990s it was unclear how financial engineering would develop. Indeed, it wasn't quite a field in those years, but an offshoot of operations research and applied mathematics geared toward solving problems in finance. Jack Muckstadt, director of ORIE in the early 1990s, recalls that back then the need was simply to develop a mathematically and practically oriented program for master's students to meet Wall Street's demand for quantitative talent. It was the "proper moment to start a program," he says, and Cornell became the first school to launch a financial engineering program in an engineering college.

But the path financial engineering would follow wasn't set. And not everyone was convinced the field would even last, despite the interest of students and ongoing demand by the financial industry for physicists, mathematicians, and quantitative analysts who could build models. "We thought it might be a temporary fad that would die out, that Wall Street wouldn't be able to absorb nearly as many quants as it has," says ORIE Director James Renegar. That uncertainty proved misplaced. Renegar notes that Wall Street's need for quants has only accelerated, and that it's now apparent that even to sell many products, financial firms "need individuals with a thorough understanding of the underlying mathematics."

For Renegar, the changing needs of financial engineering also altered the emerging discipline. Early financial engineers tended to be mathematicians—"probabilists who got interested in the field as an application of the theories they really loved," Renegar says. No longer. Over the last 10 years, he notes, Cornell's new faculty members have become financial engineers first, rather than mathematicians. "They switched from being specialists in probability theory, applying their theories to financial instruments, to being financial engineers who are open to using any mathematics whatsoever," Renegar says.

According to Jarrow, as the financial industry's dependence on financial engineering increased, the discipline became more quantitative in orientation. "The skills and sets of knowledge students need have grown and specialized, partly because people in the industry know what they need now," he says. "The field has evolved to the point where it's really applied math." Jarrow adds that when the Cornell program launched, only a couple of academic journals were devoted to mathematical finance. Now, there are at least a dozen. In his view, that's another indication of how quickly financial engineering knowledge has grown.

Ian Domowitz, a managing director at brokerage and technology firm Investment Technology Group and a former academic, agrees that the "character" of financial engineering has shifted away from pure mathematics over the last decade. "Instead of companies retooling Ph.D.s in higher mathematics to Wall Street applications, which is what occurred a decade ago, schools now teach them how to apply mathematical concepts creatively in the marketplace," he says. In his view, this is a necessity. "Financial engineering graduates and the programs that produce them need to demonstrate value to the market," Domowitz adds. "Their target market is becoming broader, which means that the educational needs are also becoming broader."

Shifting Priorities

In this new environment, ORIE has bolstered its financial engineering program to reflect changing industry priorities. ORIE in Ithaca now has four financial engineering professors: Philip Protter, Xin Guo, Stefan Weber, and Alexander Schied. Faculty from other disciplines such as mathematics or the Johnson School teach courses for financial engineering students. Jarrow, for instance, teaches an annual master's-level course on the pricing of interest-rate derivatives, which are contracts based on underlying Treasury or government bonds. Financial engineering at Cornell also includes Ph.D. and post-doctoral students, many of whom straddle departments, focusing on mathematical finance or financial engineering.

Victoria Averbukh

Provided

As the field has become more quantitative, so has the master's program, which now includes 40 to 45 students. ORIE expanded it to three semesters, included a summer internship, and made the course scheduling more rigorous. Renegar credits some of the new professors, such as Stefan Weber, for pushing for this expansion as well as the requirement that students take courses in sophisticated mathematics.

In addition to these changes, ORIE has redoubled efforts to provide students with practical financial tools and experience. To facilitate greater interaction among Cornell's students, faculty members, and Wall Street professionals, ORIE acquired offices previously used by the Cornell Theory Center, just down the block from the New York Stock Exchange, in 2004, and are turning it into what Muckstadt calls "an outpost for financial engineering."

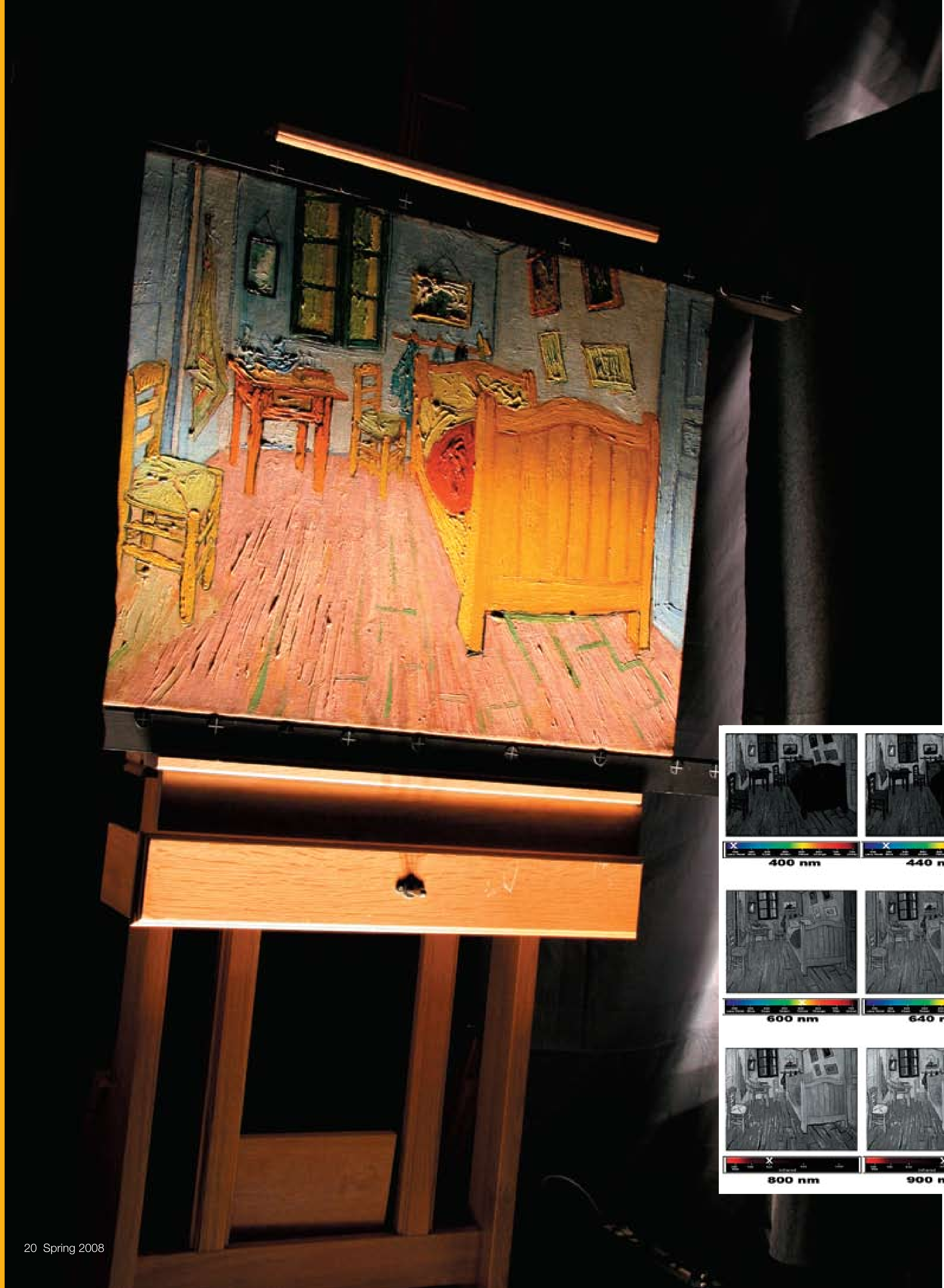
To further strengthen ties with Wall Street, ORIE recently turned to Averbukh to run the New York financial engineering facility. After 10 years at Salomon Brothers and Deutsche Bank, Averbukh plans to build up FE-Manhattan's financial engineering center as a "liaison between Wall Street and ORIE."

From Averbukh's perspective, this is a good time to expand Cornell's financial engineering presence on Wall Street. She notes that the subprime crisis has only clarified the need for financial engineers in the industry. FE-Manhattan is taking a two-pronged approach to fueling closer interaction with the financial industry. Starting in the fall of 2008, financial engineering students in the ORIE masters program can spend their third semester in New York. The important team project students did with financial institutions in their second semester will be moved to the final semester in New York, so their ties with the firms sponsoring those projects can intensify. "You can have someone who can build a term-structure model and not know what to do with it," adds Averbukh. "That's not what we want."

Weber stresses that students will get a more hands-on, practical education in their final semester in New York. In his view, the focus will be on theory in Ithaca and practical insights and skills in Manhattan. To aid that, there will be more seminars and talks by Cornell alumni and practitioners in financial engineering in the final semester.

Iva Vukina '04 ORE, an associate in the global rates group at Wachovia Bank in New York, expects the additional industry experience to be valuable. She says the theoretical background at ORIE provided a foundation for understanding pricing models, but that the team project she did offered a preview of the work environment. "Working in a group and having a deliverable and a due date, and learning to find the most reasonable solution to a problem—instead of the single right answer, which is typical of a classroom setting—was very important," she notes.

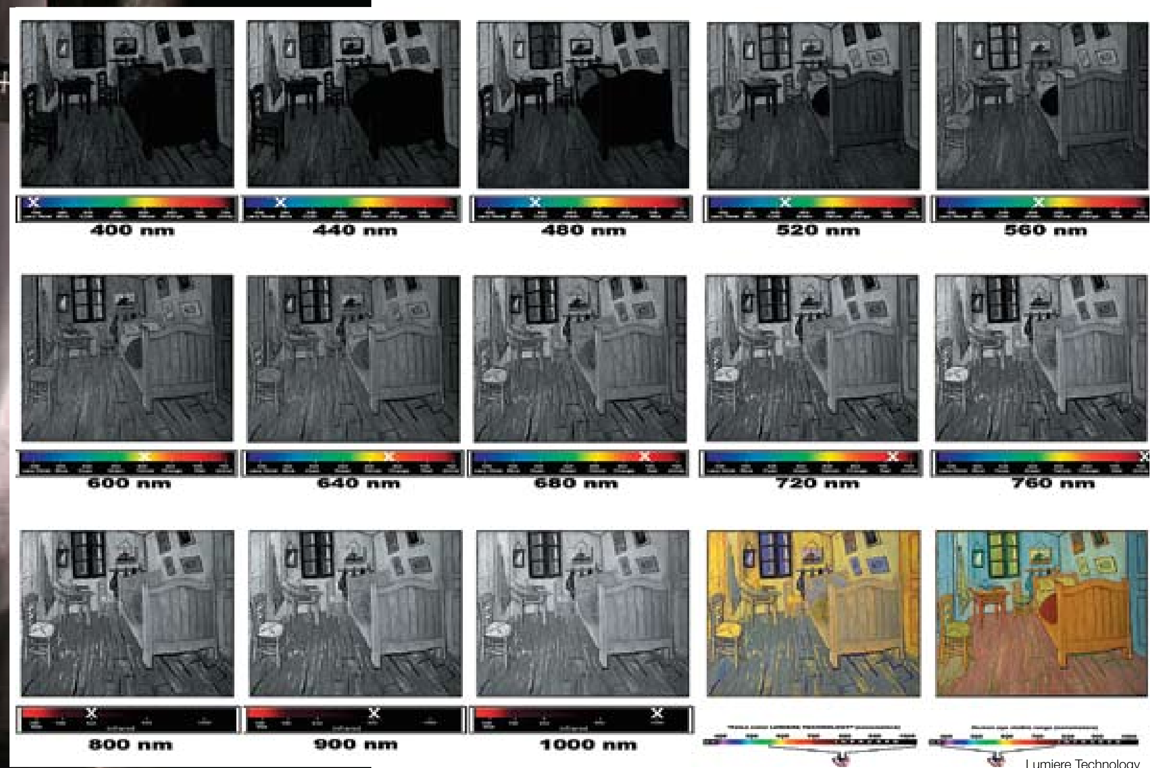
The other focus of the FE-Manhattan center is to strengthen the school's ties with Wall Street through seminars, lectures, and executive learning courses. These will take place every spring semester, starting in 2009. Averbukh, who has put together an advisory board to help sketch out plans for the future, adds that FE-Manhattan plans to add several post-doc or faculty members in the New York office during the coming year. As FE-Manhattan's ambitious plans gradually take shape, the goal is for banks and Wall Street investment firms to gain access to the range of the Cornell faculty's deep knowledge. Averbukh adds that FE-Manhattan will also facilitate research projects for Ph.D. students, post-docs, and faculty members that can be integrated with broader research initiatives planned with industry.



Bridging Worlds

ECE Prof. Rick Johnson has signal processors and art historians talking about painting authentication

By Robert Emro



Lumiere Technology of Paris used its multi-spectral digital camera to capture images of van Gogh's *The Bedroom* from ultra-violet to infrared.

Growing up in northwestern Georgia, C. Richard Johnson Jr. never visited an art museum, heard a classical music concert, or attended serious theater. A second grader when the Soviets launched Sputnik I and the ensuing space race, Johnson was channeled into engineering when he exhibited an early aptitude for math and science. Not until he was a student at Georgia Tech did he get his first taste of fine art.

He was in Germany with a study-abroad program. His travels took him to the Gemäldegalerie (Picture Gallery) in Berlin. This collection of old masters was split by the wall when Johnson visited in the early 1970s. Even so, the West German side still held an impressive collection, including *The Man With the Golden Helmet*, one of Rembrandt's most famous paintings. Seeing it for the first time was a revelation. "I spent several hours in the Rembrandt rooms," says Johnson. "I didn't know why. I just had some kind of response to it."

From a working-class family, Johnson didn't even entertain the idea that he could somehow make a career of art. "It never even crossed my mind at that point," he says. "That just wasn't done where I come from."

But he couldn't stay away. As an electrical engineering grad student at Stanford, Johnson took a course on Rembrandt knowing that if he bombed, the F would not appear in his record. Far from flunking, he was one of the star pupils. During one test, he was the only person to realize that a slide of a Frans Hals painting had been loaded backwards. He could tell because Hals always painted the light falling from the left. One class led to another and by the time Johnson graduated in 1977 he had pioneered Stanford's first Ph.D. minor in art history. The topic of his final report, appropriately enough, was Vermeer's use of the camera obscura. Careful measurement of the angles in his paintings and reconstructions of the rooms he painted them in have led some to argue that Vermeer used this rudimentary optical device in creating his almost photographic paintings.

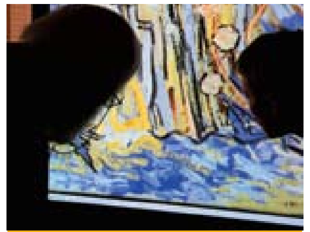
"It was a survival technique to get myself through engineering, to some extent," says Johnson. "Art history is something I found a passion for that I see in my students for technical things that I sometimes don't have."

Johnson received an appointment as an assistant professor at Virginia Tech, but he was still drawn to art history and after a couple of years he put together a book proposal on Rembrandt's self-portraits. He knew he was at a major fork in the road of his life, and he was willing to take a different path, but it turned out Kenneth Clark had just written an about-to-be published chapter on the same topic. His proposed collaborator's publisher rejected the proposal.

So Johnson took a position at Cornell instead, joining the faculty as an associate professor in 1981. He continued a successful academic engineering career in the School of Electrical and Computer Engineering, periodically reinventing himself. First he worked on the theory behind adaptive feedback systems, used to kill the echo you can sometimes hear while talking on the telephone, then he created and analyzed blind equalization algorithms, used in receiving hi-def TV. But he never lost his love of art history, so in 2005, when he was ready to change his research focus once again, he began wondering how his expertise in signal processing could get him a backstage museum pass.

"When I decided to change, I looked for an area where I would have some special talents," he says. "I asked myself, 'How can I leverage something I know into getting behind the scenes?'"

Johnson knew that art historians and curators used a variety of technologies to study paintings, including X-radiography, infra-red photography, and UV fluorescence. While on a Fulbright in Paris, Johnson arranged a lunch meeting with Louis van Tilborgh, a curator at the Van Gogh Museum in Amsterdam. He offered his services as a translator helping the art history experts at the museum communicate with the technical types doing the image processing. Tilborgh was intrigued and asked Johnson to make a more formal presentation to museum management.



Lumiere Technology

"Whether the data comes from a CAT scan or a satellite or a painting, it becomes an array of numbers to which the kit of signal processing tools can be applied."

While preparing, Johnson discovered that these tools helped de-attribute the very painting that awakened his passion for art in the first place. In 1985, the Rembrandt Research Project determined *The Man with the Golden Helmet* was not painted by Rembrandt but by an unnamed apprentice.

The museum liked the idea of having an expert in signal processing to help connect them with the computer-based technology used in painting authentication and gave Johnson a five-year appointment as an adjunct research fellow. "I'm a Ph.D. student again, working for the head of conservation at the Van Gogh Museum, doing with her what she does and finding out what we can give to a computer to do—which is mostly signal processing," he says. "Whether the data comes from a CAT scan or a satellite or a painting, it becomes an array of numbers to which the kit of signal processing tools can be applied."

"It's quite a luxury for me to have a student that's so efficient and hardly needs any supervision. He's so enthusiastic," says Ella Hendriks, Johnson's new adviser. "He's willing to spend time for things that are hugely useful."

While some in the art world balk at the idea that a computer can perform the duties of a human art expert, the Van Gogh Museum has embraced this new technology. "It's not replacing the judgment of the art historian, it's simply an added tool that will assist the art historian in making his judgment," says Hendriks. "It's very important to make a good tool and the best way to do that is to collaborate with the tool maker. If you're involved at the beginning you're going to get the best tool."

One thing Johnson has done in his new role is connect the museum with a company in Paris—Lumiere Technology—that has designed a multi-spectral camera for digitizing works of art. The company used it to reveal the true colors of the *Mona Lisa* in 2004. He helped convince Lumiere and the Van Gogh Museum to take images of *The Bedroom* and *The Potato Eaters* in October. If all goes well, the company will do the rest of the museum's collection, amassing a huge database for engineers and art historians to work with. "It's just been a dream to me because all the doors seemed to open up for the asking," says Johnson.

In a year or so, Johnson envisions teaching a new course at Cornell examining how others have approached using signal processing to authenticate art so students can infer a general approach to the problem. He hopes his interaction with the museum will eventually result in a textbook that combines art history with technical material. "I'm not an engineering professor just because I want to tinker with cool things," he says. "I'm an academic because I want to teach cool things."

Lumiere Technology

ECE Prof. Rick Johnson and Van Gogh Museum Head of Conservation Ella Hendriks observe a false color infrared digital image of Van Gogh's *Tree Trunks in the Grass* captured by Lumiere Technology's multi-spectral camera.

But first Johnson wants to bring together the scattered groups working at this intersection of engineering and fine art. "This is a field that doesn't really exist yet," he says. "There are some people out there doing things, but not as a cohesive field."

Dan Rockmore, a professor of math and computer science at Dartmouth, has been working with the Metropolitan Museum of Art in New York to authenticate Rembrandts. Professors Jia Lee and James Wang at Penn State have identified the creators of Chinese ink paintings from the 15th to 20th centuries. And researchers led by Eric Postma at the University of Maastricht in the Netherlands have developed a program dubbed "Authentic" that can distinguish between the works of Van Gogh, Cézanne, and Gaugin. Although they all use a variation of a technique called stylometry, first developed to identify literary authors, they had never met as a group to share ideas.

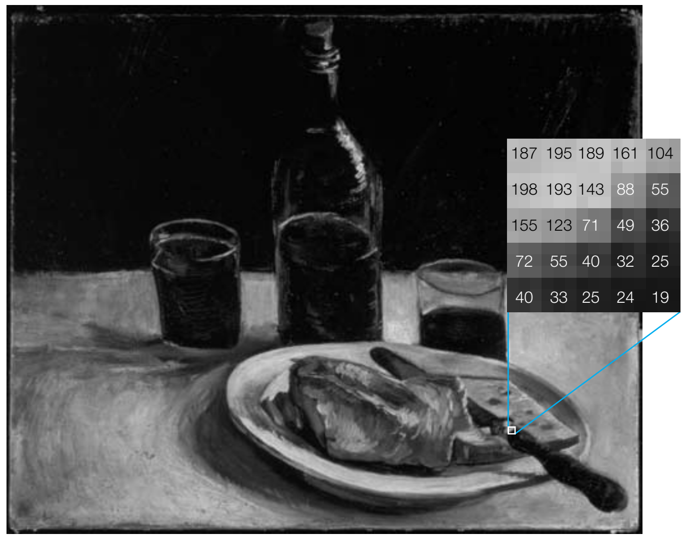
The field is set to flourish. Research on how to best collect and organize data from paintings is mature and recent technological advances have enabled museums to amass huge databases of images. "The time is certainly right in that people have been thinking about images computationally for a long time. It certainly makes sense as a science problem to compare images and see if you can find some commonality," says Rockmore. "The problem's a totally natural one. Whether it has a nice solution is one that everyone is working on. There are a lot of aspects there and you only discover them when you drill down and treat it as a science."

Beyond determining if a painting is really by a master, or just a clever forgery, forensic signal processing can help art historians determine the sequence of an artist's work, or deconstruct a painter's process by identifying which strokes went on first. "There's a lot of things I think [curators] can think of that would be impossible, but there's a lot of things we should be able to do," says Johnson. "Any time the art historian looks at the image for the information they need, we should be able to help."

To get signal processors and art curators together, Johnson organized the First International Workshop on Image Processing for Artist Identification, held at the Van Gogh Museum May 14. Johnson convinced the Van Gogh Museum and the Kröller-Müller Museum in Otterlo, Netherlands, to make digitized images of 101 of their paintings available for analysis. Most are confirmed Van Goghs, but a few are now attributed to others. This irresistible "goldmine" of data got several groups of academic signal processors on board. To get them talking with the attendees from museums across Europe, the daylong program introduced curators to the capabilities of signal processing and engineers to the techniques of connoisseurship, the traditional method of authenticating paintings. Johnson's unique background helped him get the conversation rolling. "He knows both sides of the story, which is needed," says Hendriks. "He knows the words we use to talk about things."

Van Gogh Museum

Once considered a Van Gogh, *Still Life with Bottle of Wine, Two Glasses, and Plate with Bread and Cheese* is now thought to be by an unknown friend of Vincent's brother Theo.



Working with the gray scale values of each pixel in a digital image of the painting, signal processors at the workshop were able to use wavelet processing to corroborate the connoisseur's determination.

Van Gogh Museum

Using high-resolution digital images of x-rays, the automated thread count method under development by Johnson and a team of students reveals a strip (in red) of more tightly woven canvas in a corner of Van Gogh's *Undergrowth.* Such patterns can help art historians better sequence an artist's work or art curators restore paintings that have been cut into pieces.

Six months before the workshop, three teams of computer scientists, mathematicians, electrical engineers, and statisticians from Penn State, Princeton, and Maastricht universities set about to see if mathematical analysis could find similarities in Van Gogh's works not present in the other paintings. They also checked the authentic paintings against a 102nd, a modern copy of a Van Gogh commissioned by WGBH's *Nova Science Now*. The program taped the researchers at the workshop and is scheduled to air on PBS nationally beginning next June.

All three teams were successful to some degree at distinguishing real Van Goghs from the copies. The Princeton team found a higher concentration of high spatial frequency content, corresponding to an increased number of small touches in the copies. This jibes with the commonly noted tendency of copyists to use several small brush strokes to duplicate an image that the original artist may have done in one stroke.

Even more importantly, workshop participants expressed a desire for further interaction. A repeat workshop was held Nov. 9 at the Museum of Modern Art in New York City. Already, art historians and engineers around the world are planning new projects based on the resulting cross-fertilization. "The idea is to amplify this whole thing," says Johnson. "I'm sure there are signal processing research problems in this area that people don't yet know exist, and you can trip over them a bunch of times without noticing them."

A next step to building a cohesive field, says Johnson, is to present problems to beginning engineers so they can start thinking of creative new approaches to solving them, just as in any other field of engineering. So Johnson has been recruiting undergrads and M.Eng. students to work on an automated thread-count project.

Yeounoh Chung got involved because it was a little different from other projects he has worked on. "It seemed like a really interesting project because it has to do with art," says the senior. "As an ECE student, all I've been doing is making something that people don't usually see, but this is more directly related to something people can see and appreciate, so I thought it could be something I could enjoy doing."

Knowing how many threads are in a canvas can reveal a lot to an art historian. Thread counts of the canvases used by Van Gogh and Gauguin during their time together at the Yellow House in Arles, France, in late 1888 helped art historians to construct a timeline for the paintings during this important period. Traditionally, thread counts are estimated using an average of the number of threads hand-counted in five different 2-square-centimeter sections. It's a tedious, time-consuming process and museums would much rather allocate staff time to other work. A computer could do it a lot faster, says Johnson, and by looking at more samples, more thoroughly. Unlike typical hand counts, a computer count is readily repeatable because it can keep an exact record of where it has counted.

"Beyond determining if a painting is really by a master, or just a clever forgery, forensic signal processing can help art historians determine the sequence of an artist's work."

Technology alone won't provide all the answers, however. Without knowing that Van Gogh sometimes painted on canvas from a limited number of bolts, thread counts would not have revealed much. "It depends on the artist's practice," says Johnson. "So it's a mixture of knowing what they did and relating the physical evidence to that."

The project illustrates some of the differences in mind-set among engineers, curators, and conservators. When Johnson first started working on an automated thread-count program, he asked to see the reference book that explains how art historians do such procedures and was told there was no such book. Variations of the process are passed verbally from expert to student. "But this can be broken down into an ordered series of steps. We engineers see this because we're taught to do this in everything we do," says Johnson. "Once we know the steps, we can see where we can help. So, even in this unusual application, we're going to act like regular engineers and come into somebody else's application and use our skills to make their life better."

Ryan K. Morris, National Science and Technology Medals Foundation

Robert Langer with President George W. Bush

NATIONAL MEDAL

Robert S. Langer '70 ChE was presented with the 2006 National Medal of Science award by President George W. Bush July 27, 2007. Langer received the nation's highest scientific honor for his revolutionary discoveries in the areas of polymeric controlled release systems and tissue engineering and synthesis of new materials that have led to new medical treatments that have profoundly affected the well-being of mankind.

Langer, who holds the title of Institute Professor at MIT, is renowned for his revolutionary work on new and different ways to administer drugs to cancer patients. At MIT, he runs the largest biomedical engineering lab in the world. He holds more than 550 issued and pending patents and has written some 900 research papers.

Langer's achievements have had a profound impact on the field of cancer research. His accomplishments are also unique in that he entered the field with a Ph.D. in chemical engineering when he teamed with cancer researcher Judah Folkman at Children's Hospital in Boston in 1974. At that time, the scientific community believed that only small molecules could pass through a plastic delivery system in a controlled manner.

In the 1970s, Langer developed polymer materials that allowed the large molecules of a protein to pass through membranes in a controlled manner to inhibit angiogenesis, the process by which tumors recruit blood vessels. Blocking angiogenesis is critical in fighting cancer because the new blood vessels allow tumor cells to escape into the circulation and lodge in other organs.

PRESIDENTIAL HONORS

Two Engineering faculty members get early career awards

Cornell engineering faculty members Brian Kirby and Chekesha Liddell have each received a Presidential Early Career Award for Scientists and Engineers from two different federal agencies. The winners were honored at White House ceremonies, Nov. 1.

The presidential awards are the highest honors bestowed by the U.S. government for outstanding scientists and engineers in the early part of their independent research careers.

Chekesha Liddell University Photo

Kirby, assistant professor of mechanical and aerospace engineering, was recognized for his work with nanoscale electrokinetic transport, including pathogen and chemical detection, quantum data storage, and advanced microsystems. He was among eight PECASE award winners from the U.S. Department of Energy's Office of Science and its National Nuclear Security Administration.

Kirby runs the Micro/Nanofluidics Laboratory, a mechanical engineering research group devoted to understanding and applying micro- and nanofluidic systems. Their research includes physics and techniques for making devices, defined by the length scale of flow channels.

Brian Kirby University Photo

Liddell, assistant professor of materials science and engineering, was awarded the PECASE by the National Science Foundation, along with 19 others. Liddell's research involves nanoscale particles that arrange themselves into structures and promise high levels of control over light waves in future applications.

Liddell's research group at Cornell focuses on developing colloid-based materials and on understanding the relationship between their structure and properties. The award cites her work with self-assembly of artificial crystal structures from colloidal particle building blocks, which have properties that may enhance strength of interaction between light and matter.

—Anne Ju, Cornell Chronicle

NEW RESEARCH VP

University Photo

Robert Buhrman

Robert Buhrman, director of Cornell's Center for Nanoscale Systems, has been named senior vice provost for research. He succeeds Nobel laureate Robert Richardson, who will become senior science adviser to Provost Carolyn (Biddy) Martin and President David Skorton.

Buhrman Ph.D. '73 will lead the office that guides and manages universitywide research efforts and steers local, national, and international outreach for Cornell research.

While attending to research policy at the highest level on campus, Buhrman will oversee the four national research centers and 12 Cornell research centers that report directly to the Office of the Vice Provost for Research. In his new role, Buhrman also will be responsible for the Cornell Center for Technology, Enterprise, and Commercialization, the Center for Animal Resources and Education, and several other research administrative offices.

"I am delighted that Bob Buhrman has agreed to assume this role, which is one of the most important in the university," said Martin. "He will bring a long history of research excellence, administrative experience, high standards, and great intelligence to the post. He will steer our efforts to enhance an already outstanding research program, and will have a significant impact on science policy both locally and nationally. He will continue the distinguished service provided by our colleague Bob Richardson. Buhrman will also benefit from the superb work Steve Kresovich has done as interim vice provost for research over the past semester."

Skorton, commenting on the appointment, said, "Bob Buhrman is a great scientist with significant projects under way. The university is fortunate that he will assume the responsibility, so ably pioneered by Bob Richardson, a true Cornell gem. I have every confidence in Bob Buhrman's leadership at the head of Cornell's enormously productive research enterprise, the success of which we owe to the commitment and hard work of our faculty and staff."

Buhrman, the John Edson Sweet Professor of Engineering in Cornell's School of Applied and Engineering Physics, joined the faculty in 1973. His current research interests include nanomagnetics, condensed matter physics at the nanometer scale, and thin film materials and device physics.

A fellow of the American Academy of Arts and Sciences, fellow of the American Physical Society and a member of the Materials Research Society, Buhrman plans to continue his research while juggling his duties as vice provost. He will step down as director of CNS.

"Continuing my research interests is going to be a major challenge, but it is something that I am absolutely committed to doing," said Buhrman. "It's important to have the exposure of a researcher while you are trying to help other researchers, and working with graduate students, undergraduates, and other collaborators on challenging research problems remains my greatest pleasure as a faculty member at Cornell."

Richardson became Cornell's first vice provost for research in 1998. He has represented the university on federal committees and has positioned Cornell to use its strengths in obtaining federal research funding.

"As Cornell's first vice provost for research, Bob Richardson selflessly applied his brilliance, generosity, and unique understanding of the nation's science agenda to defining the course and success of Cornell's impressive research enterprise," said Martin.

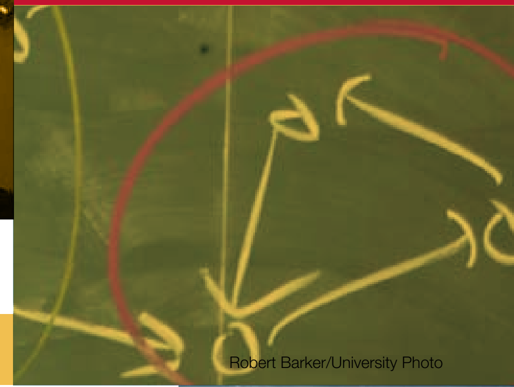
For example, Richardson was a co-author of a 2005 National Academies report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, calling for an urgent need to bolster United States science and technology competitiveness to keep pace with rapid globalization.

In his new position, Richardson will continue to represent Cornell nationally. He will also continue to serve as the director of the Kavli Institute at Cornell, a think tank charged with exploring the major challenges and opportunities for the science of very small structures.

"Bob's shoes are very big ones to fill," said Buhrman. "He has been a tremendous advocate for research here at Cornell, and I am delighted and relieved that he will be continuing to add his insights and expertise to our efforts."

A Cornell faculty member since 1967, Richardson has led an active research program to study matter at very low temperatures. In 1996, he shared the Nobel Prize in physics with David M. Lee, Cornell professor of physics, and Douglas Osheroff (Cornell Ph.D. 1973), now a physics professor at Stanford University. They received the prize for their 1971 discovery that the helium isotope helium-3 can be made to flow without resistance—a state called superfluidity—at about two-thousandths of a degree above absolute zero.

—Krishna Ramanujan, Cornell Chronicle



Robert Barker/University Photo

OPTICAL FELLOW

University Photo

Michal Lipson

Michal Lipson, associate professor of electrical and computer engineering, was elected a fellow of the Optical Society of America by its board of directors at their September meeting. Lipson was recognized for outstanding contributions to the field of silicon nanophotonics, where microchips use beams of light in place of electric currents. She was cited for the development of high-bandwidth modulators and low-power nonlinear optical devices, among other contributions.

Society members who have served with distinction in the advancement of optics may be nominated for the honor by current fellows, with final selections made by a committee appointed by the board of directors. Out of 121 nominations this year, 54 new fellows were chosen. The new fellows will be recognized at meetings throughout 2008.

Established in 1916, the society is an association of more than 70,000 scientists, engineers, and business leaders from 134 countries working to advance common interests, providing educational resources to members, and promoting the science of light and the advanced technologies made possible by optics and photonics.

—*Cornell Chronicle*

TR35 X 2

Provided

Josh Bongard

Gary Hodges/www.jonreis.com

Abraham Stroock

Technology Review, a prestigious scientific magazine published by the Massachusetts Institute of Technology, included two Cornellians among its 2007 Young Innovators on Aug. 15. They are Abraham Stroock '95, Cornell assistant professor of chemical and biomolecular engineering, and Josh Bongard, a recent Cornell postdoctoral researcher who is now an assistant professor of computing science at the University of Vermont.

Technology Review annually honors young scientists and researchers under 35 whose work it finds most exciting. The innovators' work covers a wide array of disciplines, including medicine, computing, communications, electronics, and nanotechnology.

The magazine's September–October 2007 issue explains that Stroock examines the complex world of microfluidics, which "involves moving tiny volumes of liquid through channels that are usually etched into a rigid material such as glass or silicon. Stroock, however, works with hydrogels, which are soft polymers that absorb water. Recently, he molded a capillary system that mimics a tree's system into a slab of hydrogel." The so-called synthetic tree uses evaporation to pull water through its capillaries with a force than can move liquid up a vertical column 85 meters (279 feet) high—as high as a redwood tree. This hydrogel system, the magazine says, is biologically compatible with humans, so it could serve as wound dressings that remove fluid and deliver drugs to promote healing.

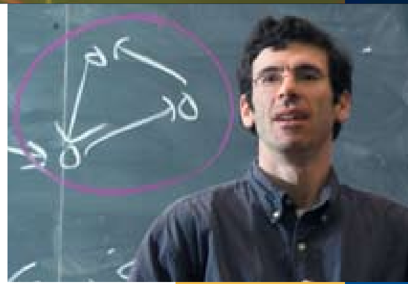
During his postdoctoral research at Cornell, Bongard collaborated with Hod Lipson, Cornell professor of mechanical and aerospace engineering, and doctoral student Victor Zykov to develop self-adapting robots, according to *Technology Review*.

The robot they built can program itself and revise the model it has developed to adapt to injury. First, it teaches itself to walk. When damaged, it teaches itself to limp. Although the robot is a simple four-legged device, the researchers say the underlying algorithm could be used to build more complex robots that can deal with uncertain situations, like space exploration, and may help in understanding human and animal behavior.

—*Cornell Chronicle*

University Photo

NET WORKER



Jon Kleinberg

Smithsonian *magazine named Cornell Computer Science Professor Jon Kleinberg one of its "37 Under 36" in October. These innovative young scholars, singers, writers, scientists, musicians, painters, and activists were chosen for their world-shaping work.*

Jon Kleinberg helps us see the invisible networks that pervade our lives. A professor of computer science at Cornell, he teaches a class with the economist David Easley that covers, Kleinberg says, "how opinions, fads, and political movements spread through society; the robustness and fragility of food webs and financial markets; and the technology, economics, and politics of Web information and online communities." If it sounds like "Intro to How the World Works," that's the general idea.

Some of Kleinberg's research builds on social psychologist Stanley Milgram's famous 1960s experiments into the "small-world phenomenon." Milgram enlisted a random group of people in Omaha and asked each to forward a letter to one close acquaintance, with the goal of reaching a certain stockbroker in Massachusetts. By tracking the letters, he came up with his "six degrees of separation" theory: any two people on Earth are connected by a string of five or fewer mutual acquaintances. Forty years later, Kleinberg runs his own tests on the small-world phenomenon sitting at his computer, poring over data from five million members of the blogging and social network Web site *LiveJournal*.

He was particularly curious to know how the physical distance between members of the online community affects the likelihood of their associating. He found that even in cyberspace, friendships depend on proximity. (In fact, the probability that people know each other is inversely related to the square of the distance between them.) "Why should it matter online if someone is 10 miles away, 50 miles away, or across the globe?" he says. "You would think friends might be uniformly spread out around the world. That's not what happened. You still see heavy traces of geography."

Kleinberg's prominence is based partly on his work navigating the Web. In 1996, as a visiting scientist at the IBM Almaden Research Center in San Jose, California, he developed an influential search algorithm (not unlike one used at Google) that ranks the popularity of Web sites by measuring how other sites link to them. More recently, he's been intrigued by the possibilities of measuring "word bursts," spikes in Internet usage of a term that would, say, reflect new social trends or political concerns. In a test, Kleinberg analyzed State of the Union addresses since 1790, showing, for instance, that the word with the most "burstiness" between 1949 and 1959 was "atomic."

Kleinberg, 35, says he expects to see machines, applications, and Web sites become better at responding to users' past behavior and prompting them. Your computer might insist you reply to an important e-mail that's been waiting too long, scold you for procrastinating or, sensing that you're about to leave the office, remind you what's left to do. In a statistical sense, he says, computers "know much more about your behavior than you do."

Each advancement will likely be hugely profitable for whoever implements it, a prospect not lost on the students pouring into Kleinberg's classes or the standing-room-only crowds that fill his lectures at Yahoo! Research conferences. But he maintains that his temperament is best suited to academia. "I've now missed so many opportunities to make money off this stuff that I figure, why start worrying about it now?" Besides, he's an idealist. "It would be great if the consequence of getting the world hyperinformed is that we understand different cultures better, are more sympathetic to different points of view, get along better," he says. But as his own research would suggest, it's the online masses that will decide the extent to which those wishes are fulfilled.

—*Matt Dellinger,* Smithsonian Magazine *(Fall, 2007). His book about the national Interstate 69 project is to be published by Scribner in 2009.*

GREAT GROUPS

The Society of Women Engineers at Cornell won first place in the Outstanding Collegiate Section Competition at the 2007 SWE National Conference in Nashville, Tenn., Oct. 27.

Also recently garnering a national award was the Cornell chapter of the Society of Hispanic Professional Engineers, which received the Outstanding Chapter of the Year Award at a national conference in Philadelphia during the first weekend in November.

Judging written reports submitted months earlier, the SWE competition recognized accomplishments of collegiate SWE chapters. Cornell's report was a compilation of all events Cornell SWE participated in throughout the year, according to Jenna Rea, Cornell SWE co-president.

"We feel very fortunate to have been awarded this year," Rea said. "Our competitors included a 500-member SWE section from California, and our section is only 250 members."

Cornell's SWE chapter organizes many events during the academic year. Two new events this year included a social T-shirt-making activity and a networking trip to New York City during Cornell's fall break.

SHPE had to submit a 50-page report on their previous academic year, including documentation of student-chapter activities for future and existing chapters, demonstration to industry sponsors of how their support is being utilized, and documentation of individual chapter efforts in accomplishing SHPE goals.

SHPE chapters are expected to host programs that offer experience in professional, leadership, academic, and chapter development, as well as outreach and community service.

—Anne Ju, Cornell Chronicle

BRILLIANT 1

Emin Gün Sirer University Photo

Emin Gün Sirer, Cornell associate professor of computer science, has been named one of *Popular Science* magazine's annual "Brilliant Ten."

Selections for the list are made, the magazine says, from hundreds of nominations by academic department heads, professional organizations, and journal editors who are asked to name people doing "the most creative and important research in the country."

Sirer studies and builds operating systems, from those that make individual computers work to those that manage networks. Last spring he attracted national attention by pointing out that the Internet's domain name system—the network phonebook—is insecure and could allow hackers to spoof an address, sending surfers to, say, a fake version of www.fbi.gov, even if the address had been entered correctly. He also is working on an operating system to enable "trusted computing" by guaranteeing that a program actually does what it claims to do.

He currently teaches a graduate course on peer-to-peer filesharing systems.

—Bill Steele, Cornell Chronicle

FAST PROGRAMMERS

Provided

Fast programmers Dustin Tseng, Hooyeon Lee, and Anand Bhaskar.

A three-student Cornell team finished first in the Association for Computing Machinery Greater New York Programming Contest, held Nov. 4 at Kean University in Union, N.J. The students will go on to compete against more than 80 other teams in the world finals in April in Banff Springs, Alberta, Canada.

Two other Cornell teams placed 11th and 16th out of the 48 teams competing. Teams from Princeton University placed second and third.

"Only four teams solved all nine of the problems, but ours did it in two-thirds the time of the next closest," said computer science graduate student Lars Backstrom, who coached the Cornell teams.

Last year, Cornell teams placed second, third, and fifth in the regional contest.

In the ACM competitions, teams of three students are supplied with computers loaded with several programming languages and asked to write programs to solve a series of problems. The winner is the team that correctly solves the most problems in the shortest time. This year's problems ranged from simple unit conversions like pounds to kilograms and engineering problems like finding the height of a rocket from ground observations to the complex problem of finding out how many ways dominoes could be arranged in a given rectangular space.

Members of the winning Cornell team were sophomore Hooyeon Lee, M.Eng. student Anand Bhaskar, and Ph.D student Dustin Tseng. Members of the Cornell team that placed 11th were Vincent Chan, Ymir Vigfusson, and Fred Howard; and the team that placed 16th included Vivek Maharajh, Vaibhav Goel, and Ramu Nachiappan. Bhaskar was a member of last year's Cornell team that placed second in the regional competition and traveled to Tokyo for the world finals. Lee was a member of last year's Cornell team that placed third.

Team members are chosen through competition on campus, open to all students and not limited to computer science majors.

The regional contest is sponsored by IBM, AdaCore, Google, and Two Sigma Investments.

—Bill Steele, Cornell Chronicle

SEEING KALACHAKRA

University Photo

Tibetan monks from the Namgyal Monatery create a sand mandala in the Johnson Museum in honor of the Dalai Lama's October visit to Cornell.

Left: this Kalachakra mandala image represents a five-story temple, from bottom to top: the temples of Enlightened Body, Speech, Mind, Wisdom, and Great Bliss. Center: The gate from the temple of Enlightened Body. Right: Detail from the temple of Wisdom.

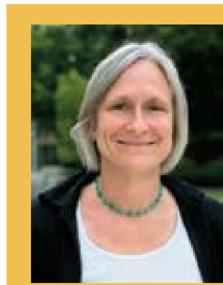
Kavita Bala, assistant professor in computer science and the Program of Computer Graphics, brought a flat sand image to dramatic life in a forum titled "Seeing Kalachakra, Being Kalachakra: An Exploration of the Farther Limits of Medicine, Neuroscience and Tibetan Buddhism," Sept. 18, in the Johnson Museum of Art. Bala displayed dazzling two-dimensional and 3D computer graphic models and animations of a grand palace in which 722 Buddhist deities reside. They can be seen online at www.cs.cornell.edu/~kb/mandala/

Tibetan monks from the Namgyal Monastary in Dharamsala, India, and its branch in Ithaca created a large Kalachakra mandala at the museum in honor of the Dalai Lama's October visit.

Kalachakra mandalas depict the palace using colored sand as pigment. Monks painstakingly create images of extraordinary beauty over a process that can take weeks. As a lesson in the impermanence of life, mandalas are destroyed soon after their creation. Kalachakra means "wheel of time" and also refers to the supreme Buddhist deity.

Bala collaborated with the monks from Ithaca's Namgyal Monastery and College of Human Ecology student Liz Popolo to create the mandala computer models.

—By George Lowery, Cornell Chronicle



WATER DIRECTOR

Susan Riha, Cornell's Charles L. Pack Professor in the Department of Earth and Atmospheric Sciences, has been appointed director of the New York State Water Resources Institute, effective Sept. 30. She succeeds Keith Porter, a senior extension associate in earth and atmospheric sciences and adjunct professor of water law at Cornell, who has directed the WRI since 1986.

The WRI has fostered and supported multidisciplinary research and outreach involving the watersheds for New York City and the Susquehanna and Hudson rivers, among others. Through the work of the WRI, Cornell faculty members have accumulated a substantial body of knowledge that applies to all major aspects of watershed management.

Riha served the College of Agriculture and Life Sciences as director of sponsored research from 2004 to 2006. From 1999 to 2004, she co-chaired the Department of Earth and Atmospheric Sciences. Her areas of expertise include plant-environment modeling, environmental biophysics, climate change, drought stress, forest soils, and land-use change.

The 55-member national network of Water Resources Research Institutes was established by federal law in 1964. In 1986 the New York State Legislature established the WRI under state law as the New York State Water Resources Institute at Cornell, where it serves as a universitywide institute to address problems of water resources through research, education, and outreach.

Provided

HOMETOWN HERO

Jeff and Dori Wolfe bring solar to the masses

BRIGHT IDEA

After a decade in the renewable energy business, Dori (Meeker) Wolfe '82 still gets a charge watching the utility meter spin backward. There's just something about knowing that sunlight is hitting an array of solar panels that she and husband Jeff Wolfe '82 designed and installed, and generating electricity that feeds the local power grid. Known as net-metering, the strategy relies on an inverter that plugs their solar system into the utility's network, eliminating the need to store electricity in expensive, bulky batteries. It's the perfect strategy for people wary of going off the grid, and far easier for the suburban homeowner intent on keeping the full array of electrical conveniences.

Net-metering also has tremendous psychological appeal. This past summer, when a local television station covered groSolar, the Wolfes' White River Junction–based company, the camera crew made sure to get a shot of Dori standing next to the meter as it made its way counter-clockwise. "We joke about it," she says, "saying it's our favorite Vermont pastime."

The Wolfes spent the early decades of their careers consulting on the engineering of mechanical systems for large-scale conventional buildings. But both came of age during the Arab oil embargos of the '70s, and each pursued mechanical engineering to enrich a personal interest in environmentally friendly energy solutions.

In the late 1990s, they quit their big-city jobs and moved to Vermont, where they founded their company—then Global Resource Options—to bring sustainability to design and renewable energy to a mass market. "I just got tired of project decisions where the three-year payback on the energy-efficient chiller doesn't make the budget but nobody asks what the payback is on the marble tile," says Jeff, who quips that he's got nothing against marble tile. "It was time," says Dori, "to stop making award-winning energy consuming buildings and instead design energy-producing buildings."

Admittedly, neither had much business background, but they relied on Vermont values and common sense to build their company. The Wolfes also took a different tack from the competition. While most of the existing solar companies installed systems for off-grid homesteads in the backcountry, the Wolfes targeted suburbanites, adopting an auto dealer's approach, complete with attractive financing and sophisticated pitches. "We decided if we're going to sell solar energy, we're going to market it the way everything else is marketed in the U.S.," says Jeff. "It's want, sex, and sizzle." A current ad campaign highlighting the happiness and security of solar depicts a middle class family—complete with children blowing soap bubbles—lounging on their suburban lawn, solar panels prominent on the roof in the background.

Customers love the idea of having solar panels, but often, says Dori, it's difficult to engage them in discussions of energy efficiency. Despite the company's energy audits to determine array sizing—greater demand equals more panels and higher costs—suggestions of high-efficiency light bulbs or replacing an energy-hogging fridge often fall on deaf ears. "People always come back," says Jeff, who says he never turns away a customer. "It might be a month later, it might be a year later, and they say, 'My meter's not spinning back fast enough. Can you help me out? What did you call those light bulbs?'"

In 2003, groSolar acquired warehouse space, took on wholesale distribution of components, and gradually increased their reach across the nation. Their largest installation to date is a Whole Foods store in Connecticut, and they are involved in one of the largest projects in California. To further expand their impact, groSolar has formed partnerships with 400 dealers from New Jersey to Oregon and opened ten offices across the United States and Canada, making it one of the leading independent U.S. solar companies today.

Central to groSolar's success, says Wolfe, is its mission, which is based on the couple's concerns about global climate change and America's reliance on foreign fossil fuel as much as their desire to make money. "You can't have profitability without social responsibility," says Jeff. "We're building this company for tomorrow, trying to grow the company as quickly as possible because we've got a problem to solve."

—*Sharon Tregaskis*

Provided