

CORNELL ENGINEERING

SPRING 2006

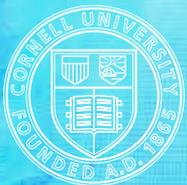
A DIFFERENT POINT OF

VIEW

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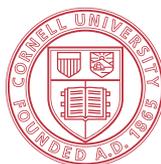
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Engineering professor Wolfgang Sachse is a

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SUCCESSFUL SEARCH

David J. Skorton named Cornell's 12th president

The six-month search for Cornell University's 12th president ended with the announcement that David J. Skorton, president of the University of Iowa, will be assuming leadership of the institution. The 56-year-old cardiologist, computer scientist, national leader in research ethics, and jazz musician will take up Cornell's highest office July 1.

The announcement was made during a special meeting of the Cornell Board of Trustees on January 21.

Skorton also will hold a primary faculty appointment in Internal Medicine at Weill Cornell Medical College (WCMC), where he will join the Department of Pediatrics as well. In addition, he will be a member of the Department of Biomedical Engineering in the College of Engineering on the Ithaca campus.

Skorton will take over from Hunter R. Rawlings, Cornell's 10th president (1994–2003), who has been serving on an interim basis since Jeffrey Lehman, Cornell's 11th president, resigned in June 2005.

At a press conference Jan. 21, Skorton said he accepted the appointment, in part, "because Cornell represented an unusual opportunity and challenge that I did not think would come up in my lifetime." He added that it was a "we" decision that presented "extremely attractive" opportunities for both him and his wife, Robin Davisson, a biologist who will join the Cornell faculty with a joint appointment in the Department of Biomedical Sciences in the College of Veterinary Medicine and in the Department of Cell and Developmental Biology at WCMC.

"Cornell is such a distinguished institution with such a leadership in so many areas [and] a robust balance of disciplines" in the sciences as well as the arts, humanities, and social sciences, he said. "It's a tremendous opportunity and challenge to be asked to sustain and extend Cornell's enviable traditions and achievements."

"As an eminent physician, scholar and accomplished leader, Dr. Skorton has established an impressive record of leadership at the University of Iowa," Cornell Board of Trustees Chair Peter C. Meinig observed. "He has demonstrated a deep commitment to excellence in interdisciplinary higher education and a thoughtful appreciation for the role a land-grant institution plays in society. We are delighted that he will be bringing his wide range of talents and engaging personality to Cornell."

"I'm very excited about the appointment of David Skorton as Cornell's new president; we are particularly pleased to welcome him to the Engineering faculty," said Kent Fuchs, dean of Cornell's College of Engineering. "His record in research and teaching suggests to me that his goals and priorities are very much in keeping with the strategic directions of Cornell and the College of Engineering. I look forward to working with him."

Skorton earned a bachelor's degree in psychology in 1970 and an M.D. in 1974, both at Northwestern University. After serving his medical residency and cardiology fellowship at the University of California-Los Angeles, he joined the University of Iowa as an instructor in 1980. He has a son from a previous marriage, who is a student at Stanford University.

For additional information, please visit cornell.edu/presidentsearch/.

—Franklin Crawford, Cornell News Service, and staff reports



"I'm so proud and very, very humbled to have the chance to be a part of the leadership of this great jewel of international higher education," David Skorton said at a press conference in Cornell's Beck Center, Jan. 21.

It's a tremendous opportunity and challenge to be asked to sustain and extend Cornell's enviable traditions and achievements.



SOLAR SECOND

After a week of tense and intense judging in the 2005 Solar Decathlon solar-house design contest last fall, the Cornell University team took second place to defending champion University of Colorado in the final rankings. California Polytechnic State University (Cal Poly) was third. This was Cornell's first entry in the competition, and it was the only solar-powered house from an Ivy League school.

"It was a lot of hard work but it feels great to come in second; it makes it feel like it was worth all the time and effort," said Larissa Kaplan, AAP '06, one of the Cornell Solar Decathlon project leaders. "And because it wasn't sunny all week, it made for a much more strategic competition—not just a display of the houses' capabilities. It really showed how our house could survive in conditions that aren't ideal. We designed a house that could be used in Ithaca."

Engineering Professor Zellman Warhaft, who has been serving as the project's adviser from the beginning, was in Washington for the final judging. He said, "In my 25 years on the faculty, this is one of the most thrilling projects I've ever seen."

The 16-by-40-foot house consists of a living room/study/kitchen, bedroom, bathroom, numerous nooks and crannies for storage, a large array of photovoltaic (PV) cells, an evacuated solar tube collector, and a large battery bank to collect and store enough energy to run all the appliances in the house as well as an electrically powered car. All the house's systems are controlled by a touch-screen remote.

The Cornell house features a custom-designed energy recovery ventilator (ERV). ERVs are very effective at reducing the additional energy load for ventilation. To maintain healthy indoor air quality, adequate ventilation is necessary. The problem with good ventilation, however, is that it takes a lot of energy to heat cold, winter air or to cool and dehumidify hot, humid summer air.

Of all the innovative technologies in the home, "I am most proud of the ERV and the control system we developed for it," says Tim Fu, mechanical engineering grad student.

In 2003, 10 undergraduates submitted a proposal to the DOE, which accepted the proposal and gave the team \$5,000 in seed money. The team recruited dozens of students to participate and raised about \$65,000 in cash from about 15 individuals, mostly alumni, and another \$120,000 in product donations from about two dozen companies. The project also has received funding from Cornell's College of Engineering, College of Architecture, Art and Planning (AAP), and College of Agriculture and Life Sciences. The entire Cornell project cost about \$350,000, including the cost of donated items.

—Susan S. Lang, *Cornell News Service*



David Skorton, left, chats with Cornell President Emeritus Frank H.T. Rhodes Jan. 21 in the Beck Center before the press conference.



Stefano Paltera / Solar Decathlon

(Above) The interior (left) and exterior of Cornell's solar house. (Top right) Members of the 2005 Cornell Solar Decathlon Team, including Joshua Bonaventure-Sparagna and Emile Chin-Dickey, center, celebrate their second-place finish.



There were 18 entries gracing the capital's National Mall for the U.S. Department of Energy's international Solar Decathlon competition. Teams were judged in 10 areas, including architecture, dwelling, documentation, comfort zone, appliances, hot water, lighting, energy balance, communications, and "getting around": the teams had to provide enough solar energy to power a small car.

Cornell's team consists of about 50 undergraduate students from six of the seven undergraduate colleges at Cornell—about 40 percent of them engineering majors, 40 percent architecture majors, 10 percent business or economics majors, and 10 percent with other majors—as well as a handful of graduate students.

In my 25 years on the faculty, this is one of the most thrilling projects I've ever seen.

FOURTH IN THE NATION

The first annual college guide introduced by the magazine *Washington Monthly* last summer has ranked Cornell University fourth in the nation, leaving Yale and Harvard in the dust at 15th and 16th.

Differing itself from other guides that emphasize academics, the magazine said its rationale for the new guide is that, "While other guides ask what colleges can do for students, we ask what colleges are doing for the country." The magazine said it includes such factors as the number of low-income students a school graduates, the school's production of research valuable to society, and its commitment to national service. Top-ranked were the Massachusetts Institute of Technology, University of California-Los Angeles, and UC-Berkeley.

"I am pleased that Cornell is consistently ranked as one of the top universities in the country—indeed in the world," said Cornell Provost Bidy Martin. "When the rankings accurately reflect the quality of our faculty, students, and programs, of course we're the best."

—Bill Steele,
Cornell News Service

OR IN THE CITY

More than a century ago, Cornell offered its first course in industrial engineering. Fifty years ago the College of Engineering's School of Operations Research and Industrial Engineering (ORIE) used the emerging digital computer to move beyond industrial engineering to the esoteric new world of operations research.

Now ORIE is moving into yet another era: using advanced algorithms and high-performance computing to solve some of society's very large-scale problems in public health, finance, and companies' supply chains. It will do this through collaborations with the public sector and academic institutions, including Weill Cornell Medical College (WCMC).

To bring its skills directly to its potential customers, ORIE has opened a New York City Financial District branch, called Operations Research-Manhattan (or OR-Manhattan), at 55 Broad Street in quarters once occupied by the Cornell Theory Center.

The new center was officially launched Dec. 7 before an invited audience of 200 alumni, businessmen, city officials, and faculty members. Opening the event, Kent Fuchs, dean of the College of Engineering, noted that OR-Manhattan will be providing outreach to Manhattan and the Financial District, to WCMC, "and, indeed, to the country."

Fuchs introduced OR-Manhattan's director, Jack Muckstadt, the ORIE Acheson-Laibe Professor of Business Management and Leadership Studies, who pointed out that ORIE has pioneered discrete event simulation technology and fundamental optimization techniques. These two areas have already come into play in the school's work with WCMC.

Today, Muckstadt said, the school is again pioneering in financial engineering education with seminars, courses for credit, a short course, a master's engineering internship program, and computational finance.

—David Brand, *Cornell News Service*



Neil Cummings photo

Dr. Nathaniel Hupert, left, assistant professor of public health and medicine at WCMC, with Jack Muckstadt, the ORIE Acheson-Laibe Professor of Business Management and Leadership Studies and director of OR-Manhattan, at the official launch of the new office.

SECURING THE GRID

Cornell University will be one of four institutions participating in the "Trustworthy Cyber Infrastructure for the Power Grid," a five-year National Science Foundation (NSF) project to design, build, and validate a secure cyberinfrastructure for the next-generation electric power grid.

The goal is to design a power distribution system that is secure against breakdowns either from natural causes or hacker attacks.

William H. Sanders, professor of computer science at the University of Illinois at Urbana-Champaign, will lead the consortium, which also includes researchers at Dartmouth College, Washington State University, and Cornell. Robert Thomas, Cornell professor of electrical and computer engineering, will guide Cornell's participation.

NSF will provide funding of \$7.5 million over five years, with between \$500,000 and \$1 million coming to Cornell. The Department of Energy and the Department of Homeland Security have pledged to collaborate with NSF to fund and manage the power grid effort.

The project will address both the physical structure of the grid and the computer communications network that operates it, Thomas said. "Most people think of the grid as just the wires and transformers, but that's not all of it," he said. The grid, he explained, includes automatic control systems as well as thousands of relays designed to take equipment out of service in case of physical or electrical problems. The relays are activated by sensor information and some computation, because problems arise so quickly that humans would not be able to respond in time.

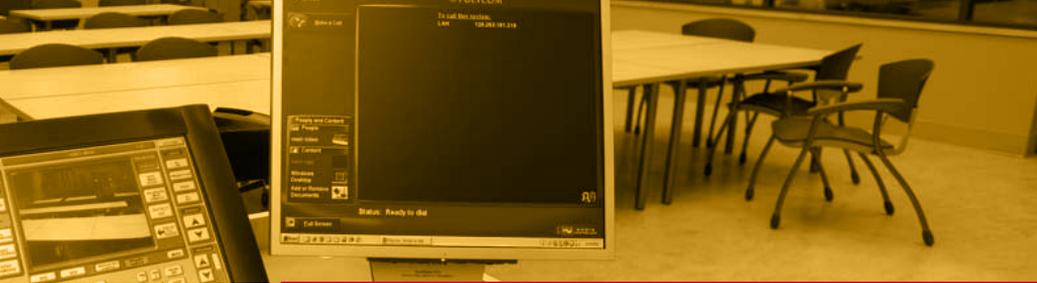
Cornell's share of the work will focus on determining what parts of the system are sensitive to failure and looking at marketing and technical aspects as well as computing.

—Bill Steele, *Cornell News Service*



Photo provided

The 2003 blackout wasn't just about fallen trees and broken transmission lines. It resulted from a combination of many grid events, computer glitches, and human interaction.



ETIQUETTE FOR ENGINEERS

Want to design bridges? Better mind your manners. This was the message Robert A. Shutt, president of RASolutions of Binghamton, N.Y., tried to impart to a banquet hall full of 20-year-old engineering students last summer at Cornell University.

His presentation on business dining etiquette at the annual Engineering Co-op Send-off Dinner came as a surprise to many of the technically minded students. Telling engineers it matters if they tip their soup bowl can be a hard sell. "Did we accidentally come to a dinner for the School of Hotel Administration?" joked one young woman student.

But administrators in Cornell's College of Engineering did not make a mistake when they hired Shutt to talk on table manners. Training sessions on topics of etiquette and interpersonal skills have become a growing trend at universities and businesses across the country intent on giving their young professionals an edge on success.

Speaking to 150 aspiring engineers seated at tables covered in white linens and fine china, Shutt suggested that although the students may have the technical skills to become innovators of the future, they will have a tough time landing their dream job at an upper-tier engineering firm without developing some business etiquette skills as well. He provided guidance on topics as diverse as accidentally passing gas, talking with spinach stuck in a tooth, what to order, what silverware to use when, and whether to tip the soup bowl (don't).

Cornell's Engineering Co-op program enables students to spend the junior year fall semester interning at companies as preparation for entering the workforce. The annual send-off dinner serves as the last gathering before the students travel to their internships.

—Thomas Oberst, *Cornell News Service*



Photo provided

CHALLENGE IN THE DESERT

Cornell's self-driving vehicle performed beautifully in the DARPA Grand Challenge, as far as it went, but was eliminated after nine miles of the course due to a software weakness, the team reported.

Stanford University won the competition's \$2 million prize, completing the 132-mile course in 6 hours, 53 minutes. Only four other vehicles out of 24 entries completed the course.

The Cornell team reported on its web site, <http://dgc.cornell.edu>, that "Titan," its modified Spider Light Strike military all-terrain vehicle, was performing perfectly until it was paused by the DARPA chase vehicle because it made a controlled sharp turn. The Spider's software causes it to slowly come to a stop when paused, and the timing of the pause was such that the Spider stopped with its wheels resting against a guardrail.

The team had prepared software that would enable the vehicle to back up, but it had not been enabled due to time constraints, so the vehicle was not able to back away from the guardrail and continue after the pause.

"The nine miles that the Spider did complete went exceptionally well, and the logs that we retrieved showed that all of its systems ran as they should have," the team reported.

—Bill Steele, *Cornell News Service*

Guest speaker Robert Shutt, left, gives etiquette advice to engineering students who are leaving for internships soon, as CBS cameraman Eric Teed films for CBS Evening News.

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A DIFFERENT POINT OF VIEW

Graduate students complete a six-week immersion term at Weill Cornell Medical College to get a first-hand look from a medical perspective at the challenges and opportunities in biomedical engineering.

By Jay Wrolstad

Monday: I reported to the OR at HSS at 8:30 to shadow Dr. Bostrom. While with Dr. Bostrom I was able to observe two total knee replacements, two total hip replacements, and finally a total knee revision.... I could see just exactly how each tool was attached to the knee to provide aid in making precise cuts when shaving off the femoral condyles and the tibial plateau. My final experience on Monday, Dr. Bostrom allowed me to scrub in and view a total knee revision up close.

—Blog entry by Jeff Ballyns

Standing at the elbow of a surgeon in the operating room isn't something most engineering students expect to do as part of their coursework. But there are substantial benefits for both doctor and observer in such situations that help develop and put to use new technologies that improve treatments in a broad array of medical specialties.

A handful of Biomedical Engineering (BME) students discovered those benefits for themselves last summer while spending six weeks in New York City working with physicians at the Weill Medical College of Cornell University and its affiliate, the Hospital for Special Surgery (HSS). It was, by all accounts, an eye-opening experience for the graduate students, who now have a much better appreciation of the applications for their research.

The program's inception dates to 1999, when Cornell professor Donald Bartel, who has collaborated on various projects with the Hospital for Special Surgery for some 30 years, first conceived the idea of an immersion term.

“We initially offered a program in orthopedic biomechanics at HSS, which is the orthopedic affiliate of the medical college,” says Bartel, who holds a joint appointment as the Willis H. Carrier Professor of Engineering in the Sibley School of Mechanical and Aerospace Engineering and a senior scientist in the Department of Biomechanics at HSS.

Bartel’s prototype immersion program was developed with backing from a Whitaker Foundation grant to build bridges between the Ithaca campus and the medical college. “That program focused almost exclusively on orthopedics at HSS, whereas the present program has a broader focus that includes a variety of medical specialties,” Bartel says.

“We felt the students needed exposure to the clinical environment and to research that can’t be done on the Ithaca campus,” he says. “Those in the biomedical engineering field need experience collaborating with medical practitioners. They need to understand how institutions like the HSS and the medical school operate.”

While the focus of the summer immersion course is an introduction to the clinical environment, students also receive formal instruction in medical ethics in a course developed by Betsy Myers, associate professor at Weill Cornell and associate scientist at the HSS, and Timothy Wright, professor of applied biomechanics in orthopedic surgery at Weill and associate engineer at HSS. Participants spend much of their time in operating rooms and clinics at the two facilities, each of them shadowing a designated physician mentor and learning first-hand how patients are diagnosed and treated. They also pursue an independent study project.

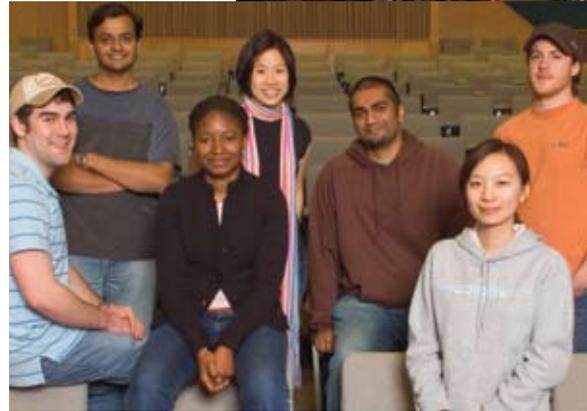
The immersion term, a requirement for all BME Ph.D. students, offers exposure to a range of medical imaging technologies used in routine clinical diagnosis. Participants observe surgical procedures such as replacing a broken hip, repairing a severely damaged knee, or removing a cancerous prostate.

The students focus on five primary medical concentrations: neurology, cardiology, radiology, orthopedics, and neo-natal pediatrics—fields in which there is a predisposition for the kinds of technology engineers can deliver.

“A lot of the BME research can be done here on the Ithaca campus—working with animals at what is one of the best veterinary hospitals in the country—but we also want our students to have an appreciation of what it’s like to work in the human clinical environment,” says Michael Shuler, the Samuel B. Eckert Professor of Engineering and the James and Marsha McCormick Chair of the BME department.

Students making medical devices have to understand the physicians’ needs, he explains, and they should be exposed to medical research as well as the ethics associated with human research, all of which are part of the immersion program. “But the most unique part is the chance to have first-hand experience being in the operating room,” Shuler says.

Yi Wang, Faculty Distinguished Professor of Radiology at Weill, offers a similar take. “The clinical exposure lets students see how technology is being used in practice,” he said. “There is an immediate return for the engineering students, who gain specific and valuable medical knowledge



Ph.D. candidates in the biomedical engineering program include (front row, from left) Jeff Balylins, Omotunde Babalola, Hui Xu, (back row, from left) Abhishek Ramkumar, Clarissa Lui, Satish Degala, and Diego Rey. Degala was unable to participate in the immersion term due to an injury.

first hand in addition to getting academic credit. This specific knowledge may be called on for guidance in their current and future engineering work. And they learn how to collaborate with physicians on projects. Such experience in interacting with medical people will be important later on in their careers when they work with practitioners. So there is a long-term benefit.”

Wang, who helped develop and administer the immersion program, says the physicians, as a whole, were open to working with the BME students. “The Weill mission is to focus on medical research and treating patients as well as educating medical students, and this program is another aspect of that mission,” he said. “On the other hand, the participating physician mentors also benefit directly from the summer immersion, because our technology-savvy engineering students participate in and contribute to their mentors’ research projects.”

Shuler notes that the clinicians appreciate the skills and training that BME students bring to the table. “Medicine has become dependent on technology of different types. Doctors want to involve students who have an understanding of the technology that is complementary to their specialties,” he says. That means explaining not just the use of current technologies, but also the shortcomings of those technologies in clinical practice.

“Many physicians are naturally inventors and they often relate well to engineers,” says Shuler. In fact, he adds, during the immersion program clinicians presented some problems to students that will turn into continuing research projects.

The surgery gave me a feel of the kind of user interface the surgeons are familiar/comfortable with. I have learnt one thing that I will always remember when I design instruments/devices in the future: keep everything simple and ready to use. It's not that the surgeons don't understand how it works but it's the simple fact that in the OR there is no time.

—Blog entry by **Abhishek Ramkumar**

One promising project was conducted by BME student Hui Xu, who developed an inflatable cuff to enhance peripheral magnetic resonance imaging while working with Dr. Martin Prince, a professor of radiology at Weill Cornell.

“I'm interested in this technology because it's a very powerful medical tool,” Xu says. In measuring data obtained through MR imaging, the contrast agent is injected into the arterial vessels, so maintaining a constant blood pressure level is critical to get a clear image, she explains. “Most blood-pressure devices are hand-inflated, but they can leak, affecting the image, so I worked on a pressure regulator unit that was used successfully on some volunteer patients. It was exciting to see that my design did work, and it did improve the quality of the MR image by reducing the venous contamination.”

Diego Rey also was able to experience the sense of accomplishment from seeing his research applied successfully in the clinical setting. In collaboration with Dr. Alexis Te in the urology department at Weill Cornell, Rey successfully tested a device to treat symptoms of an enlarged prostate.

“Currently, it's common to treat the condition using a catheter with a microwave antenna that is inserted in the body and uses radiation to kill prostate tissue and open the urethra,” he says. “The idea is to heat the targeted area without affecting external tissue.”

But no tests had been done on the effectiveness of different types of devices used in the procedure and the heating levels they produce. “Our experiment was designed to test all the devices for their efficacy. This involved using a jelly-type material, with properties similar to prostate tissue, and observing how it reacts to microwave radiation.”

He completed a proposal for such testing and the experiment has been passed on to master of engineering students (M.Eng.) to take to the next level. A paper based on the proposal was submitted to the American Urological Association. “It's satisfying to know they were able to use the work I did,” says Rey.

Jeff Ballyns conducted experiments in cartilage and tissue engineering while working with Dr. Hollis Potter, who runs a clinical MR unit at HSS, observing knee surgeries and methods of creating new tissue that replicates the functions in the body.

“MRI imaging is the basis for understanding the geometry of the meniscus tissue in the knee and for making a mold to create a replica,” he says. “Seeing how the hospital facilities work, how efficiently the surgeries are performed, and the tools available to surgeons, was very educational. I also discovered the vast amount of research being done in hospitals. The surgeons were very open to talking with engineers and explaining their work and having us get some first-hand experience.”



The most unique part is the chance to have first-hand experience being in the operating room.



Michael Shuler, the Samuel B. Eckert Professor of Engineering and the James and Marsha McCormick Chair of the Department of Biomedical Engineering

Two teams of surgeons were working on her for this replacement. The first team was a group of orthopedic surgeons, performing the total knee revision. But working right next to them, on her torso, were a group of plastic surgeons from NYP-Weill, working on harvesting some muscle tissues from the left side of her ribcage.... I had never seen a plastic surgery, so this proved to be a very exciting and educational case...even the orthopedic surgeons were very impressed.

—Blog entry by Tunde Babalola

Clarissa Lui, who focused on vascular surgery during the immersion program, evaluated the prospects for new technologies in surgical procedures. “Treatment for an abdominal aortic aneurysm, for example, is now being done with less invasive procedures,” she says. Instead of opening up the abdomen, a catheter is inserted in the femoral artery to position a device that can fix the dilation of the blood vessel.

This stent-type device could be improved using new materials and designs. It may be possible to include microfabricated sensors to monitor the blood pressure in the affected area of the body, rather than relying on a CT scan, Lui says.

“I learned the clinical side of how technology is applied, and I went on rounds to visit patients with the doctor as he explained the surgery, which gave me a much better idea of how disease is treated,” she says.

For Omotunde Babalola, the immersion program marked a return to familiar turf, as she had worked at the Hospital for Special Surgery, doing research in biomechanical implant testing, before enrolling in the BME program at Cornell.

At that time she served as a research engineer focusing on osteoporosis and fracture healing models, including hip and knee implants. “What was great about the immersion program is that I was exposed to a number of other medical disciplines outside of implant research, such as imaging technologies and tissue engineering and regeneration, and was able to observe the actual replacement surgeries,” says Babalola.

Instruction in medical research ethics and statistics provided insight into additional areas of interest for biomedical engineers, she added. “I discovered potential applications of my work that I was previously unaware of. It’s easy to work in the lab, but observing surgery and the process of putting an implant into a body will help me create better tissue designs because I have a much better idea of what the surgeons need.”

Babalola supports the immersion program as a BME requirement, noting that it fosters collaboration between students and the medical school. “Now I know people there who can help me with my research and can assist with evaluating my work,” she says.

Abhishek Ramkumar, a student who worked on a computational model for an infant lung while in the immersion program, says the opportunity provided a glimpse of what to expect in his future interactions with doctors.

“Everyone in BME needs to do this; to see that doctors

and engineers don’t think alike, which is something I did not understand before,” he says. “We learned what types of technology doctors need, and that’s an important consideration when designing a product. Collaborating with doctors is critical in developing any detection tool or technology, because it helps eliminate assumptions about the design of a device.”

Rey notes that in encouraging engineering students to join them in the operating room, the clinicians wanted not only to demonstrate the procedures and tools being used, but also to ask for the students’ input.

Adds Xu, “Our goal is applicable for clinical diagnoses, and it’s good to know what is available to doctors now, and improve those tools or build new ones. I enjoyed observing the interaction between doctors and their patients. And it was helpful to see how technology is applied to research.”

Participants in the immersion program, who lived in a dormitory at the medical college, provided periodic progress reports on a web log (blog) site set up by Diego Rey, met weekly with Wang, and at the end of six weeks, wrote term papers and delivered 30-minute presentations on the experience.

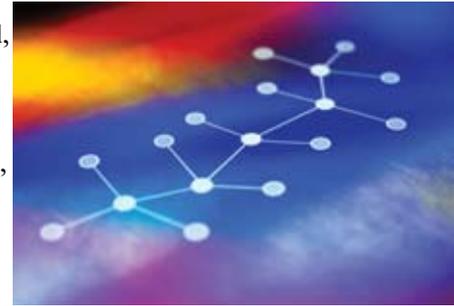
Shuler says that beginning this year, an orientation session for the immersion program will be held in the spring and students will be debriefed in fall semester. “We are looking to send a much larger group this year, about 14 students, compared to six in 2005, and we are fortunate that there is a reservoir of doctors in New York City willing to participate,” he says. Lawrence Bonassar, associate professor in the Sibley School of Mechanical and Aerospace Engineering and the Department of Biomedical Engineering, will be the Ithaca coordinator for this year’s term, working with Wang, his counterpart at Weill.

Scrubbing in was quite an experience seeing just how careful one has to be once washing your hands and putting the headgear on along with the smock and gloves. Seeing the operation up close is quite a different sensation with all the new smells and seeing all the debris that is removed when changing the implant.

—blog entry by Jeff Ballyns

Among the collaborators is Timothy Wright, an immersion program coordinator and professor of applied biomechanics in orthopedic surgery at Weill Cornell. “The program reinforces the strong connection between engineering and medicine,” he says. At the HSS, says Wright, the idea is to offer a broad experience, with some formal training, including lectures on responsible conduct in surgery and experimental design.

In the labs the students were shown technologies not available in Ithaca that will help them with their research, says Wright, adding that the engineers benefited from comparing notes with students at the medical school.





“Exit interviews reveal that, beyond a doubt, observing in the OR is the most exciting experience,” says Wright. “We are a teaching hospital, and the surgeons want to describe what they do to the engineers, who were able to observe joint replacement surgery, for example, and get a look at the actual cartilage tissue and the restrictions faced by surgeons doing replacements.”

Potter, the attending radiologist, notes that the students were enthusiastic about learning in the hospital setting, inquiring about the work of clinicians and thinking about how to model their projects to meet physicians’ needs.

“This is an opportunity for students to see how technology is implemented, at the bedside, and how it is applied to patients,” she says. Potter points out that while Ballyns was able to conduct experiments in cartilage and tissue engineering, he also examined research data and talked to a GE scientist who was at the hospital at the time, providing him with an industrial perspective on medicine.

“There are many ways to apply BME,” Potter says. “Engineers can work in research, or a hospital. The students here learn that they don’t work in a vacuum. They get to see how their work interacts with that of the doctors, and they learn that they have to balance feasibility with science.”

Surgeons benefit from the program as well, says Dr. Tom Sculco of HSS, learning from teaching students who

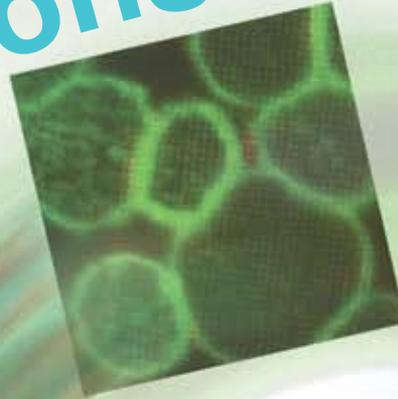
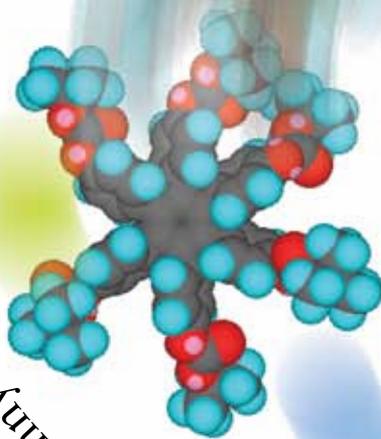
come from different, but related disciplines. “The immersion term fits well with our educational efforts at HSS,” he says, pointing out that the hospital has a long history of participation with Cornell biomechanics students interested in orthopedic surgery as motivation for their thesis research. “It’s gratifying to see the program expand to the rest of BME and Weill Medical College.”

Cornell’s interest in interdisciplinary endeavors like the BME immersion program is based on the principle that each party can benefit from the knowledge and experience of the other. The program has recently been awarded one of 12 seed grants, funded jointly by the Office of the Provost at each campus. The one-year, \$50,000 grants are designed to encourage cross-campus interactions between researchers at Cornell’s Ithaca campus and at Weill Cornell.

“Certainly in this program there are complementary strengths on the two campuses,” says Shuler. And with an increasing number of graduate BME students choosing faculty members at Weill as their research project advisers, Shuler says, a long-range goal is to create a seamless connection between the two campuses as well as the disciplines. The immersion program is a strong first step in that direction. ■ ■ ■

Unexpected directions

By Kenny Berkowitz '81



Following the unpredictable path of discovery in polymer research, Chris Ober was looking for potential applications that would make a difference in human health and quality of life, not fame. But it found him anyway.

First, there was a telephone message from the president of the American Chemical Society. Then there was another, and another, until Christopher Ober, the Francis Norwood Bard Professor of Materials Engineering, found time to return the call.

“I knew he wanted to talk to me, but I thought it involved work, so I wasn’t trying to get back to him right away,” says Ober, taking a break in his Bard Hall corner office. “When I did, it turned out he wanted to let me know that I’d won this award and ask if I was willing to accept it. I said yes. I was thrilled to receive the news, because a lot of the best polymer scientists in the world have won this award, and I’m flattered and pleased I am to be included in that number. There’ll even be a symposium given in my honor, which will be really strange. But there’s an element of mystery to the whole thing, because they haven’t yet revealed to me why I won it.”

Given the chance, Ober argues that he doesn’t really deserve the ACS Award in Applied Polymer Science. There are any number of other medals on his shelves, which he also downplays as “just little trinkets,” and his only rationale for this latest is a quietly shrugged “maybe just hard work.” With long hours and looming deadlines, he’s perfectly happy to wait for the formal presentation this spring and to rely on the ACS’s 22-word citation until then: “For his exceptional ability to craft unique polymer architectures having practical applications in solving timely and important environmental, microelectronic, and biological problems.”

Like Ober, it’s far-ranging and broadly defined, using only as many words as necessary to summarize a lifetime of research. But for his colleagues in the Department of Materials Science and Engineering (MSE), there’s little surprise he’s been given this award and absolutely no question about whether he deserves it. “He’s an outstanding researcher and an excellent teacher,” says Emmanuel Giannelis, Walter R. Read Professor of Engineering and the current director of MSE. “Some of us are good in one or the other, but there are very few people who can do an outstanding job at both. Chris leads by example, and he continues to push himself and his group to have an impact on research. He is well-recognized both nationally and internationally, and we knew it was only a matter of time before he was given this award.”

“Chris is a great man,” says collaborator and fellow MSE professor Uli Wiesner, who credits Ober with his initial Cornell appointment. “He is a very humble person who always puts down his own contributions, rather than trying to appear in the limelight. He’s one of the kindest researchers I know, someone who deeply cares for the people he works with and for this university. And he’s really devoted to polymer science.”

As Ober tells it, after studying chemistry in high school, he fell in love with polymer science as an undergrad at the University of Waterloo in Ontario, where he earned his bachelor’s degree in 1978. He still thinks of his co-op experience as the turning point in his career and was in the process of synthesizing natural materials for pharmaceuticals when he realized that something was wrong.

“I knew this was a noble calling,” says Ober. “But what frustrated me was that at the end of the day, I might hold up a container that looked entirely empty, because there were only a few micrograms of material sitting at the bottom. Somehow, I liked dealing with things that were more substantial. In the polymer world, the chemistry can be just as complex as it is with pharmaceuticals, but you’re not done until you have a substantial amount of material—something you can actually see, with some pretty well-focused properties. And you have a huge number of tools to create materials with all these different properties.”

As a grad student at the University of Massachusetts Amherst, Ober began concentrating on liquid crystalline polymers, and he’s never slowed down. For four years, he worked in industry, investigating polymers at the Xerox Research Centre of Canada. But the longer he stayed, the narrower his research became, and the only way to recapture that larger picture was to return to the academic world.

Ober arrived at Cornell in 1986, taking his first and only appointment in academia. In the 20 years since, he’s focused on creating new polymers on a smaller and smaller scale for microelectronics, environmentally friendly materials, and nanobiotechnology. In one of his best-known projects, Ober developed environmentally friendly polymer coatings that enable ships to clean their hulls of bacteria and barnacles, which results in decreased drag and greatly increased fuel efficiency. In another, he invented a new glue for computer circuit boards; robust at room temperature, Alpha-Terp breaks down easily at 430 degrees Fahrenheit, creating enormous possibilities for recycling computer parts and reducing manufacturing costs.

Those two inventions—Ober estimates that he has “a dozen, fifteen, twenty patents for a variety of things”—bookend his work, with little in common except for his method, which relies on subtle changes in polymer structure to lead him from one discovery to the next. While some

researchers seek solutions for existing problems, Ober works in the opposite direction, exploring the properties of his newly created materials to discover potential applications.

“Sometimes we dress things up to give them a good story, but usually these advances are evolutionary,” says Ober. “We’re pulled in directions we don’t always expect, and sometimes it’s a chance conversation with a colleague, and sometimes it’s a researcher who approaches us to ask, ‘Can you do this?’ ‘Well, I don’t know anything about it—but it sounds interesting.’ Every time we take on a new project, we learn something that helps us move on to the next one, even though we’re not always sure what that next project will be.”

Ober talks about the advantages of having a short attention span, and how polymer science has encouraged him to jump easily from one research project to another.

But his real strength, says Ned Thomas, who has co-authored sixteen papers with him in the last 10 years, is Ober’s ability to move smoothly between different fields.

“He’s an anomaly, a researcher who’s equally at home with chemistry and materials science,” says Thomas, the Morris Cohen Professor of Materials Science and Engineering and director of the Institute for Soldier Nanotechnologies at the Massachusetts Institute of Technology. “Some people have lots and lots of citations, because they do something that’s really easy and they do it first. And some people do things that are really hard, that nobody else can do, and they get a lot of citations because everybody recognizes just how good they really are. That’s the category Chris is in. He would be equally at home in a chemistry department as he is in a materials science department, and those two worlds aren’t easy to straddle. But he can do it, because he’s a damned good chemist.”

In 1995, after co-authoring his first paper with Thomas, Ober became associate editor of the journal *Macromolecules*, and in 2000, he became the director of the Department of Materials Science and Engineering. That launched a time of great change, when Ober helped restructure the department’s undergraduate curriculum into four research areas—nanotechnology, biotechnology, energy and the environment, and information technology—and create a new state-of-the-art laboratory, the Hudson Mesoscale Processing Facility, which, along with the Cornell Nanoscale Science and Technology Facility and the Cornell High Energy Synchrotron Source, all play a part in his current work.

During the same period, Ober was given the 2000 Semiconductor Research Corp./Semiconductor Safety Association/International Sematech Award for research in manufacturing and environment, safety and health; the Semiconductor Research Corporation Award for Creative Invention in both 2000 and 2003; the 2003 International Sematech Outstanding Contribution Award; and the 2004

He’s an anomaly, a researcher who’s equally at home with chemistry and materials science.

Polymer Science and Technology Award. And in all that time, he was also running the largest research group in the department.

“That’s something I’ve never quite been able to figure out,” says Ober, talking about the size of his lab, which currently has 15 members, including five post-docs. “It’s a combination of intellectual curiosity and the relevance of the work that we do. Whether it’s in the area of photolithography or biomaterials or environmentally friendly anti-fouling surfaces, everything that goes on in our group has a very practical focus. That focus directs our activities, and enough people think what we’re doing is interesting that we’re able to find the funding to make it happen—which is ultimately what makes large groups possible. It’s an extremely talented group of individuals, and they’re coming up with some great ideas. Really, my job is just to foster their creativity as best I can, and enjoy the cool things that come out of it.”

At her first meeting with Ober, Katy Bosworth knew she’d found the right lab. “I came for visiting weekend, and the second I met Chris and the other group members, I absolutely wanted to join the Ober Group,” says Bosworth, currently a third-year Ph.D. student in chemistry. “I just felt like I fit, and it’s turned out exactly as I hoped it would. We work on things that have real structure, and do things on a scale that you can observe. The engineering is very palpable, with very real-world applications. And from the start, Chris has been very calm, fair, and patient.”

“Chris is a very easy-going guy, so getting along with him is really no problem,” says Nelson Felix, a fourth-year Ph.D. student in chemical engineering and the senior member of the Ober Group, currently working with supercritical CO₂. “He’s not a fan of putting pressure on people or trying to force the situation, and I think that says a lot about him. You have to be passionate about your research, because he’s not going to micromanage you; he’s not going to egg you on. He’s going to let you figure it out on your own, give you the space to do it, and keep his eye on the grand vision of how all this work fits together.”

At the start of each year, Ober refocuses the group on that larger picture, bringing members together with Ober Group alumni, colleagues in industry and academia, and collaborators from around the world. Held at sites around the Cornell campus, the Ski Hut Meeting has since retreated to the warmth of the A.D. White House, where

its 40 or 50 participants spend a January weekend sharing their work and discussing their strategies for the coming year’s discoveries, with a little time left over for skiing.

Photos from past years’ Ski Hut Meetings serve as the screen saver for Ober’s computer, alongside pictures of his wife (an editorial assistant on *Macromolecules*), son (a chemical engineering sophomore at Cornell), and two daughters (a high school senior and third-grader). The family likes to travel together and is looking forward to Ober’s sabbatical this year, when he plans to split his time between MIT, collaborating with Thomas, and the University of Bayreuth, Germany, where he was a visiting professor in 2004.

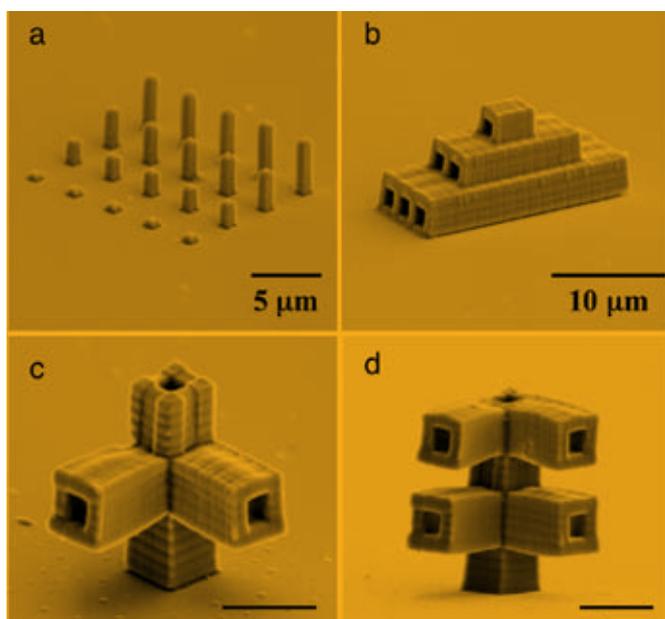
Until then, Ober has set up any number of challenges for himself. He’s serving as vice president of the polymer division of the International Union of Pure and Applied Chemistry and reviewing proposals, among other things, as a member of the Cornell Nanobiotechnology Center’s executive board. In keeping with his group’s new directions, he’s teaching an undergraduate course in biomaterials, which he’s never done before. And in the coming year, he’s pushing his group to drive polymer lithography toward smaller and smaller scales; collaborate with New York’s Wadsworth Center in a study of brain function; refine its environmentally friendly photo-acid generators; and explore the possibilities

of molecular glasses in photoresists.

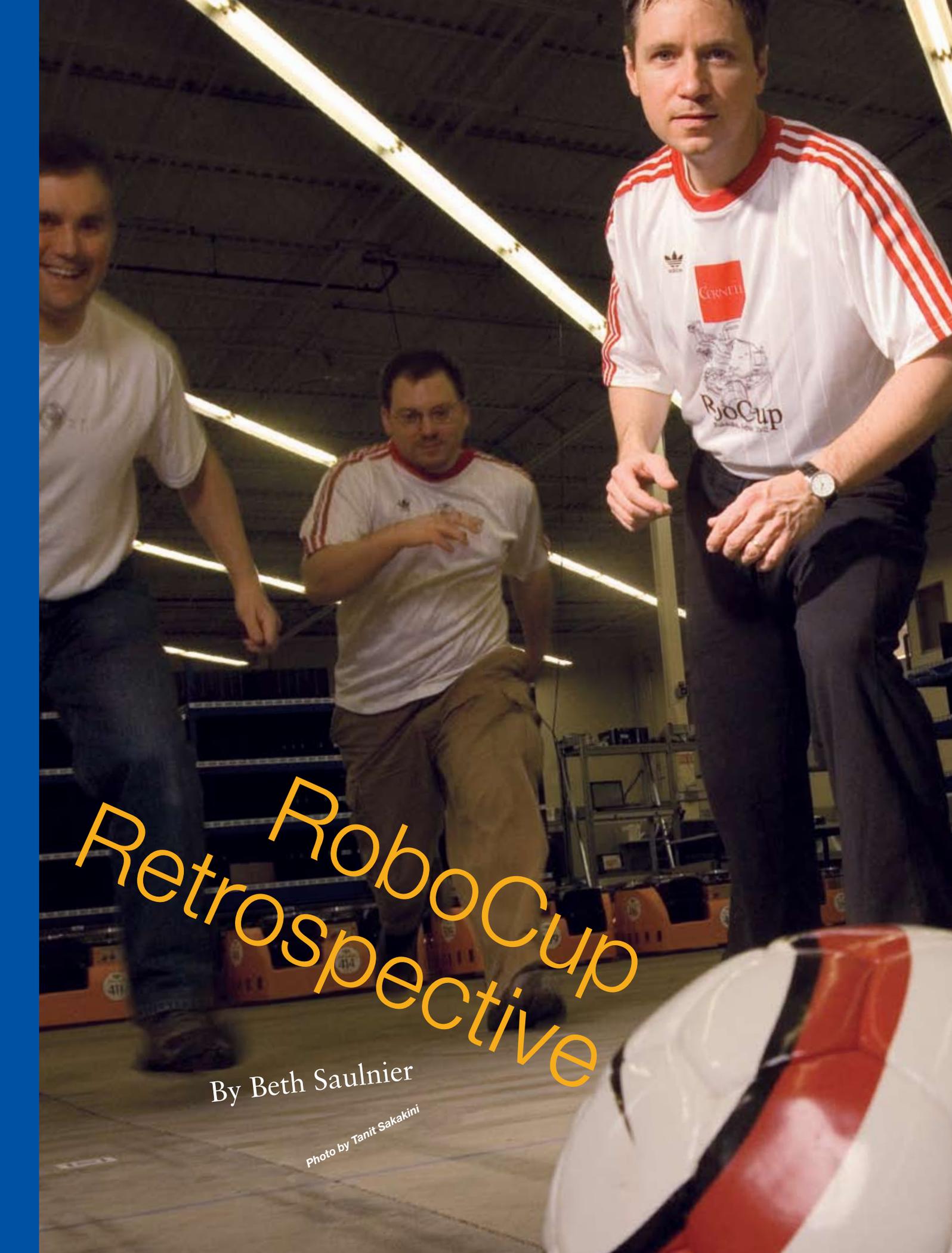
Along the way, he’ll need to prepare his talk for his award symposium and find something to wear for the award ceremony. “I don’t own a tuxedo, and I’m going to try to find a way around it,” says Ober, who describes himself as an oxford-shirt kind of guy. “I wouldn’t rent a tuxedo for my wedding, so how can I possibly rent a tuxedo for an awards ceremony? But there’s going to be this symposium in my honor, with all these presenters talking about my work. Then, there’s a ceremony where all the national award winners get dressed up and have a fancy dinner and traipse across the stage and shake hands with each other.

“That’s what’s going to happen,” he says. “And I think it’s going to be pretty cool.”

Maybe a tuxedo isn’t out of the question after all. ■ ■ ■



3D structures we have prepared to test new concepts in microfluidics



RoboCup Retrospective

By Beth Saulnier

Photo by Tanit Sakakini



From 1999 to 2005, Cornell's Big Red robot soccer team dominated the international competition.

Why it's time now to call it quits.

Nicole Schlegel was tired. Very, very tired.

She was exhausted from jet-lag after the flight from New York to Australia; from long nights of frantic work; from the stress of the upcoming competition. Schlegel was finally getting some sleep when there was a knock on the door of her Melbourne hotel room: she had to come right away. Still clad in her pajamas, she raced downstairs—and spent a sleepless night trying to stop a small robot from jumping around a miniature soccer field like the proverbial headless chicken.

The 2000 computer science grad was in charge of artificial intelligence for Cornell's goalie in RoboCup, the international robot soccer competition in which the Big Red has long been the undisputed powerhouse in the small-size league. Her late-night adventure—she managed to correct a problem with how the goalie was processing information fed to it from an overhead camera and help the team to its second consecutive win—is just one of countless RoboCup war stories. There was also the time when mechanical and aerospace engineering professor Raffaello D'Andrea, the team's adviser, was mugged after scoping out the 1998 contest—but managed to hold on to his video camera while whacking a pair of Parisian thugs with his laptop computer.

And when the team landed at the Stockholm airport for the '99 competition, only to learn that the airline had lost most of their equipment.

And when they were tied 0-0 in the 2000 semi-finals against one of their arch-rivals, the game hinging on penalty kicks. Schlegel forgot to command the goalie to switch sides, costing Cornell the first point (and, quite likely, shaving a few years off the team's collective lives).

And when the Cornellians had to stand idly by during a 2001 game in Seattle, teeth clenched, while another team pinned the ball against the wall and ran out the clock—skirting the rules against immobile players by having the robot twitch every twenty-nine seconds.

"It was quite a bit of sleepless nights, and it was very nerve-wracking at the end," sums up Bryan Audiffred, M.Eng. '00, an electrical engineer and alumnus of the 2000 squad that won in Melbourne, "but it was definitely one of the greatest experiences of my life."

But after amassing the strongest record in RoboCup history—including four wins, a place, and a show—the Big Red is retiring; for a variety of reasons, D'Andrea has decided not to field a team for the foreseeable future.

When the next tournament is held in Bremen, Germany, in June, the competition can breathe a little easier: Cornell is staying home. "In a way, it's sad that we can't carry on our legacy," says Schlegel, a Ph.D. candidate in earth and planetary sciences at the University of California, Berkeley, who keeps current with RoboCup news via the organization's list-serve.

RoboCup took up a fair chunk of D'Andrea's time, but that's not his primary motivation for retiring the squad. Like the game itself, it's complicated. One reason is a sense of frustration with RoboCup rules that don't acknowledge the technical level of the competition: some rules needed modification as the teams improved; others were imposed before the competition was ready for them.

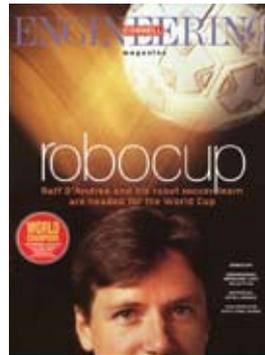
Then there's a difference of opinion over how much the game ought to be faithful to the precepts of real-life soccer. Since the ultimate goal of the RoboCup competition is to field a team of person-size robots who can play against human athletes by the year 2050, organizers want the game to resemble soccer as much as possible. That prompted them, for instance, to remove the walls surrounding the pitch, but the change led to frequent stoppages when the ball went out of play. Schlegel and others found such decisions more than a little constricting. "With what they allow," she observes, "you can only do so much."

But D'Andrea's principal reason for retiring the team was something else entirely: the fact that, essentially, RoboCup was a victim of its own success. For the past decade, some of the world's best and brightest student minds have been puzzling out how best to play five-on-five soccer, with 15-centimeter-high robots battling over a neon-orange golf ball—and they pretty much figured it out. Although dramatic improvements were made in the first few years, lately the advances have been increasingly incremental.

"We were kind of like the Bell Labs of the competition," D'Andrea says. "We always showed up with new things, were always innovating—not necessarily polished, but something really pushing on the creative side. But as the competition matured, you couldn't do that as much; everybody tended to converge to the same solution. This year in Japan, everybody's robots looked just like ours—four-wheeled, omni-directional robots." He compares the situation to the design of automobiles, which all tend to have four tires and a steering wheel. "Most look pretty much the same, because we've had eighty or ninety years to converge to a solution that's optimized," he says. "The constraints remain the same; the roads haven't changed much. Therefore, everybody pretty much figures out the best way to do it."

Sherback, too, is a bit nostalgic for the early days of the competition. Although the robots were slower and less dexterous, he and his teammates were working in the kind of anything-goes atmosphere that no engineer could resist. "Back in the day, there was a lot of latitude," he says. "It was not at all clear what the best way to do things was in terms of hardware. There was a lot of freedom to have some wacky idea and see it through." To this day, Sherback believes that one of the dumbest decisions of his entire life was opting to go straight to work at Applied Materials after graduation, rather than accompanying the team to Melbourne. When the Big Red won, he says, "I was blown away. And I found out about it in an e-mail in my cube at work."

Aris Samad-Yahaya, a 1999 electrical engineering grad who runs his own software company in his native Malaysia,



We always showed up with new things, were always innovating—not necessarily polished, but something really pushing on the creative side.

relished the project's research challenges. "Doing something like RoboCup, you're not using technology that's fully resolved or fully in the literature," says Samad-Yahaya, who remembers wearing the same clothes for several days after the lost-luggage incident in Stockholm. "You look at what's out there, and if nothing fits the application you want to do, you have to create a solution of your own. You have no idea what the outcome is going to be. You really need to solve a problem, to take things you learned in your undergraduate career and apply them in a very real way."

Although Cornell's RoboCup days may be over, the team spirit lives on. Interdisciplinary projects with the opportunity for hands-on engineering are wildly popular among students. The engineering college is home to more than a dozen teams competing in everything from the design of a solar house to the creation of a concrete canoe.

Ask some of the 150 or so students who participated in the RoboCup over the years, and they'll tell you: the games were fun, and winning was even better, but the greatest pleasure of the project was getting the chance to work with other engineers from across the college. "One person just couldn't build it by himself," says Oliver Purwin, a Ph.D. candidate in mechanical engineering. "The whole team effort is amazing."

Purwin was an M.Eng. student on an exchange program from Germany when he worked on the team that finished third in 2001; he still gets steamed over that twitching robot. He helped improve the omni-directional drive—which allowed the robots to move in all degrees of freedom—and as a grad student he worked on trajectory generation, figuring out the best way to get a robot from Point A to Point B. His fellow RoboCup alums have tackled that issue and a wide variety of others: how to control the ball, interpret visual information, improve agility, or just plain kick harder. "It's a really great feeling, how in the end it all comes together," he says. "The whole thing is just bigger than the sum of all the parts."

Purwin is sitting in Cornell's RoboCup headquarters, a large room on the first floor of Rhodes Hall. The walls are decorated with posters and shirts from previous tournaments around the globe, but the dominating feature is the regulation RoboCup soccer pitch: a green-carpeted surface 2.8 meters long by 2.3 meters wide. Down the hall is a display case featuring the trophies the Big Red brought home every year.

Except one: in 2004, the team made an ambitious foray into distributed intelligence, but wound up being eliminated in the first round. In the space where a trophy might have been, instead sits a small wind-up toy robot, painted bright red but looking rather sad. (Last year, however, Big Red had an improved distributed platform that performed well, and the team came in second.)

"It's great when you have a whole bunch of smart kids working toward a common goal," says D'Andrea. "They see that the stuff they learn in school is actually useful. You work for a year toward building something complex like this, and you go to a competition and you win—that gives you the confidence that, 'Hey, I can do anything if I set my mind to it.'"

Watching a RoboCup match can make you kind of dizzy: those little robots career around like lightning, and the ball moves so quickly it can be hard for your eyes to follow it. Despite the governing organization's focus on imitating human soccer, a RoboCup match is much more like hockey. "It's a fast game," D'Andrea says. "It's entertaining. It's exciting. When you watch some of the games it looks like they're alive, like the robots have a mind of their own."

The present regulation pitch is roughly four times the size of the 1999 field; design improvements made the robots go so fast, they were constantly knocking into each other on the smaller surface. "If you watch the game in 1999, the robots were maybe moving at top speeds of one meter per second," D'Andrea says. "There was essentially no passing, just getting to the ball and aiming it toward the net. By the time of the competition in Japan last year, robots were routinely passing the ball to each other, they were moving at speeds up to 2.3 meters per second, kicking the ball at speeds up to ten meters per second."

On top of offering students a chance for teamwork and technical innovation, RoboCup and other such competitions have another advantage: they're great topics for job interviews. When companies ask for examples of how they've solved problems or worked on a team, students can point to long nights trying to figure out how to whack a golf ball into a soccer goal or build an autonomous submarine. "A common complaint about engineers coming right out of college is that they have absolutely

no idea about practical limitations and how to connect theory and practice," says Audiffred, now an instructor in electrical engineering at Louisiana State University. "This kind of project forces you to do that."

Sherback, who worked in Silicon Valley for three years between college and grad school, took the lessons of the RoboCup with him to the office. The experience, he says, may not have turned him into a computer scientist or an electrical engineer—but it gave him a working knowledge of what those colleagues confront when they're solving problems. "Like any team thing, you learn not to charge in like a bull in a china shop and start barking complaints and orders at people," he says. "You can empathize and understand what kind of burdens you may be putting on them, and appreciate their efforts. It prepares students to go out into the so-called real world." ■ ■ ■



Award-winning teachers in the College of
Engineering share their **teaching**
philosophies, along with
personal tips and
tactics

for connecting with students.

By Peggy Haine



Internationally recognized for cutting-edge research, Cornell Engineering can also point to award-winning teaching that has helped to place it among the top undergraduate engineering programs in the world. Each year the college selects its best teachers to be honored with awards for excellence in teaching and advising. The university also recognizes good teaching with the annual Stephen H. Weiss Presidential Fellowships. Thirty percent of that elite Cornell group are members of the Engineering faculty.

The Weiss Fellowships were established by the Cornell Board of Trustees in 1993 in recognition of the importance of undergraduate teaching at the university. The awards—\$5,000 a year for five years for each faculty member—are named for Stephen H. Weiss '57, emeritus chair of the Cornell Board of Trustees, who endowed the program.

The awardees, nominated by faculty, academic staff, and students, and selected by a presidential committee of Weiss Fellows, other faculty members, and undergraduates, are chosen based on their sustained record of effective, inspiring, and distinguished teaching of undergraduate students and contributions to undergraduate education.

At a meeting in Duffield Hall's Young Colloquium Room, seven of the college's Weiss Presidential Fellows—T. Michael Duncan, David Gries, Daniel Huttenlocher, Michael Kelley, Clifford Pollock, Stephen Sass, and Charles Williamson—gathered to talk about teaching, what makes it work for them and their students, and how they balance teaching and research responsibilities.

Moderator: How did you feel when you heard that you'd been nominated by your students and colleagues and selected for this honor?

Sass: I was surprised, but also pleased, primarily because the students had major input into this. There are lots of awards with faculty input—that's one thing—but having students who are willing to say apparently nice things about me and some of my colleagues, that made me feel very good.

Pollock: I feel the same way. When I got the message that Hunter Rawlings wanted to talk to me, I thought, "Oh no! What did I do?" I was kind of terrified for a day, but then when he told me what it was, I was really thrilled.

Kelley: It's a real grassroots sort of process we all appreciate. You know, you can get your awards for your scholarship and so forth, and those are great. But this was

Huttenlocher

Kelley

Sass



Weiss Fellows for 2005 were announced in November, just weeks after Engineering Weiss Fellows had convened for their discussion. It came as no surprise that there was a member of the Engineering faculty in this latest group of Fellows: Professor Anthony Ingraffea. Here's his take on teaching.

A "PERSONAL EXPERIENCE"



Professor Anthony Ingraffea, Dwight C. Baum Professor of Engineering in the School of Civil and Environmental Engineering, has been teaching structural mechanics, finite element methods, and fracture mechanics at Cornell since 1977. He also teaches an introduction-to-engineering course and a key sophomore-level course, and his students consistently praise them as among the most enlightening, provocative, and insightful classes they have taken.

Ingraffea was an early adopter of the Internet in the classroom as a communication medium. "It gives us access to other peoples' way of teaching, real life examples, explanations in three dimensions, in video, from all over the Internet, in real time," he explained. With engineering faculty at Syracuse University, he has been experimenting in distance learning, with lectures given at Cornell or at Syracuse and received live by students at both universities on wireless tablet computers.

How does he define good teaching? "It's not the result of research or the result of reading the journal of the American Society of Engineering Education every month for the last twenty years, though I do. It's the result of my own personal experience.

"As I'm preparing notes for a lecture I'm constantly challenging myself to think back to when I was 17 or 18 years old and seeing things for the first time, and trying to subtract everything I know now. I try to think like a student. It makes me feel young, too. Almost all the students will fall into predictable chasms—things are very abstract and it's difficult to make them concrete. If there's a chasm I go to extra lengths to try to explain as many ways as I can and to slow down. That's totally different from saying it in the most elegant way, the most succinct way.

"I find that what students respond to is being treated like budding young professionals. I never use the word

'homework' (that's what you did when you studied with Sister Mary Margaret). And I never use the word 'class'; I have 'professional meetings.' There are no 'exams'—there are 'preliminary reviews' and 'critical reviews.' I try to use the language of professionals. I also expect the students to act professionally. There's a lot of discussion; I want them to ask questions as they would their boss or a colleague."

His advice for new teachers? "Demand from Cornell students more than you expect that they can give—the worst you can do is to demand too little. We get the best. Always expect that there's going to be someone in the classroom smarter than you, and be happy when you find that person. Let that person be a challenge. Don't let the difficult balance of research and education get in the way of treating education as a scholarly enterprise—it's not just something you have to do to fill in the time between research projects. Every new class is a new set of challenges and what worked in the first class may not work in this one. It's open-ended research; it never finishes."

—Peggy Haine

something different. I don't know if they still do it now, but I felt like a rock star at the presentation!

Gries: It's also a nice recognition from your colleagues. The department had a lot to do with putting forth the nominations.

Huttenlocher: Perhaps I can add perspective from the side of the selection committee. What the students have to say about the faculty, about their commitment to their students, and the students' appreciation of that, affected me more than the award itself.

Duncan: I, too, was perplexed when I was told the president would call me at a certain time. I was afraid I was going to be tapped for some university committee. I was surprised—I didn't know that the nomination had gone in and I was really taken aback. I was, of course, very flattered, mostly from the recognition that my department chose to submit a nomination.

Williamson: I heard that the president had been trying to get hold of me for two days, before I owned a cell phone—1999—and so actually did not get the message until I arrived home at 4 a.m. in the wee hours of a Monday morning, having driven in from a U.S. national sailing championship. I immediately guessed what the message was about and was totally thrilled. The recognition from students, colleagues, and the university is one thing, but to be part of a group with other professors whom I so respected already as my total heroes was another.

Moderator: You've all been recognized as good teachers, and you're all clearly very different kinds of teachers. What do you think makes a good teacher?

Pollock: Well, I think it's many things, but in general a good teacher is someone who's really gone out of the way to engage a student or help them or give them an experience they wouldn't have gotten. It's someone who has real passion that's palpable, an enthusiasm for what they're doing. They enjoy what they're doing, and the students enjoy participating.

Kelley: At Cornell, at least, I think students really appreciate it when they come to see you and you actually talk to them. You don't say, "Come back tomorrow," or meet them in the hall and say "I've got to go." I think that means a lot. I think there's something right at that instant—whatever's on their mind—that's the most important thing.

Sass: This is a research university. The students come here because of that. But what's special, I suspect, is that people who are good researchers generally have great drive to do an excellent job of teaching. We're good at giving students personal attention, getting them started in research in their freshman year. I always liked the research and I did pretty well teaching. But I didn't take teaching really seriously until my son was a freshman here and one of his friends was in my class, and I suddenly thought, "What if he tells my son, 'Your dad's a loser?'" These are someone's kids. I want to do well by them.

Gries: I had the same thing with my son in my

class. There were 300 students in my class, and I stayed away from his exams and so on. But it still gives you a certain feeling. Any one of those students could be your child, and you should treat them properly.

Moderator: Do you think there is a certain "thinking outside the box" that you feel you need to do in order to teach well?

Huttenlocher: I'm in this field because I'm excited about it, and it's important to me to convey that excitement to students. I was one of the people who, as a student, blew off a lot of my lectures, so I think I've always felt very motivated to try to convey some of what excites me about a topic in the classroom. You have to draw on examples from your own experience to supplement the often unexciting text and let them know why you think the material is exciting.

Pollock: I think that's exactly the issue. You have to go in and be really, sincerely enthusiastic. You're up there and you're having a good time, and you're conveying "This stuff is so cool—look at it!"

Williamson: For my class, I have tried to bring the subject to life with in-class demos, mostly desktop, and with even simple props to reinforce fundamental book work and to spice up the engagement with the students. Humor, which is not generally found in textbooks, also helps. But these demos must have a serious basis pedagogically, of course, and are sometimes subtle and often quite involved.

Duncan: I've found that the greatest demand on my creativity is formulating exercises. I have a certain number of concepts or goals I want to get across in the lectures. For my recitations I prepare a set of exercises that the students work together. We share the answers and discuss them. I find the students learn best by doing the exercises, so they've got to be designed to start easy and grow in difficulty. I feel they don't get a lot out of the lectures because they're mostly passive—they're stenographers. In most of my lectures, they aren't taking notes—they're watching what I'm doing. And then they go and do it themselves in recitation and homework.

Kelley: Something I've been doing for about 10 years now is organizing recitation sections in small groups where they actually teach each other. In addition, I try to bring in undergrad seniors to work with the students, and that's an area where I think we're certainly underfunded. We have graders and we have TAs, but there's not much opportunity for Cornell undergrads to get involved in teaching. I think there's a big untapped resource there, and it's important training. When you have student TAs, you spend a lot of time in teaching how to teach. I keep telling my TAs that they're going to be teaching somebody something for the rest of their lives, either a technician who's doing things for them, or a CEO who's approving some hundred-million dollar plant or something, and you need to reach these people to teach them.

Moderator: How can you tell when you're getting through to your students—or when you're not getting through to them?

Sass: Well, I guess you can tell if they're staying awake.

Gries: You know when you're connecting just by looking at the body language.

Sass: I remember years ago, it was April, and it was getting warm out, and I was at a boring point in the lecture, and you could see the students desperately trying to hold on. I put my notes aside and started telling anecdotes, stories that we find from our own experiences. It's useful to have a sense of humor and to be able to make fun of yourself. I talk about things that happened 2,000 or 50,000 years ago and make it relevant in today's world. I always joke that I'm kind of parental about this, or worried about that. Making it personal is really what counts, I think. It's harder for a young faculty member to do that because they may not have the background, the experience, the stories.

Duncan: You have to do something every twelve or fifteen minutes to re-set their attention clock. You can break from the normal story with, "And now a word from our sponsor," a commercial interruption. You do something else, and they stop and think and listen to this, and then you say, "And now back to our story." It helps to take them away from what they were doing and then bring them back, to re-set their attention clock for another ten minutes.

Moderator: Do you feel that you teach differently if you're in front of a large class, as opposed to a seminar?

Huttenlocher: For me big lecture classes are primarily about performance at some level. Even the question-and-answer in a large lecture course is a caricature of a real question-and-answer because the students that speak up in a large class are usually not the ones who don't know what's going on. And it's not that this doesn't have value. It's just that it's very different from a small setting, say office hours, or a seminar, where students are less afraid to look stupid because it's just you or a couple of other students.

Duncan: The goal is to get the students in a large class to feel they're in a small class. And you can tell when you've lost a big class because it's as if they're watching TV—they're passive and they'll be probing various body orifices, as they'd be doing in front of a TV and not be doing if they knew you were talking to them one-on-one. You're looking at them, you know if they're there or not, and there are things to do to get them to feel you're talking directly to them. It helps if you know their names.

Kelley: I've experimented with having a few short-answer things I ask them to do together. By breaking up the class, you lose a few minutes, but they've actually learned something. The room buzzes awhile, but they settle down and you can go on just as well.

Gries: Once in awhile I try to give them a question where the answer is not so obvious. There may be several ways a problem might be done, and you encourage them

to look for three, four, or five different answers and give reasons for each.

Sass: I taught history of science classes for students in the Arts College and what I was amazed about was how differently they interact in the class than engineering students do. I had humanists, linguists, art historians in this class, and I asked a rhetorical question. I turned to a blackboard to answer because I assumed that, as in engineering, no one would answer. And as soon as I asked it they began throwing answers at me. People in Arts and Sciences are very used to interacting and discussing. For people in Engineering, there's a right answer and there's a wrong answer. They don't want to look foolish. So what I've learned from that is to wait. You know if you ask a rhetorical question you wait and wait—you don't just give up.

Huttenlocher: Yes, knowing to pause long enough is an incredibly important device. I can't bring myself to sit there and count to five or ten slowly enough, so the device I use is to pace all the way across the front of the lecture hall because I know that takes me about five seconds to pace back.

Duncan: I use a cup of coffee. They know you're not going to stop the clock, as long as you've got the cup to your face, and if you take a good sip and then swallow, they know they still have time to answer.

Moderator: How do you balance this very wonderful teaching with your research and administrative responsibilities? Do you find that one suffers as a result of the other?

Kelley: Well, I think we're pretty blessed at Cornell in terms of relative time that we put into teaching—we have pretty reasonable teaching loads most of the time.

Sass: My wife taught writing at a local college and taught three or four courses a semester, and if I ever complained [about my teaching load], the discussion ended in a hurry. Mike's right—we're very fortunate.

Huttenlocher: Teaching is a contributor; it pushes your research forward. You start thinking, when you're teaching a class, how it relates to your research and how to break some of these ideas down into the curriculum. You

get a better understanding. I think it's important not to lose track of the fact that these aren't purely things that trade off against each other.

Williamson: Getting undergrads involved in research—real research—is great. Students hear what you're doing through your class, and they want to work with you.

Pollock: This is kind of ironic, but I get more done when teaching starts, become better organized. It's more than synergy—it's stimulating. It's refreshing.

Moderator: Do you think winning a teaching award is the kiss of death for young faculty members?

Williamson: I think that this very special award is so totally *not* the kiss of death; it is veritably the "kiss of life"!

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There is no one who has been awarded this fellowship who is not also accomplished in research, with a long track record in both research and teaching, and usually merging to some extent the two passions.

Huttenlocher: I think the reality of it is that to succeed at Cornell you absolutely have to be a researcher and that's the way it is and the way it should be. And sometimes if people are weak in one thing and strong in another they'll be recognized for the thing they're strong in. So just because someone's gotten a teaching award, to me it's not an argument that they should be tenured at Cornell. They have to be a researcher of the right quality too. And that's why I feel like these Weiss awards are probably better, because they are oriented more toward senior faculty. I think [junior faculty] should be mentored by their departments and see, through role models, that the senior faculty in that department take both teaching and research seriously.

Pollock: I find that the award winners are not just strictly outstanding teachers.

Huttenlocher: I agree. They're awarded to someone who's had an impact on the field, the university, and society, as well as in the classroom. I can't think of any Weiss fellow who's not also an outstanding researcher.

Pollock: To me, one thing about being a good teacher is not just to be a popular teacher, and I think that's a delicate but important line. If you can be popular and good, that's great. But there are ways in which you can pander to students to increase your popularity, and I think the way the Weiss is structured, it doesn't tend to select that kind of person. And it looks at the broader role within the university. I think one thing that research universities that pay attention to teaching have to offer is that people who are interested in and able to really put effort into their teaching, when their research is still a primary piece of their career, can really challenge their students.

Moderator: What advice do you have for new teachers?

Pollock: I would say just be enthusiastic.

Williamson: And of course really knowing your stuff, and being yourself instead of trying to be somebody else—that comes across.

Gries: And don't worry if it doesn't go right the first time.

Williamson: But be worried enough to get it right the second time.

Sass: But life's an experiment and not every experiment works. And maybe when you teach it the second time, you get it right. ■ ■ ■

WEISS WINNERS SINCE THE BEGINNING

The Stephen H. Weiss Presidential Fellowships were established by the Cornell Board of Trustees in 1993 in recognition of the importance of undergraduate teaching at the university. Engineering faculty members are listed in red.

1993

Richard D. Aplin, Agricultural Economics
James B. Maas, Psychology
Mary J. Sansalone, Civil and Environmental Engineering

1994

David A. Levitsky, Nutritional Sciences
Walter LaFeber, History
Stephanie Vaughn, English

1995

David M. Galton, Animal Science
David Gries, Computer Science
Meredith Small, Anthropology

1996

Frederick M. Ahl, Classics
Daniel P. Huttenlocher, John P. and Rilla Neafsey Professor of Computing, Information Science, and Business, Computer Science
Lois S. Willett, Agricultural, Resource and Managerial Economics

1997

Joan Jacobs Brumberg, Human Development and Family Studies
Debra Ann Castillo, Romance Studies
David M. Feldshuh, Theatre, Film and Dance
Clifford R. Pollock, Ilda and Charles Lee Professor of Engineering, Electrical Engineering

1998

Ali Hadi, Industrial and Labor Relations
Michael C. Kelley, James A. Friend Family Distinguished Professor of Engineering, Electrical Engineering
Isaac Kramnick, Government

1999

Florence Berger, Hotel Administration
Daniel Schwarz, English
Charles H.K. Williamson, Mechanical and Aerospace Engineering

2000

Jeffrey Haugaard, Human Development
Kenneth C. Hover, Civil and Environmental Engineering
Deborah Hale Streeter, Applied Economics and Management

2001

Rosemary J. Avery, Policy Analysis and Management
Timothy J. Fahey, Natural Resources
Stephen L. Sass, Materials Sciences and Engineering

2002

W. Bruce Currie, Animal Science
Richard Polenberg, History
Mariana F. Wolfner, Molecular Biology and Genetics

2003

Louis D. Albright, Biological and Environmental Engineering
Geraldine Gay, Communication
Kenneth A. McClane, English

2004

T. Michael Duncan, Chemical and Biomolecular Engineering
C. Richard Johnson, Electrical and Computer Engineering
Peter J. Katzenstein, Government

2005

Ronald Ehrenberg, Industrial and Labor Relations
Anthony Ingraffea, Dwight C. Baum Professor of Engineering, Civil and Environmental Engineering
Paul Sherman, Neurobiology and Behavior

EXCEPTIONAL CREATIVITY

Cornell Professor Jon Kleinberg receives MacArthur “Genius Award”



I was completely surprised when I heard about this. Then I thought back on all the people who have won this and felt humbled.

The John D. and Catherine T. MacArthur Foundation last fall named Jon Kleinberg, Cornell professor of computer science, among the 25 new MacArthur Fellows—the so-called “Genius Awards”—for 2005. He will receive \$500,000 in no-strings-attached support over the next five years.

Kleinberg, who received his bachelor’s degree from Cornell in 1993 and became a faculty member just three years later, is a computer scientist with a reputation for tackling important, practical problems and in the process deriving deep mathematical insights. He is best known for his contributions to network theory, particularly in expanding the “small worlds” concept and in developing improved methods for searching the World Wide Web.

But his research also covers Internet routing, data mining, comparative genomics and protein structure, and the sociology of the web.

“I was completely surprised when I heard about this,” Kleinberg said. “Then I thought back on all the people who have won this and felt humbled.”

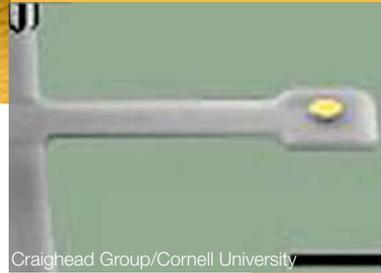
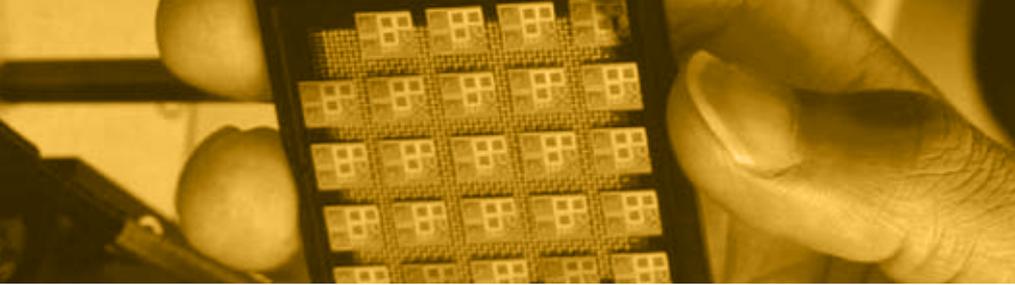
The MacArthur Fellowships are awarded based on “exceptional creativity, promise for important future advances based on a track record of significant accomplishment, and potential for the fellowship to facilitate subsequent creative work.” The foundation does not require any reports or evaluation from the recipients. “It’s a chance to do things that would be hard to do otherwise,” Kleinberg said. “It gives you a level of freedom and flexibility that would be hard to get any other way.”

It has become widely understood that any two people are linked by a relatively small number of connections among mutual acquaintances—or “six degrees of separation.” The same mathematical principles apply to computer or other networks as well as networks of people. Kleinberg extended this concept by introducing the notion of navigability—how well the information structure of the network allows individuals to make distant connections efficiently. He was able to prove that in networks with random connections, a computer algorithm with only local information has no way to find the shortest path to a distant point. This demonstration has important implications in sociology and in distributed network architecture design and in applications, such as peer-to-peer file sharing.

In addition, Kleinberg has developed an algorithm—a method on which computer programs can be based—for identifying the structure of web site interactions. His algorithm distinguishes “authority” sites, which contain definitive information, from “hub” sites, which refer to authority sites using hyperlinks. The algorithm is used in several contemporary web search engines, where sites that are most linked to by the most important hubs are listed higher in search results. Beyond that, the algorithm makes it possible to identify communities of interest on the web without explicit effort needed by members and even without an awareness of the existence of the community, simply by examining links between sites.

Recently he has applied these ideas to sociology and is a member of a group of computer scientists and sociologists collaborating to study the sociology of the web. “It’s great to be working with sociologists, because they bring such different perspectives and they’re so good at posing interesting questions,” he noted.

—Blaine Friedlander Jr, Cornell Press Office



Craighead used tiny oscillating cantilevers to detect masses as small as 6 attograms.

Craighead Group/Cornell University

ZIP CHIP



It's so common that it's almost a cliché: To start a high-tech company, you need to team a scientist with a business person.

Rajit Manohar, Cornell associate professor of electrical and computer engineering,

has been working for over a decade on a way to increase the speed of computer chips. He wasn't planning on starting a company, but he happened to describe his idea to John Lofton Holt, a former electrical engineer who has spent the past decade as a business consultant on high-tech matters. And Achronix Semiconductor was born. Holt is chief operating officer; Manohar is chief technology officer.

Manohar had submitted his invention to the Cornell Center for Technology, Enterprise and Commercialization (CCTEC), which is responsible for moving research results into the marketplace. CCTEC had applied for a patent, but according to Ernest Davis, the CCTEC technology manager assigned to manage the invention, it seemed, initially, that more licensing opportunities existed with existing manufacturers, rather than through startups.

Manohar was thinking along the same lines. Or perhaps, he thought, starting a company that would just help other companies design products with the new technology. "I knew that John had done a lot of consulting and had a very good handle on the business side of things, so I asked him for advice, and if he would be interested in getting involved," he recalls.

What Achronix will market is a very fast "field programmable gate array" (FPGA) chip. Never heard of it? These chips are all around you—and if Achronix has its way, there will soon be a lot more.

Practically everything electrical has a chip or three or four in it: telephones, cars, video games, microwave ovens, cameras, even some toast-



VLSI layout for an asynchronous FPGA

ers—some \$77 billion a year worth of chips, \$24 billion of which are "custom logic" chips, with programming specific to the device. About 75 percent of those are "application-specific" chips, with the programming hard-wired into them. The rest are FPGAs, currently representing about a \$4 billion market.

Manohar's innovation is a way to speed up an FPGA chip by, ironically, removing the clock. He devised a way to let each component on the chip run at its own maximum speed, notifying the next in line when it is finished processing and can pass along its result. FPGA chips using Manohar's technology can run as fast as application-specific chips while offering the flexibility of programmability, and adding power efficiency as a bonus.

CCTEC's Davis is managing the patent application and has executed an agreement for Cornell to license the patent to Achronix. Under Cornell policy, inventions by faculty are the intellectual property of the university, with licensing revenue shared among the inventor, the inventor's department, and the university. So, technically, Manohar's company had to secure a license to market its co-founder's invention. Fortunately, Holt says, speaking from a lot of business experience, "Cornell is a very pleasant organization to work with."

As soon as a prototype chip was designed and tested, customers started calling, Holt says. The company expects to ship its first orders by the end of the year.

—Bill Steele, *Cornell News Service*

GUINNESS RECORD FOR CRAIGHEAD

Harold Craighead, Charles W. Lake Jr. Professor of Engineering in the School of Applied and Engineering Physics, and research assistant Rob Ilic have their research featured in the 2006 edition of *The Guinness Book of World Records*.

In its Science and Technology section, the book cites the "Lightest Object Weighed": a mass of 6.3 attograms. An attogram is one-thousandth of a femtogram, which is one-thousandth of a picogram, which is one-thousandth of a nanogram, which is a billionth of a gram. The entry is based on research reported in the *Journal of Applied Physics* in April 2004 (and profiled in the April 15, 2004, *Cornell Chronicle*), in which the researchers used changes in the vibration of a nanoscale oscillator to detect the mass of a single E-coli bacterium.

Researchers in the Craighead lab have since extended the work to detect the mass of viruses, and expect to go even smaller.

—Bill Steele,
Cornell News Service



FUELING THE FUTURE



Larry P. Walker has been awarded \$750,000 by a New York state research agency to explore the use of plant and microbial resources to produce biofuels, industrial chemicals, natural products, and other consumer goods.

Walker, a professor in the Department of Biological and Environmental Engineering, received the award through the New York State Office of Science, Technology and Academic Research's (NYSTAR) Faculty Development Program. The funds are designed to assist universities in the recruitment and retention of leading research faculty in science and technology fields with strong commercial potential.

The award was part of more than \$4.4 million in funding to researchers at five universities in New York state.

Walker's NYSTAR-funded research will concentrate on integrating nanotechnology with classical molecular biology and microbiology techniques to engineer industrial enzymes or to identify novel microorganisms that are important in the

production of biofuels and industrial chemicals. His research group has been actively involved in developing more efficient and cost effective enzymes (cellulases) that can convert plant-derived cellulose into fermentable sugars and developing the processes that can convert these sugars into ethanol, hydrogen, and other important fuels or industrial chemicals. Another major focus of Walker's research group is to develop a lab-on-a-chip device for an accurate and detailed description of bacteria and to identify novel industrial microorganisms and enzymes that could be employed in bioconversion.

Walker has been involved in a number of biomass-to-energy and chemical projects, including an assessment of New York state biomass resources available for ethanol production, on-farm methane production and cogeneration, the application of nanotechnology to discover and study important biocatalysts for industrial biotechnology, and the optimization of solid-state fermentation for the production of biocontrol products.

—Susan S. Lang, *Cornell News Service*

OVERSEEING CNF

While faculty and administrators at the National Science Foundation (NSF)-funded Cornell NanoScale Science and Technology Facility (CNF) search for a new director, John Silcox, the David E. Burr Professor of Engineering at Cornell University, stepped in Oct. 1 as interim director.

"We're very fortunate that John Silcox, an experienced and effective science administrator with deep roots in the materials community at Cornell and CNF, has agreed to serve once more," said Joseph A. Burns, vice provost for physical sciences and engineering. In the past, Silcox has served twice as director of the School of Applied and Engineering Physics, as director of the Cornell Center for Materials Science, and as vice provost for research for physical sciences and engineering prior to Burns's appointment.

"This is an extremely important facility for Cornell and many others who visit us, so it will be a challenge to keep it going as successfully as it has been over the past 25 years," said Silcox, one of the world's leading researchers in the field of electron microscopy.

CNF is a national facility serving Cornell and external users for research and instruction

in nanoscale science and technology. Researchers and students encompassing astronomy, plant pathology, materials science, physics, chemistry, life sciences, various departments of engineering, and industry use the tools available in the facility for building structures, devices, and systems from atomic to complex large-scales.

Jurriaan Gerretsen, currently the associate director of the NSF-funded Center for Nanoscale Systems, will serve part-time as interim associate director of CNF.

Meanwhile, a search committee, led by Burns, has been formed to permanently replace the previous director, Sandip Tiwari, who has moved to a new position as director of the National Nanotechnology Infrastructure Network, a nanoscience research consortium of 13 universities.

"We are looking for an internationally known scientist or engineer to lead CNF and join the faculty," said Burns.

The CNF is supported by the NSF, New York State Office of Science, Technology and Academic Research, Cornell University, industry, and users.

—Krishna Ramanujan, *Cornell News Service*

We're very fortunate that John Silcox, an experienced and effective science administrator with deep roots in the materials community at Cornell and CNF, has agreed to serve once more.



TIMELY IDEA

Adam Hocherman '97 ME, now a second-year MBA student at Cornell University's Johnson Graduate School of Management, had a little idea that has had big press coverage and healthy sales—not to mention better class attendance on campuses around the world.

The Neverlate 7-Day Alarm Clock was featured on CBS's "Early Show" as "the perfect off-to-college gift" and has won praise in the *New York Times*' Circuits section as well as in magazines and newspapers in Europe and Asia.

With seven independent alarms, one for each day of the week, the tableside clock radio can be set just once a semester for a student's entire schedule—9 a.m. classes on Monday, Wednesday and Friday, a late lab on Tuesday, no classes on Thursday. Changes, such as a canceled class, are easily accommodated without having to reprogram the entire setup.

The feature that Hocherman is proudest of is a simple but revolutionary "nested rotary control" that he invented and is patenting. The easy-to-use rotary-style dials for the clock's various settings

replace traditional push buttons. There is a unique "customizable snooze" feature, allowing reprieves of 1 to 30 minutes for students who aren't quite ready to rise, he says. Other features that can be customized are a power nap timer (a student favorite) and a sleep timer.

An industrial designer helped him fine-tune the 5-inch-square clock's appearance, which is, in Hocherman's words, "retro but modern, with a clean look and a small footprint."

Hocherman, who manages to run his business between classes at the Johnson School using "really good time management" skills, says the idea for the clock came to him as a Cornell undergraduate (he earned a B.S. degree in mechanical engineering in 1997). The motivation to actually develop it didn't arrive until years later, however, when he tried to purchase a clock radio for a girlfriend as a holiday gift: "I stood in the store marveling at how unattractive and difficult to use the products for sale were and thinking to myself, 'I can do better.'"

—Linda Myers, *Cornell News Service*



MBA student Adam Hocherman with his Neverlate 7-Day Alarm Clock. Hocherman, who got the idea for the clock as an undergraduate engineering student, runs his startup business while studying business at Cornell University.

ASSESSING KATRINA

Thomas O'Rourke, the Thomas R. Briggs Professor of Civil and Environmental Engineering, has been named to a panel convened by the National Academy of Sciences and the National Academy of Engineering to study the effects of Hurricane Katrina and the adequacy of hurricane protection infrastructure in New Orleans.

The committee will provide an independent review of the government's interagency investigation of the disaster. A primary study is to be conducted by an Interagency Performance Evaluation Task Force (IPET) headed by the U.S. Army Corps of Engineers and including representatives from the Federal Emergency Management Administration, the National Oceanic and Atmospheric Administration, the U.S. Bureau of Reclamation, and the U.S. Department of Agriculture. The group is also working with an external review panel from the American Society of Civil Engineers (ASCE).

The group O'Rourke is joining was created at the request of the Department of the Army to ensure an open and unbiased review of the study, O'Rourke said. The committee will consist of 16 scientists and engineers from academia and industry, none of whom have any ties to the Corps

of Engineers or any other entity with a stake in New Orleans infrastructure. G. Wayne Clough, president of Georgia Institute of Technology, will chair the committee.

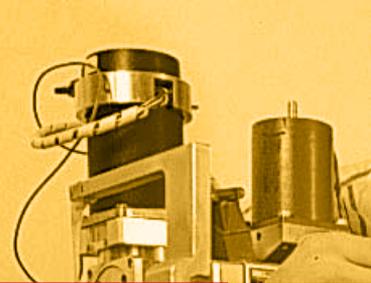
The panel's job will be to review the work of the IPET and ASCE teams to ensure correctness of their data and consistency with accepted engineering approaches and practices. They will review the teams' conclusions and seek to determine lessons learned from Katrina and to identify ways that hurricane protection system performance can be improved in the future.

"As I understand it," O'Rourke said, "the interagency group is supposed to get the facts, the ASCE group is to do its best to verify those facts, and our job is to synthesize them."

At Cornell, O'Rourke conducts research on the effect of earthquakes, wind, and other disasters on infrastructure, with a focus on underground utilities. He has studied the effects of the World Trade Center collapse in New York City in September 2001 and the recent subway bombings in London.

—Bill Steele, *Cornell News Service*





CONFERENCE CHAMPS



Colin Cerretani '07, Phillip Nelson '07, Kristal Ramjeet '07, and Alex Loo '06 made up the winning team in the College Bowl competition at the 18th annual Society of Hispanic Professional Engineers Technical Career Conference in Philadelphia in October.

Members of the Cornell University chapter of the Society of Hispanic Professional Engineers (SHPE) returned from the society's Eastern Technical Career Conference in Philadelphia last fall with an armload of prizes.

In the College Bowl competition, a Jeopardy-style quiz with engineering questions, a team composed of Colin Cerretani '07, Alex Loo '06, Phillip Nelson '07 and Kristal Ramjeet '07 (alternate) took first place, with each team member receiving an iPod Nano, courtesy of conference sponsor Lehman Brothers. Four teams had been selected for the College Bowl based on written tests. Cornell and the University of Pennsylvania wound up in the finals, with the Cornell team sailing to victory with a score of 1,200 to 299. The team went on to compete at the society's national conference at Disney World in January.

In a technical web site competition sponsored by Morgan Stanley, a team composed of Sahib Dhindsa '08, Gino Gonzalez '08, and Phillip Nelson

'07 came in second with a site showing how Amazon.com rankings could predict stock prices for product manufacturers. Each team member was awarded a \$1,000 scholarship.

In a technical paper competition, papers by graduate students Jing Shi and Carlos Torre tied for third place, with each student receiving a \$750 grant from BAE Systems.

The Cornell chapter of SHPE, founded in 1979, has about 50 members. Activities include career development, community service, academic enrichment, and social and career networking. The organization is open to anyone, regardless of major or background. Information is available on the web at shpe.cornell.edu.

—Bill Steele, Cornell News Service

TECHNOLOGY INNOVATORS

Technology Review magazine has named two Cornell University faculty members to its "TR35" list, the magazine's selection of top technology innovators under age 35. They are Matthew DeLisa, assistant professor of chemical and biomolecular engineering, and Rajit Manohar, associate professor of electrical and computer engineering. Winners from previous years, the magazine says, "have changed the world."

Manohar is a co-founder of the Computer Systems Laboratory, which brings faculty of the School of Electrical and Computer Engineering and the Department of Computer Science together to research problems of mutual interest. His research focuses on the design of integrated circuit chips. *Technology Review* cited him for an innovation in chip design that removes the "clock" from a chip. Rather than having all operations on a chip move in lockstep to a single timing signal, Manohar designs chips in which each operation can signal that it is finished, allowing the next operation to begin immediately. In addition to being faster than chips with a conventional clock, Manohar's chips are 10 times more energy efficient because "You only activate the part of the chip that's doing the work you need." He has used the

technology to make sensors that could run on the same batteries for years instead of weeks.

DeLisa studies the machinery cells use to make proteins and has used the results to improve the biomanufacturing of drugs. Many drugs are now made by growing huge vats of bacteria that have been genetically engineered to use their protein-making machinery to produce drug molecules or human proteins such as insulin. DeLisa has gone further by modifying the protein-making machinery itself to make it more efficient, inserting genes from higher organisms. In particular, he has studied the transport mechanisms cells use to move proteins inside the cell and across cell membranes. In addition to improving drug manufacture, the research could lead to improved drug design and new drug-delivery systems. He also studies the mechanisms by which proteins "aggregate," or clump together, a process involved in diseases like Alzheimer's.

—Bill Steele, Cornell News Service



SPARKING THE WOBBLE

Steve Strogatz has a penchant for things that happen in unison. So when the Cornell University professor of theoretical and applied mechanics heard that thousands of pedestrians had caused London's Millennium Bridge to rock from side to side on its opening day, he was intrigued.

Before the bridge across the River Thames opened, designers hailed it as "a pure expression of engineering structure." They compared its sleek look to a blade of light. Engineers called it "an absolute statement of our capabilities at the beginning of the 21st century."

But here's what happened: The Millennium Bridge, a 320-meter-long lateral suspension bridge connecting London's financial district to Bankside, south of the river, opened June 10, 2000. Thousands of pedestrians streamed over it. At first, the bridge was still. Then it began to sway, just slightly.

Then, almost from one moment to the next, the wobble intensified. And suddenly, people were walking like tentative ice skaters: planting their feet wide, pushing out to the side with each step. Left, right, left, right, in near-perfect unison.

The synchrony was utterly unintentional. But it was those unchoreographed footfalls, says Strogatz, that were responsible for turning a \$32 million design triumph into a very embarrassing engineering quandary. The bridge was closed almost immediately.

Strogatz, who has studied the collective behavior of biological oscillators from neurons to fireflies, described each of the factors that contributed to the bridge's swaying in a paper published Nov. 3 in *Nature*. Cornell graduate student Daniel Abrams is one of the paper's co-authors.

The problem, says Strogatz, was one of crowd dynamics as much as engineering. The bridge surpassed standards for withstanding weight and wind. Every nonhuman element had been tested.

Instead of focusing on the structure, Strogatz examines the strange phenomenon of people unknowingly working together, simply by walking.

The military has known for years that troops marching in step can create enough vertical force to destroy a bridge. But the Millennium Bridge problem is not quite the same, says Strogatz. In this case, the movement was lateral, not vertical. And the people were just pedestrians. No one was trying to walk in step.

But which came first, the bridge's movement or the synchronous strides? And what set the whole thing off?

"It's a chicken-and-egg problem," says Strogatz. "That's what our paper explains." From



The notorious opening-day oscillations of London's Millennium Bridge were examined in the Nov. 3 issue of *Nature*.

the beginning, the bridge had two factors working against it: It was by design a flexible structure, and its natural frequency is close to that of human walking. From there, Strogatz says, all it needed was a relatively small crowd to spark the wobble.

"If the people are initially disorganized and random, if a few of them get into sync by accident, the bridge would become unstable," he says. With a certain critical number of pedestrians, the wobbling becomes marked enough to force everyone into stride—thus compounding the problem.

And the critical number of pedestrians, tested subsequently on the Millennium Bridge and derived independently by Strogatz and co-authors, is as low as 160. An estimated 80,000 people crossed the bridge on opening day, with as many as 2,000 on it at any one time.

"I'm not a civil engineer. I know nothing about bridges," says Strogatz. "What I do know is group behavior. That was our contribution."

If Strogatz's analysis is correct—"and we hope someone will test it," he says—engineers will be able to use it to prevent such expensive, embarrassing, and possibly dangerous fiascos in the first place.

"They could solve the problem before they build it," says Strogatz. "That's what this theory will do."

—Lauren Gold, *Cornell News Service*



Provided

HOMETOWN HERO

Dancer-choreographer Martha Graham called dance the “hidden language of the soul.” It’s a language that Wolfgang Sachse speaks fluently.



Wolfgang Sachse is an engineering professor who dances tango. He tangos in Ithaca, Syracuse, and Rochester; he tangos in Austria, Germany, and Switzerland; he tangos at airports, at village fountains, and atop

mountains. He is a man who dances wherever he can. And he’s not alone: There has been a global explosion of tango during the past decade. “You can look online,” enthuses Sachse, “and find tango communities all over the world.”

Sachse earned his B.S. in physics at Penn State and his M.S. and Ph.D. degrees in mechanics and materials from Johns Hopkins before joining Cornell in 1970. The Meinig Family Professor of Engineering, Sachse is on the faculties of Theoretical and Applied Mechanics and Mechanical and Aerospace Engineering, where his teaching covers the fields of experimental mechanics, dynamics, vibrations, elastodynamics, sensors, and actuators. Over the past decade he’s been teaching a freshman Introduction to Engineering course focused on the diverse technologies and design integration of digital audio and video players. His research focuses on the use of ultrasonic techniques to characterize material properties, to detect and diagnose possible failures in them, and to predict their future performance. He has authored and edited four books, written over 200 technical papers, and received two patents while editing the journal *Ultrasonics* and chairing the biannual Ultrasonics International conferences.

But does any of this relate to the tango? “Oh, not at all,” Sachse confirms. “It’s yin and yang. I have my research and my professional life and this is the antidote. I’ve discovered another part of the universe here in Ithaca: At our weekly *practicass* and *milongas* less than one third might be Cornell people, the rest are locals.” He jokes, “I’ve been told there are 300 important people in this town, and I am proud to say I’ve now met 72 of them.”

Sachse first got involved with tango by taking pictures of it. “In 1994, three out of four of my grad students were learning to dance tango, so I went to a couple of events. I saw the incredible motion, of two people

moving together in a beautiful way. I found the connection between people fascinating, so I tried to capture that on film.” His wife, Gretchen, died of cancer in 1999 at age 54. “That was a reality check. It made me realize there was more to life than just work.” But what finally pushed him over the edge from watching into dancing was attending a friend’s 40th wedding anniversary *milonga*. “I saw the couple dancing together and smiling, after all those years of marriage. A few months later I went to a memorial *milonga* to celebrate the life of a young *tanguera* who had died of cancer. I learned that tango celebrates milestones in people’s lives, both good and bad. This dance has helped me to move on with my life.”

Tango as a dance includes three principal styles: There is the *tango* which is the classical dance music comprising a melody with a bass beat; the *vals*, which is flowing so that the dancers are moving continuously, and the *milonga* which is usually fast and has the dancers stepping on every beat. The way in which these are danced

may be show or performance tango or classical, Argentine tango. “In Ithaca we dance Argentine tango,” says Sachse, demonstrating with precise, tiny steps in his eclectic office in Thurston Hall, where piles of his panoramic photos and homemade tango calendars fight for space with engineering materials. Sachse shares tango books and pictures, playing tracks off a new tango CD from Japan while simultaneously explaining his work with passive ultrasound. “I listen to materials talk.” He rips a piece of paper. “Do you hear that? It’s like a fault that’s moving. It’s seismology of the microscale.”

On the macroscale, Sachse has clearly also learned to listen to his own moving parts. “Now I’m able to move comfortably. I try to give a strong lead, so my partner can just close her eyes, enjoy the movement and sensuousness while gliding across the dance floor. Fifteen years ago I was afraid of moving my body, but tango has let me connect my body to my soul to be touched by my partner. Tango is not just a dance.”

—Melanie Bush

INCREDIBLE MOTION



Photos by Wolfgang Sachse

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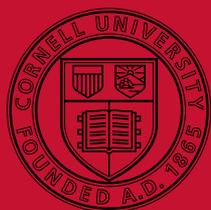
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