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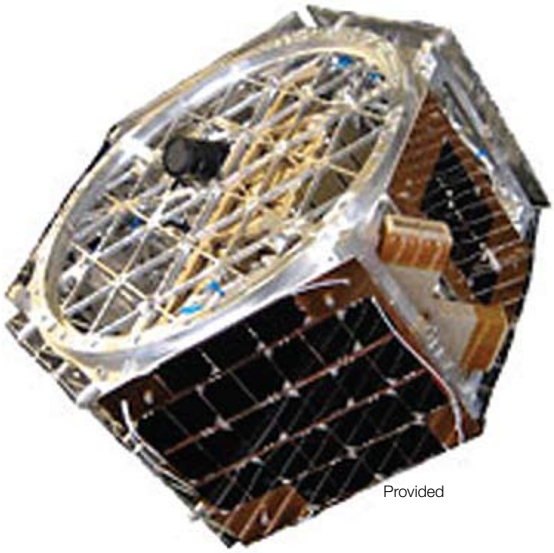
A FREE LAUNCH

Cornell's satellite wins first prize in NASA competition.



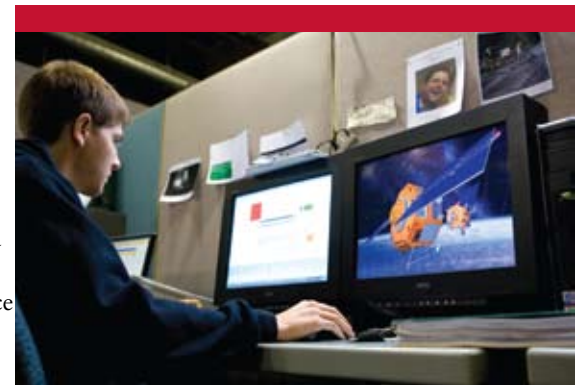
Provided

One-half of the CUSat satellite. In orbit, two identical halves will separate to test tracking and imaging software.

Over the past two years, Cornell's CUSat satellite project has engaged and educated a parade of engineering students, sometimes changing their careers. Now the final product—an innovative experiment in outer space maneuvering and inspecting—has received the go-ahead for a NASA launch into orbit.

Cornell's CUSat was chosen March 27 as the winner of the University Nanosatellite Program's Nanosat-4 competition sponsored by the Air Force and the American Institute of Aeronautics and Astronautics.

"The purse represented by this prize is probably the biggest ever received here," said Mason Peck, assistant professor of mechanical and aerospace engineering and principal investigator on the project. "The prize is a free launch, worth millions of dollars."

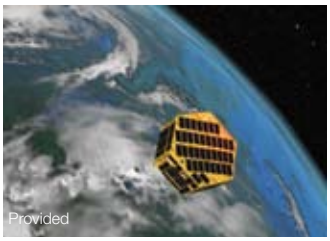


Jason Koski/University Photography

Rob Kesselman, an undergraduate in mechanical and aerospace engineering, works on the attitude-control flight software for the satellite.

Cornell's satellite was chosen from among 11 entries by a panel of 20 government and industry judges based on student participation, the flight-worthiness of the design, and relevance of the mission to NASA and the Air Force. "Robustness was one of the factors that helped us win, but the judges also said it would be a very relevant mission," Peck said. "There is new stuff being done here, with new results NASA cares about. We're not just flying a brick."

CUSat is actually two identical satellites linked into a hexagonal package, weighing about 90 pounds. Once in orbit the two satellites will separate and orbit each other, about 10 yards apart. Using highly refined global positioning system (GPS) devices, one satellite will orient itself toward the other and relay pictures of it to a ground station in Ithaca, where a 3-D model of the target satellite will be constructed. Such a system could be used to diagnose problems with future spacecraft, including examination of tiles on the space shuttle.



Provided

Artist's conception of one of the satellites in orbit after separation.

> "The purse represented by this prize is probably the biggest ever received here."

For navigation, CUSat uses signals from orbiting GPS satellites. Ordinarily these signals can locate an object to within a few feet. CUSat uses algorithms developed by Mark Psiaki, associate professor of mechanical and aerospace engineering, and his Ph.D. student Shan Mohiuddin, that provide accuracy down to a few inches. Peck credits Associate Professor Mark Campbell with the design of the satellite's thrusters, which burn solid Teflon, a much safer system than compressed gas. Campbell and Psiaki also help advise the team; Kris Young, M.Eng. '07, is student program manager.

About 80 students currently work on the project, Peck said, but about 225 have been involved over the past two years. Although the project has received about $160,000 from the

University Nanosatellite Program, engineering alumni, and the College of Engineering, as well as hardware and other assistance from many corporate sponsors, the biggest contribution has been student time, he said. "If they were practicing engineers it would add up to millions," he said.

"They're really passionate about spacecraft," he added, "and they have been heavily recruited by NASA and the aerospace industry. In many cases this opportunity has helped shape their careers."

For the competition Cornell submitted a partially completed model in which at least one of every element had been built, demonstrating that the team could complete every aspect of the project. The win brought additional funding of $110,000, but to complete the satellite and make it ready for launch will require up to half a million dollars, Peck said, so the program is eagerly seeking more sponsors. One possibility, he said, is to find a company that wants to add its own experiment to the satellite, to be carried out after the main mission is done.

There will probably be a wait of at least two years for the launch, Peck said.

For more information on the project and the satellite team, visit http://cusat.cornell.edu.

—Bill Steele, Cornell Chronicle

BACK AND BETTER

Anyone who noticed the large, silver-metallic sundial missing last fall from the Joseph N. Pew Engineering Quad should be glad to know it's back and better than ever. It is even rustproof.

Beginning in early September, the sundial's co-designer and builder, Cornell President Emeritus Dale Corson, and scientific instrument maker Rodney Bowman began preparing the sundial for its next quarter-century and beyond. The sundial was moved from the quad to Clark Hall's basement machine shop for minor redesigns and repairs, with some help from computer technology to improve its precision.

Corson built the sundial in 1980, three years after retiring as Cornell's eighth president. He shares credit for its intricate design with Professor Emeritus Richard Phelan, who created the mechanism in its base that allows it to read clock time. Earth's elliptical orbit and the tilt of its axis can cause solar time to differ from clock time by as much as 16 minutes, depending on the day.

"This is my legacy to Cornell," Corson said. He shares that legacy with Phelan, Corson added, and now with Bowman, who made the new parts.

During the sundial's hiatus, Bowman cleaned up some small rusted components of the 650-pound sundial, which had to be taken apart to be moved across campus. Some of those pieces were sent to a workshop in Syracuse to be chrome-plated for rustproofing, Corson said.

The heart of the sundial's functionality, a roundish steel disc called a cam, was also replaced with a stainless steel, slightly better-functioning one, connected to an hour and minute scale by small, stainless steel cables via a pair of precisely designed pulleys. This setup enables anyone to correct for the difference between solar and clock time by simply turning a knob to set the date.

Last winter, Corson and others noticed that the date could no longer be set on the instrument, which, after inspection, was found to be the result of rust and corrosion, primarily in the cam.

Corson said he feels that, overall, they have made the sundial a better timepiece.

"We have had the advantage of 25 years of experience with it, and the machines that made some new parts, like the cam, are better machines now than we had available 25 years ago," Corson said.

—Anne Ju, Cornell Chronicle

President Emeritus Dale Corson points to calibration markings on the sundial's scale.

Jason Koski/Cornell University Photography

Close-up of a pulley that is part of the sundial's mechanism for reading clock time.

C·ENG.NEWS

SPRING 2007

NEW "I" IN ORIE

Cornell University Photography

Rhodes Hall is still home to ORIE but now the I stands for Information.

Cornell's operations research school is operating under a new name. Now the School of Operations Research and Information Engineering (ORIE) uses "information" for the "I" in its acronym instead of "industrial," a move that was made official in January.

The fresh new name, school officials say, should help communicate their academic mission more clearly.

"To some extent it's a reflection of reality as much as a change of direction for the unit," said David Shmoys, an ORIE professor in charge of a publicity campaign for the new name. "This is really a better labeling of what the unit actually is."

A field that is only about 50 years old, operations research is rooted in the logistical underpinnings of military operations, Shmoys explained. Operations research grew out of a tradition that was based in industrial engineering, back when the economy was heavily manufacturing oriented.

As the economy evolved into a predominantly service industry, "industrial engineering" in the school's title began to feel obsolete.

"For virtually any element of the service industry, a primary commodity is information," Shmoys said. "And that is exactly the reflection of what's going on in the name change."

By calling themselves operations research and information engineering, school officials hope to be a trendsetter for other ORIE programs.

"We hope that by capturing this name and putting it in the forefront, we'll not only reflect what is happening, but what will happen, in a more pervasive way, and show leadership in the field," Shmoys said.

—Anne Ju, Cornell Chronicle

NEW AAD DIRECTOR

Tim Dougherty was appointed assistant dean for alumni affairs and development for the College of Engineering, effective Jan. 1.

Dougherty, who has served as an individual-giving officer in major gifts at Cornell since 2004, replaces Marsha Pickens, who retired from the position in June.

Prior to working at Cornell, Dougherty served as vice president for Institutional Advancement for the Global Health Council, director of Resource Development and Communications for Habitat for Humanity International in Africa and the Middle East, and vice president for development for the Boys and Girls Clubs of Metro Denver.

He also served as assistant director for development for the College of Business at the University of Colorado at Boulder.

Dougherty earned his bachelor's degree from Cornell's College of Human Ecology in 1988. He also received a master's degree in public administration from Syracuse University in 1994.

—Anne Ju, Cornell Chronicle

WHERE'S THE BOOM

Lindsay France/Cornell University Photography

The Cornell Ranger is designed to help understand the mechanics of human walking. It can go about a kilometer on one battery charge.

Once upon a time, computing was just for computer scientists. Today, practically every machine has a chip in it, and most of our work involves some sort of processing, networking, or data storage and retrieval.

The annual BOOM (Bits On Our Minds) exhibition is a celebration of the ubiquitousness of computing. Run by Cornell's Department of Computer Science and the Faculty of Computer and Information Science, it invites students from every college to display projects using digital technology. This year's exhibition, held Feb. 28, filled the Duffield Hall atria with booths, posters, and gadgets and drew hundreds of visitors.

Computer science students were certainly there, some with posters describing arcane advances in database management and networking, others with practical ideas to speed up airplane boarding or schedule courses. Engineers tended to dominate the landscape, with self-driving cars and planes and a variety of robots. But also in evidence were computer-generated art and music and even some computer-based sociology.

Several projects earned awards:

- AmEbot, an amorphous robot that emulates the motion of an amoeba, given by event sponsor Credit Suisse.
- Sound Sculpture: Timbre and Movement, a system creating sounds in a 3-D space, given by event sponsor Cisco.
- Subni Rfid, a system integrating radio frequency ID chips with the Web to locate and identify objects that could potentially assist the visually impaired, the "Where's the BOOM?" award, chosen by computer science and information science faculty.
- The Cornell Ranger, a robot that showed off throughout the event by walking from one end of the atrium to the other, The People's Choice Award, based on votes from attendees.

A list of all BOOM exhibits is online at http://www.cis.cornell.edu/boom/2007sp/.

—Bill Steele, Cornell Chronicle

A SIMPLE TEST

Antje Baeumner is working to develop a cheap, quick HIV/AIDS CD4+ T-cell test.

Cornell University Photography

A Cornell researcher is working to develop a quick, simple, and cheap immune-system test for people in the developing world. It could help HIV/AIDS sufferers in the poorest countries get appropriate treatment to extend their lives, possibly by as much as 10 to 15 years.

The work is part of an $8.6 million international consortium, called the CD4 Initiative, led by Imperial College in London and funded by the Bill & Melinda Gates Foundation. Antje J. Baeumner, Cornell associate professor of biological and environmental engineering, has been awarded an initial $386,000 (subject to annual renewal for four years) from the consortium to determine a way to simply assess the critical HIV/AIDS immune system factors—CD4 T-cell count, or CD4+ T-lymphocytes count—in the blood.

"When patients are infected with HIV/AIDS, the number of circulating CD4 T-cells drops significantly," explains Baeumner. "If they get the appropriate retroviral treatment, their life span can be increased by many years. CD4 counts assist in the decisions on when to initiate and when to stop the treatment, which makes this test so important.

"Currently, most people in the world, such as those in Third World countries, infected with HIV have no access to detection technology," says Baeumner, noting that 40 million people live with HIV/AIDS worldwide, many of them in areas where electricity is unreliable or nonexistent, water quality is poor and there are few, if any, highly skilled health-care technicians. "This test, however, is being developed to endure harsh temperature conditions and be truly simple—no batteries will be needed, for example."

Other members of the consortium include Beckman Coulter Inc., PATH, Zyomyx Inc., and the Macfarlane Burnet Institute of Australia.

—Anne Ju, Cornell Chronicle

STEP INTO YOUR SCREEN

This screen shot shows a virtual world in which students at Wa He Lut Indian School explore watershed science with the help of their teachers and Cornell mentors.

Provided

Cornell has been awarded nearly $600,000 by the National Science Foundation for an innovative program to attract more people to computing careers. The project, "Worlds for Information Technology and Science," will create a "virtual world" called CYCentr/CYFair (for "Cyber Youth") and a new undergraduate course, Computing in Context, in which noncomputer majors will learn computer skills and then become mentors to middle school students meeting in the virtual world.

The effort is a demonstration project in NSF's Broadening Participation in Computing program, which aims to increase the number of U.S. citizens and permanent residents receiving postsecondary degrees in the computing disciplines, with an initial emphasis on attracting women, underrepresented minorities, and persons with disabilities.

"This grant will help us to not only attract Cornell students into computing but also will serve to build awareness of and excitement for computing in secondary schools," said David Gries, professor of computer science and associate dean for undergraduate programs in the College of Engineering, who will direct the program with Margaret Corbit, outreach manager for the Cornell Theory Center. "At the same time, we will be learning about what does and does not work in teaching computing at these levels."

In virtual worlds, the computer screen becomes a window into a three-dimensional environment in which participants are represented by figures called avatars that can move around and interact one-on-one or in groups, conversing via text messages and voice transmitted over the computer network. CYCentr will contain worlds created by Cornell to present learning experiences; in the CYFair environment, the middle school students will create their own interactive galleries and game-based experiences.

—Bill Steele, Cornell Chronicle

CORNELL ENGINEERING

ISSN 1081-3977
Volume 13, Number 1
Spring 2007

Cornell Engineering Magazine is published by the Cornell University College of Engineering

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All photos by University Photography unless otherwise indicated

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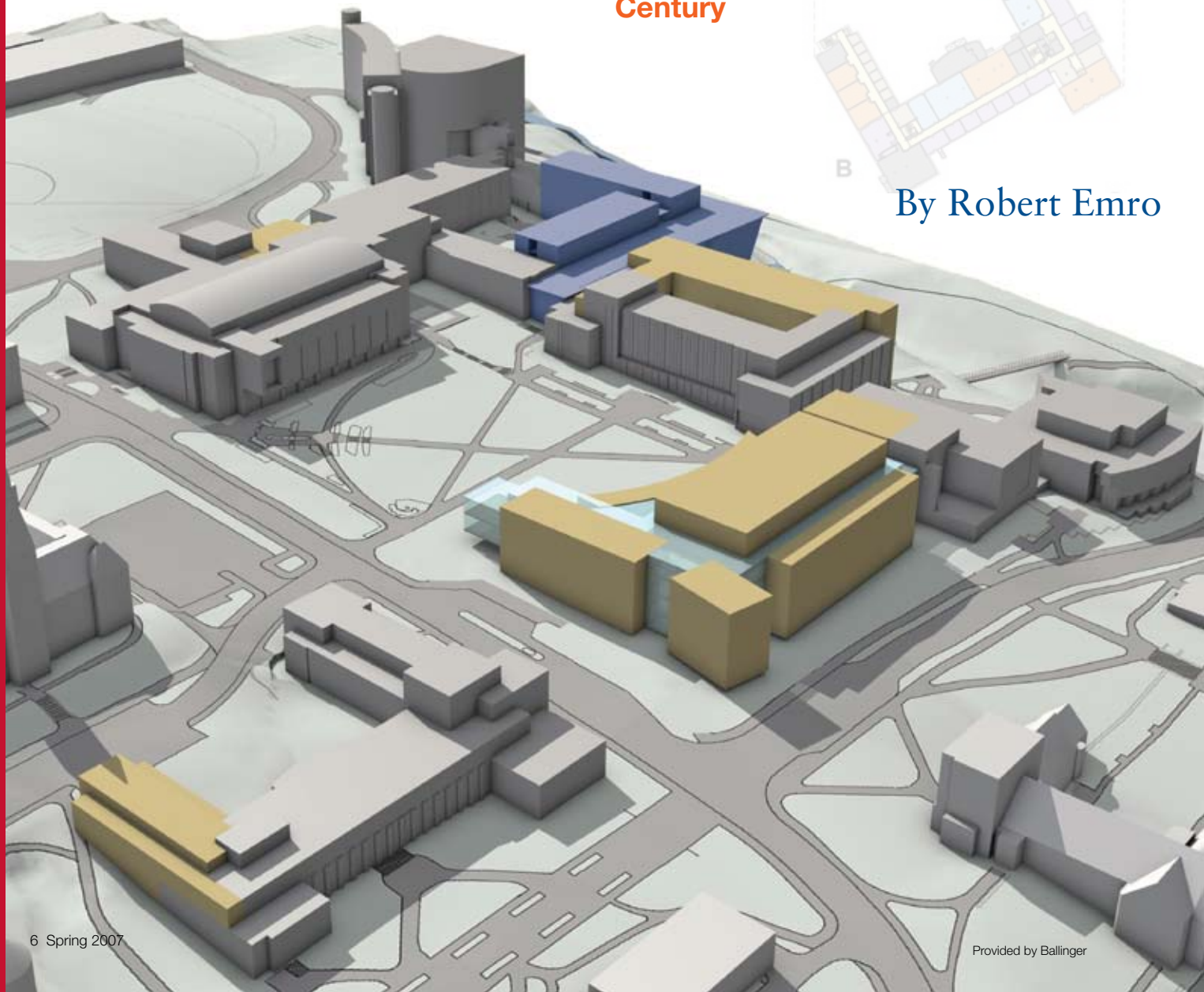
Planning for the Best

Engineering's longterm facilities master plan charts course for the 21st Century

By Robert Emro

Aerial view from the northwest of a model of the Engineering Quad showing proposed new construction in gold and Gates Hall in blue. The actual design of the buildings is yet to be determined.



Provided by Ballinger

University Photography

Duffield Hall's three connected atria (below) are a popular place for students, faculty, and staff to meet and exchange ideas.

Matt Fondeur/University Photography

Preserving existing open space around the Engineering Quad is a top priority.

University Photography

Cornell Engineering has big plans.

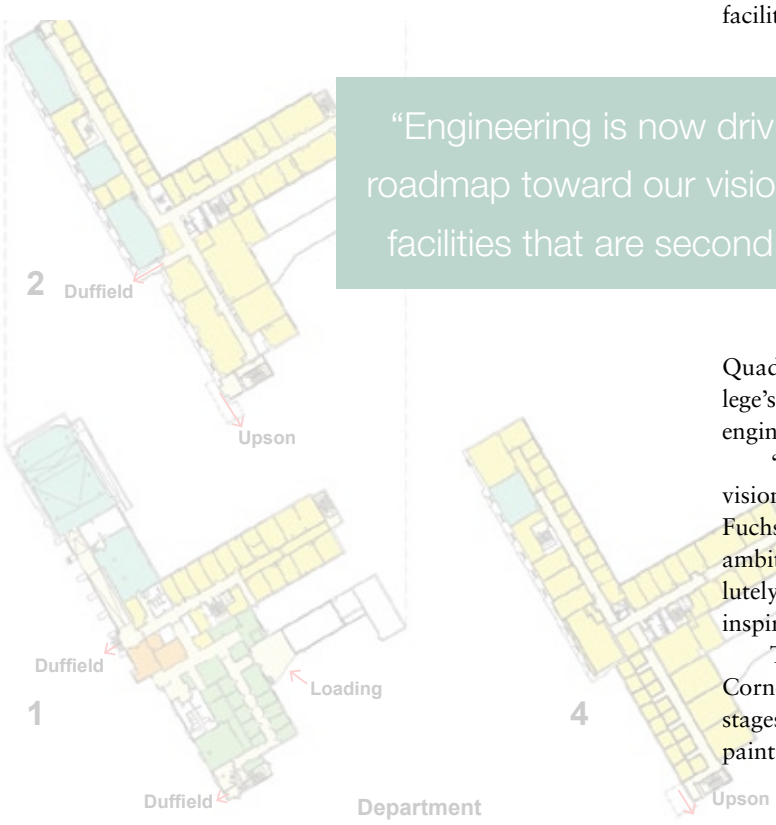
In 2005, the College of Engineering published a strategic plan setting five goals essential to achieving its mission of exceptional education, research excellence, and service to society (see Strategic Goals). Each goal reinforces the others; to be consistently considered one of the top five engineering colleges, for example, requires educating the most sought-after engineering graduates in the world. But perhaps no single goal is more important to fulfilling the others than having top-notch facilities.

Now, after a year-long study with input from faculty, students, alumni, and staff, the college has completed the first step in achieving that key goal with the approval of a facilities master plan. Developed with the Philadelphia-based architecture and engineering firm Ballinger, the $440-million plan calls for the construction of several new lab facilities, the demolition of buildings, and renovations around the quad. Besides an additional 260,000 gross square feet of much needed program space, the plan promises to transform the Engineering Quad into a celebrated campus gateway, enhance the college's identity, and create more common spaces in which the engineering community can meet and share ideas.

> "Engineering is now driving with a roadmap toward our vision of having facilities that are second to none."

"Engineering is now driving with a roadmap toward our vision of having facilities that are second to none," says Kent Fuchs, the Joseph Silbert Dean of Engineering. "This is an ambitious goal, but one that is entirely possible and absolutely necessary if we are to have a physical environment that inspires and enables excellence."

The Engineering Facilities Master Plan predates Cornell's Comprehensive Master Plan, still in its formative stages. Where the university's plan will use broad strokes to paint a picture of the entire campus far into the future, the



college's plan uses fine brush work to portray a more immediate prospect for the 13 buildings around the Engineering Quad, right down to the fire alarm systems.

"The College of Engineering Master Plan is doing a lot to inform the university's Comprehensive Master Plan," says Kyu-Jung Whang, Cornell's vice president for facilities services. "In itself, it's very comprehensive and well thought out."

Like children who remain the same height for months and then shoot up several inches seemingly overnight, college facilities tend to grow in spurts. Cornell Engineering saw its last major growth spurt in the 1950s, when Kimball, Thurston, Phillips, Carpenter, Upson, Hollister, and Grumman halls were all built. Today, their infrastructure is hard-pressed to meet the demands of modern research and instruction.

"We've examined all of the building assets that the College of Engineering manages and we've concluded that our facilities come far short of our aspirations as a college over the next 50 years," says master plan steering committee member Lance Collins, professor and S.C. Thomas Sze Director of the Sibley School of Mechanical and Aerospace Engineering.

Retrofitting these older buildings, many of which were designed as classroom spaces, with the modern systems required by today's research and instructional labs—electrical, plumbing, telecommunications, and heating, ventilation, and air conditioning—would be more expensive than building new ones in many cases, and impossible in others, given their minimal floor-to-ceiling heights.

"Some of these buildings, skeletally, cannot accommodate the upgrades that we need," says Collins. "Modern mechanical engineering includes nano-fluidics, biomechanics, MEMS (Microelectromechanical Systems)—areas that require laboratories with a lot more services."

But the changes called for in the master plan are driven by more than the need to modernize. Since the construction of these buildings, the College of Engineering has grown significantly. Since 1965, the faculty has increased 44 percent, the undergraduate population 28 percent, and the number of Ph.D. candidates 91 percent, according to data gathered during the master planning process. The amount of net assignable square feet has also grown, but only by 35 percent. So while the average space per undergraduate has increased slightly, the space per faculty member has actually decreased and the space per Ph.D. candidate has plummeted. In the same time period, the master of engineering degree has grown tremendously, increasing its enrollment from 34 to 405 students. Add to that an increase in research staff driven by a doubling of research dollars, top with 13,000 pieces of capital equipment, and you have a recipe for space crunch.

> "Some of these buildings, skeletally, cannot accommodate the upgrades that we need."

These numbers helped the college chart where it is going, as well as where it has been. "I think you need controlled growth and this was a way to make us go back to the drawing board and make us think about the rational plan of departments," says steering committee member Paulette Clancy, professor and the William C. Hooey Director of the School of Chemical and Biomolecular Engineering. "There was a lot of self study that went behind all of this."

The planning process also highlighted qualitative changes in engineering education over the past half century that create demands on space independent of the college's growth. Today, engineering education emphasizes group study and hands-on learning. In 1965, only a score of students participated in project teams. Today, that number is more than 450. Undergraduate research has also become much more prevalent—44 percent now do some form of research with faculty. And the growth of the master of engineering program has added greatly to the number of design projects completed every year.

"There's so much more group study now in terms of the way learning is being implemented compared to 20 years ago, so you need spaces where that group learning can be fostered," says Ballinger Architecture Principal Terry Steelman. "The other top engineering schools with whom Cornell competes, such as MIT, have highly invested in these types of spaces in all of their research buildings."

The increasingly interdisciplinary nature of teaching and research, especially in the new areas identified in the College's strategic plan (see Research and Education Foci), is also driving the need for changes called for in the plan. "The old paradigm of the professor who can say, 'There's my lab' is giving way to groups of faculty with shared space," says Collins. "We have faculty with well defined disciplines, but they are linked together on projects that are crossing over these boundaries, so it's natural for them to want the students and labs involved to overlap to some degree."

With its emphasis on the direction of future research, the college's master plan becomes more than just a plan for buildings. "It's really a conceptual view of what the College of Engineering will look like programmatically in the next 25 to 30 years, in terms of the needs of students and faculty," says Stephen Golding, Cornell's Samuel W. Bodman Executive Vice President for Finance and Administration. "At the end of the day, facilities are a manifestation of the academic plan for the college."

Several building projects currently under way or in the

Research and Education Foci

The College of Engineering has identified six strategic areas of focus for the next decade. While a large number of additional ongoing research and education initiatives will continue to be of importance and supported by the College of Engineering, these six areas of inquiry uniquely span the breadth of the college. They build on the college's current excellence, and they are expected to grow in importance.

- Systems biology and biomedical engineering
- Nanomaterials, nanoscience, and nanodevices
- Energy, environment, and sustainable development
- Information, computation, and communication
- Advanced materials
- Complex systems and networks

Strategic Goals

In order to achieve its mission and bring its vision to life, the College of Engineering has established five goals.

GOAL 1 To be considered one of the top five engineering colleges in undergraduate and graduate studies.

GOAL 2 To be recognized as the premier research university in advanced materials, information sciences, and nanoscience, and a leader in bioengineering, complex systems, and energy and the environment.

GOAL 3 To recruit, retain, and enable a diverse community of exceptional faculty, students, and staff.

GOAL 4 To educate future leaders who are the most sought-after engineering graduates in the world.

GOAL 5 To establish and maintain facilities and infrastructure that are second to none in supporting the achievement of the college's vision, mission, and values.

Building for the Future

Construction of several new buildings was already planned or under way when the college began its planning process. While not formally part of the Engineering master plan, the expected impact of these facilities helped shape its final recommendations.

Life Sciences Technology Building
This $157-million facility will serve as the hub for life sciences and provide a research setting that promotes interdisciplinary collaborations. Construction of the 250,000-square-foot building is under way on the western end of Alumni Field, with a tentative completion date of 2007. It will be home to both the College of Engineering's Department of Biomedical Engineering and Cornell's new Institute for Molecular and Cell Biology, and serve as a catalyst for advancing collaboration between the Ithaca campus and Weill Cornell Medical College faculty. This new building, along with the other life sciences facilities on campus, will be the largest life sciences research and educational complex in New York State.

planning stages will provide modern labs for some departments (see above). And Duffield Hall, completed in 2004, has provided state-of-the-art facilities for nanoscale science and engineering. But Ballinger found that this will not be enough to meet the needs of the college in the coming decades. The master plan calls for a new building to house the mechanical and aerospace and civil and environmental engineering programs in a flexible research-focused lab facility, as well as two major lab additions, to Olin Hall and the Kimball-Thurston-Bard complex, and an addition to Phillips Hall.

Preserving the existing open space around the quad was a top priority for the college, so to make way for the new lab building, the plan calls for the demolition of Carpenter Hall, home of the Engineering Library and the central college administration, and part of Hollister Hall, home to Engineering Admissions and the School of Civil and Environmental Engineering. Ballinger found that these two buildings made inefficient use of space on the quad, lacked the structural "bones" necessary for modern labs, and did little to take advantage of their prime location.

"We believe at the corner of College Ave and Campus Road there needs to be a building that invites you into the College of Engineering Quad and establishes the identity of the college," says Steelman. "By location Carpenter could be a gateway to the entire campus, but in fact it's not. Right now, you don't feel like you've arrived at the campus until you're beyond the College of Engineering."

Duffield Hall, opposite the quad from Carpenter, is a clear example of what Steelman is talking about. Visit the building on any day during the school year and you will find not just high-tech clean rooms full of researchers in "bunny suits," but also three connected atria—an open, vibrant place full of energized people sharing ideas, studying for exams, grabbing a bite to eat—the kind of place that attracts top students and faculty and inspires those already here to greatness. It has unmistakably enhanced the identity of the college as a place where the next great discoveries are being made.

> "At the end of the day, facilities are a manifestation of the academic plan for the college."

Visit the older buildings around the quad, however, and you would probably not suspect that inside, some of the world's best education and most advanced research is happening. "What's going on inside those buildings is much more sophisticated than what they convey," says Steelman. "The image of the college needs to be more tightly linked to

Physical Sciences Building
This $140-million project will result in a 118,000-net-square-foot complex that will provide space to the College of Engineering's School of Applied and Engineering Physics, as well as the College of Arts and Sciences' Department of Chemistry and Chemical Biology and Department of Physics. The project encompasses a new building contiguous to Clark Hall and Baker Laboratory and an extensive underground laboratory space that will extend research space already in Clark Hall.

Gates Hall
William H. Gates Hall will provide needed space for the Department of Computer Science and the university's Faculty of Computing and Information Science. Currently in the feasibility study stage, it is estimated to be 100,000 square feet and the first phase is projected to cost about $50 million. The Bill & Melinda Gates Foundation awarded $25 million to support the construction of the new building, which will have a presence on the Engineering Quad between Kimball and Upson halls and overlook Cascadilla Gorge.

the ideas and actions they are built to support."

Such intangible things as identity and image can be difficult for engineers to give weight to, says Collins, but are nevertheless important. "This is where the architect's eye is essential," he says. "Engineers tend to focus on square footage, but the architects realize that space has a symbolic aspect to it as well, and our college needs a well defined presence on the campus."

The atria in Duffield are integral to creating its identity and the master plan calls for more common spaces like that around the quad. "We've been compressed and one of the key things that has suffered is the lack of communal spaces," says Clancy. "I think having such places is very important and there is an attempt in the plan to find communal spaces in every building."

Another way the planned upgrades will enhance the identity of the college is by making it more sustainable. "An engineering school needs to set the example for what we can do to minimize our energy consumption, so we've established aggressive benchmarks to make these buildings more efficient than they are now," says Steelman. "It is a high priority for us, for the university, and for the college."

Minimizing disruption during implementation of the plan was a complicated logistical puzzle. "The complication is that there's very little swing space," says Collins. "Every nook and cranny we can legally occupy is occupied."

Ballinger's solution is an implementation plan with a year-by-year set of steps that must happen in exact order, like dominoes falling, as units are relocated to new homes around the quad. So, for example, once the schools of Mechanical and Aerospace Engineering and Civil and Environmental Engineering move into the new building on the site of Carpenter Hall, Upson Hall will be renovated to accommodate the Engineering Library, Admissions, Student Services, and College administration, as well as additional space for the School of Electrical and Computer Engineering. The college has started with infrastructure upgrades to Olin Hall, site analysis for the building to replace Carpenter Hall, and a construction feasibility study for enhancing Philips Hall, but it will take more than a decade, and approvals at each stage, for the plan to be fully realized.

When the work is done and each unit is settled into its new home, Cornell Engineering will look and feel like a whole new place—one more in keeping with what you would expect from a top-ranked engineering school. "A physical environment can either constrain creativity and productivity, or it can inspire and enable excellence," says Dean Fuchs. "This major revitalization of our facilities and technical infrastructure will ensure Cornell Engineering remains among the best engineering schools in the world."

In Their Back Yards

Jon Reis Photography

Graduate students Rachel Dunn, Veronica Morales, M. Ekrem Cakmak, Professor Tammo Steenhuis, and project leader Ian Toevs worked with graduate students Adrian Harpold, Rachel Shannon, and Jennifer Smith, and junior Brianne Smith (not pictured) to be "another set of eyes" for a neighborhood troubled by TCE contamination.

By Glenn Scherer

Jon Reis Photography

Students help a neighborhood understand TCE pollution

South Hill in Ithaca, New York, is a microcosm of urban America, a peaceful tree-shaded neighborhood that grew up in the shadow of industry in the late 19th and early 20th centuries. But just like thousands of other U.S. urban neighborhoods that flourished before the introduction of important environmental safeguards and regulations, South Hill is bedeviled by an Industrial Age relic: an unseen but potentially toxic chemical plume that runs beneath it, polluting its groundwater and seeping, as vapor, into home basements.

In the case of South Hill, the principle culprit is TCE, trichloroethylene, a potentially carcinogenic solvent used to clean metal machine parts by Ithaca's Morse Chain factory, now owned by Emerson Power Transmission. The health effects and economic fallout due to the TCE contamination are of major concern to South Hill's residents—a concern that has left them feeling vulnerable and unsupported.

So it was that in 2005 New York State assemblywoman Barbara Lifton responded to the fears of South Hill residents and went to Cornell University requesting its engineering students to provide "another set of eyes" to examine data related to the TCE contamination on behalf of community members. The result was a semester-long study in spring 2006, performed by the combined classes of Professor Tammo Steenhuis of the Department of Biological and Environmental Engineering and Professor Larry Cathles of the Department of Earth and Atmospheric Sciences. Their undergraduate and graduate students' hundred-page final report and oral presentation helped unravel some of the mysteries and uncertainties of South Hill's TCE contamination for local residents. (Click on "South Hill TCE report" at http://soilandwater.bee.cornell.edu for the full report.)

"The objective of our geohydrology class project was to understand the situation on South Hill in all its aspects, including technical, toxicological, geological, and economic concerns—the whole broad perspective," says Cathles. "The students acted much like an environmental consulting firm, though an unusual one."

> "The students acted much like an environmental consulting firm, though an unusual one."

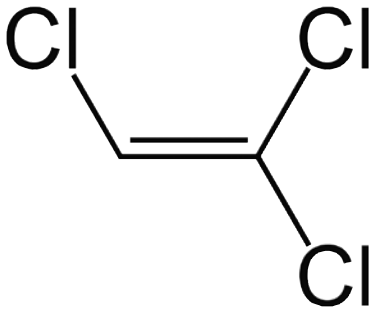
Free of the preconceptions of the various parties involved in the TCE dispute, the students had the advantage of a fresh perspective, says Cathles. "Our client was the homeowners, and the students' job was to make a report to the residents that explained the situation in lay language," he says.

The residents weren't the only ones to benefit from this unique collaboration. The students gained "years of consulting experience compressed for them into one term," Cathles says. The eight students "got to work with a real problem, in a real setting, not just on a textbook case," adds Jim Gillett, Cornell professor emeritus of toxicology who provided technical assistance to the project. "South Hill represents an awkward, awful, difficult case, complicated by fractured geology, the pollution of various types of industry over various time periods, with various attempted treatments."

Perhaps most useful for the students was their chance to work with or access work by many of the parties involved in the TCE case, including the New York State Department of Environmental Conservation, various environmental consultants, the principal responsible parties including Emerson, and the residents. "They got to see how different sets of people with different goals and problems cope with the same issue in very different ways," says Gillett. "They learned that there is no single right answer."

"Most valuable for me was participating with the community members while doing real research," agrees second-year grad student Veronica Morales. "We tried to give the residents some information they didn't have, and to explain technical information that some of them didn't understand up to that point. I feel like we definitely helped people in the community."

Trichloroethylene or TCE is the most commonly reported organic groundwater contaminant in the nation. It's a probable human carcinogen, especially at higher concentrations.



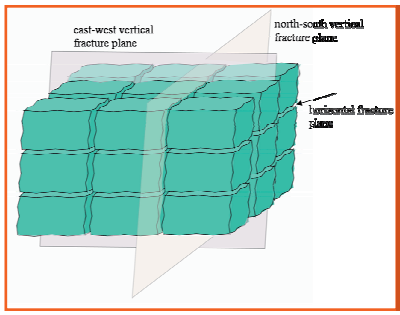
The former Morse Chain factory, now owned by Emerson Power Transmission, is the source of TCE contamination that flows down into Ithaca's South Hill neighborhood.

An Unseen Toxic Legacy

South Hill homeowner and activist Stan Scharf sums up the neighborhood's TCE toxic worries: "I am not happy living in a house with this contamination. It is always a threat. It is always on the mind. How dangerous it really is, is hard to say, but there has to be an increased risk of cancer here."

Trichloroethylene, or TCE, is a chlorinated solvent used extensively by industry in the 20th century as a degreasing agent to remove oils from metal parts. Ithaca's Morse Chain factory heavily utilized TCE in the 1960s and 1970s, discontinuing use by the 1980s when concerns arose about its health hazards. Unfortunately, TCE was deposited in large amounts in a Morse Chain underground concrete fire reservoir that then leaked into South Hill groundwater. It is also possible that TCE entered South Hill from a variety of other locations within the manufacturing plant.

In 1987, Emerson Power Transmission, the new owner of the Morse Chain facility, let NYSDEC know that they had discovered TCE leaking from the fire reservoir. Environmental consultants quickly learned that South Hill groundwater had been contaminated. In the 1990s, NYSDEC and Emerson began an attempted remediation process, extracting and treating groundwater from wells near the fire reservoir. Unfortunately, remediation didn't solve the problem. TCE remained inside South Hill.



The siltstone underlying South Hill is fractured into blocks. The cracks allow the TCE to take many possible paths, complicating transport assessment.

Provided

In May 2004, Walter Hang, president of the Ithaca-based Toxics Targeting consulting firm held a press conference documenting the spread of TCE under South Hill. His work catalyzed community residents into action. "I got really involved then," notes South Hill resident Ken Deschere. "Residents became really concerned. We started a Yahoo Internet group of neighbors exchanging e-mail information, and we started working with local politicians to get public meetings." Testing of homes around South Hill found varying levels of TCE vapor, some in violation of state health standards. In those homes where violations were found, Emerson paid to install mitigation devices—pump and fan systems that remove TCE from the contaminated soils beneath the basements. Still many homes went untested, and fears and uncertainty plagued homeowners.

Residents like Ken and Regina Deschere and Stan Scharf participated actively in the Cornell geohydrology class. They wanted to know how far and wide the TCE had spread downhill from the Emerson plant, and what the risks were to neighborhood health. The student report attempted to answer those difficult questions.

Graduate student Jennifer Smith wrote the section of the final report on TCE toxicology. She noted the alarming fact that "TCE is the most commonly reported organic groundwater contaminant" in the nation and that "between 9 and 34 percent of drinking water in the United States has TCE contamination." Smith also noted that TCE is a probable human carcinogen, especially at higher concentrations. "Humans occupationally exposed to TCE have increased incidence of liver, kidney, and cervical cancers as well as non-Hodgkin's lymphoma, Hodgkin's disease, and multiple myeloma," wrote Smith, "though these concentrations are many orders of magnitudes higher than air in homes measured on South Hill."

Research into the toxicological effects of the low levels of TCE vapor found in South Hill homes (in the range of parts per billion) was difficult to obtain, especially for long-term inhalation exposures. "In high concentrations TCE is a neurotoxin, but in the concentrations to which most people are exposed, we don't know of any real health problems," explains Gillett. "Carcinogenicity is not eliminated, but [TCE at low levels] is not a very potent carcinogen. The levels of TCE people are experiencing on South Hill may be one-ten-thousandth the levels that workers can safely use in the workplace. But while it may not be enormously dangerous, the fact remains that it is a trespass, and people have a right to not have to worry about it. The residents are well within their individual rights to try to get Emerson and whoever else is responsible to take care of it."

Puzzles in the Bedrock

Tracing TCE's course through the underground labyrinth beneath South Hill proved very difficult for the students. The problems begin with several odd qualities of TCE, which is classified as a dense nonaqueous phase liquid, with a specific gravity of 1.46. That means TCE is significantly heavier than water; it also has low solubility in water. These two facts "can potentially make assessments of transport difficult, since migration … is dependent on water concentrations, water table depth and fluctuations, and temperature," says Jennifer Smith in the final report.

Add to these difficulties the convoluted geology of South Hill. Like the rest of Ithaca, the hill is underlain by a jumble of glacial till and highly weathered and fractured siltstone. A first set of siltstone vertical fractures runs approximately north-south, a second vertical set runs approximately east-west, while a third set runs horizontally. The result is that the bedrock is cut into variable-sized blocks, with each block surrounded by fractures. These fractures can range in size from small openings less than a millimeter wide to larger ones inches wide. "Because most of these fractures are deep underground, it is impossible to estimate where exactly all the fractures occur, or even how many there are," wrote

student Rachel Shannon in the report.

"I found the migration pathways for the TCE quite interesting," says Ian Toevs, a graduate student and the project team leader. "Because the TCE is denser than water, it sinks to the bottom [of cracks in the bedrock], though it can [also] rise as a vapor," entering through cracks in home basements. The odd behavior of trichloroethylene and the multitude of fracture paths that it might follow make the location, concentration, and migration of TCE pools below South Hill virtually unknowable by any science available today.

"The main thing our final report did was to clarify the difficulty of the geohydrology," says Steenhuis. "People had wanted Emerson to clean up the hill. But the students' report clearly showed that that isn't going to work. For now, we're stuck with the pollution in the hill. It is scattered all over, and you can't tell where it's been, or where it is going for all practical purposes. The students' study also demonstrated that straightforward mitigation methods—interrupting the flow or getting rid of the material from the source—were not going to be easy, would be very expensive, and maybe not even possible, whereas mitigation of individual homes is a temporary solution that may protect homeowners from the fleeing contaminant."

Nonetheless, recently released post-mitigation results have left South Hill residents displeased with the efficiency of the mitigation systems. Several homeowners have discovered that their indoor concentrations have not been reduced to the acceptable maximum concentrations required by the EAP, while others have found these new concentrations to be higher than what they had prior to mitigation.

Ken Deschere '71 and his wife Regina have lived on South Hill for more than 25 years.

A Winning Collaboration

Once their report was written, the students took a further step to help residents understand their TCE predicament. In May 2006, their project culminated with a very well received oral presentation to 40 South Hill residents at Ithaca's town hall.

"The report and presentation seemed to relieve a lot of the anxiety concerning unknowns that the residents had," says Cathles. "While I'm not sure the students found anything that wasn't already known, they were able to articulate in a clear fashion so residents could understand [what was happening under the hill and in their homes]. Essentially the students found that the movement of TCE contaminants in South Hill is so complicated through the fractured rock that the chemical's position and concentration is virtually unknowable." He adds, "I also think that one of the most important elements of the students' research was to look carefully at the toxicology, which found that while this level of TCE contamination certainly was not a desirable thing to have in your backyard, it may not be as dangerous as it is believed to be."

"As both a city resident and an alum, I want to say what a wonderful example this is of Cornell's involvement in the community," concludes Ken Deschere, a South Hill resident who graduated from Cornell in 1971. "The level of sophistication of the students today with their computers, sampling devices, and other high tech equipment was far beyond what we had in our day. But the expertise the students brought to bear wasn't all just academic blackboard knowledge. They were really interested in using what they were learning in school to solve real-world problems. And it was marvelous to see their willingness to get involved with the residents. They made a very complicated scientific issue far more approachable. It was a great learning opportunity for the students and a great service to the community. I was delighted to be a part of it."

Still, notes Deschere, TCE concerns did not end with the Cornell project. "I worked 20 years in my basement [on South Hill], and in 2003 was diagnosed with an unexplained cancer. The only person I know of with this same type of cancer lives right down the street from me. People's kids played in their rec-room basements for years before we knew about the contamination. We still have big questions about what TCE has done and is doing to our health. We're hoping that continued efforts like the one with the Cornell class will get us more educated about toxicity and help us move forward."

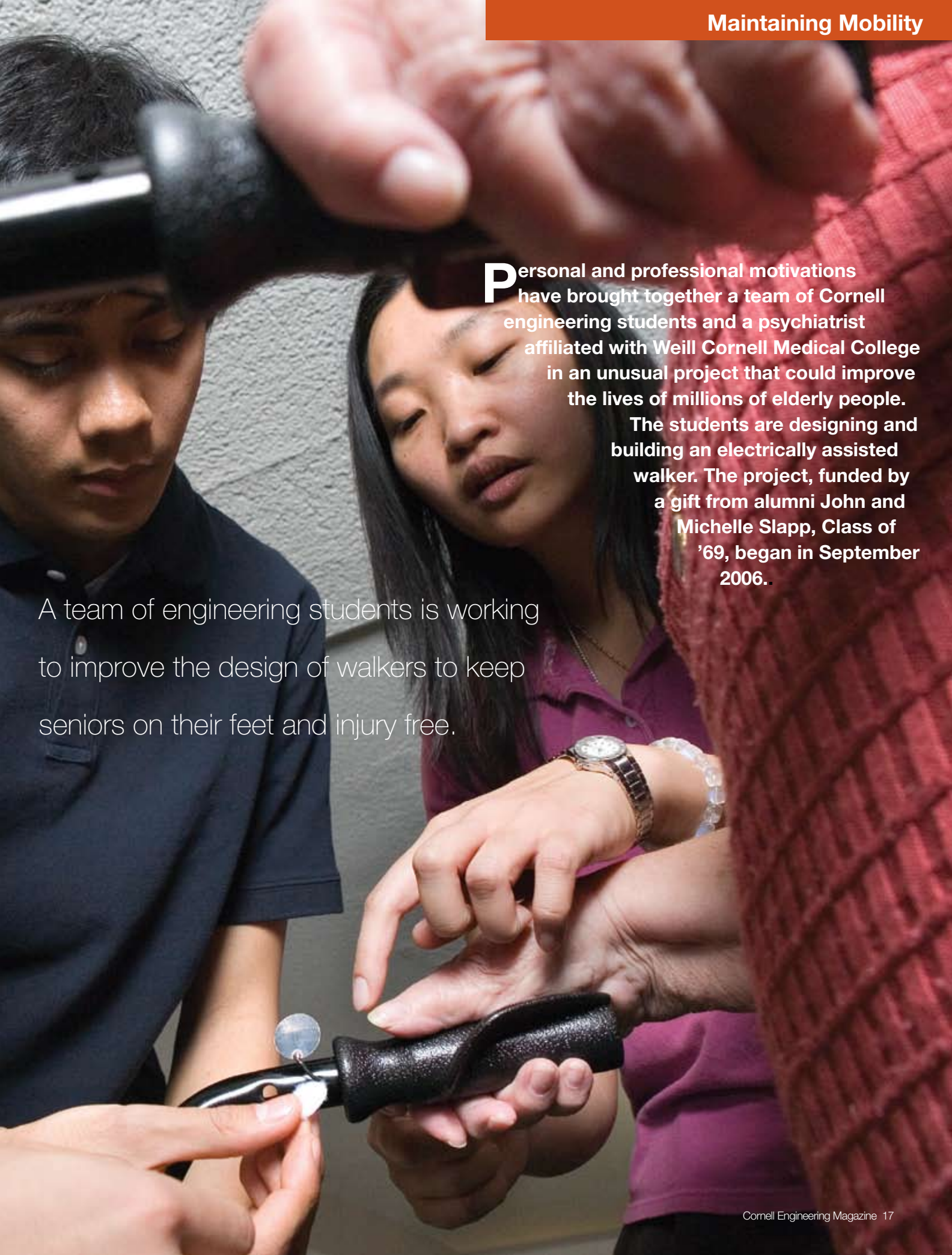
Cornell students continue wrestling with the South Hill TCE problem. Grad student Veronica Morales is pursuing a yearlong project sampling TCE levels in South Hill basements through 2007. Also this year, the university is sponsoring a contest for teams of students who are seeking to design a mathematical computer model explaining the sources and extent of TCE contamination under South Hill (more info at http://www.math.cornell.edu/~mcm/).

"The people who live on South Hill now have a much better understanding of what is known and what is not knowable about the TCE contamination, and what the risks are," says Steenhuis. "For the students this was an ideal project for teaching engineering design. They learned a great deal about what it is to go out in the field and practice engineering, and do design in an uncertain environment. When you are in the classroom, everything is very certain, the answers are always known, and they can be checked. On South Hill, the students were interacting with real citizens, taking their concerns into account, and dealing with those uncertainties."

Maintaining Mobility

By Melanie Bush

Lindsay France/ University Photography



Personal and professional motivations have brought together a team of Cornell engineering students and a psychiatrist affiliated with Weill Cornell Medical College in an unusual project that could improve the lives of millions of elderly people. The students are designing and building an electrically assisted walker. The project, funded by a gift from alumni John and Michelle Slapp, Class of '69, began in September 2006.

A team of engineering students is working to improve the design of walkers to keep seniors on their feet and injury free.

The team is focusing on making the walker's braking system electronic, and they hope ultimately to create a walker that is safer and easier to use, encouraging elders to maintain an active lifestyle; inactivity is a leading cause of weakened motor skills, which can lead to injury.

The electrically assisted walker project is unusual in several ways. To begin with, it has an unusual genesis: It stems from a patent held by a psychiatrist in New York City.

Dr. Eli Einbinder, who is affiliated with Weill Cornell Medical Center, was a tennis player and skier before 1993, when he injured his back. "So I'm sitting there in my office looking for another hobby," recalls Einbinder, "and all of a sudden I start noticing people with walkers—how difficult they are, how non–user-friendly. I'm also an inventor, so I decide to design a mechanical walker that works better. I soon realize that an electrical model with a button for braking is much simpler, and I patented that in 1998, only to realize that batteries and motors do not exist that are small or efficient enough to operate it."

"Last May," continues Einbinder, "I e-mailed David Lipson [senior lecturer in Cornell's Department of Biomedical Engineering] to ask if batteries and motors had improved, and to my surprise, instead of 'Yes' or 'No' he said, 'How would you like to help organize and sponsor a project with my students?'"

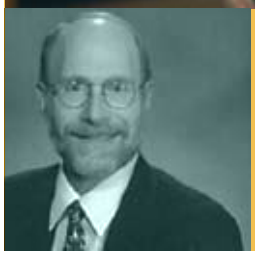
Einbinder says he only realized then that his interest in walkers actually dates from much earlier. He had encephalitis as a child, a disease that strikes one of every 30,000 people who catch chickenpox, and was for a time unable to walk. "Now, for me, this whole story makes sense, because I would have been mobile several weeks earlier with the help of the walkers I've now designed," he says.

Einbinder has been a consultant to the project since its inception, working with the team at least weekly via conference calls and e-mail, as well as having frequent communication with Lipson.

The project is personal to the students, too. As biological engineering senior Suneth Attygalle writes in his project proposal: "For 94 years, my grandmother in Sri Lanka has lived a long, independent life in the comfort of her own home. Although she has remained healthy throughout this time, age has naturally weakened her motor skills. ... For example, now, when walking long distances, she requires someone's sturdy hand to support her, as well as to protect her in case she trips. Such situations are common among the aged. There is a clear need for safe, assisted walking devices for the elderly or disabled. The traditional 'walker' relies entirely on the user for control, making it unusable for those with weakened strength or response time. Thus, I seek to design a novel, electronically and mechanically assisted walking device with a team of three other students."

Those three are Sheryl Lau, the team leader, and Phillip Wang, both graduate students in the master of engineering program in biomedical engineering; and Homer Chiang, a junior in mechanical engineering. Lau worked in a rehabilitation hospital in Chicago and believes the project is important because "there are a lot of people in the U.S. getting older and they're going to need support."

Lindsay France/ University Photography

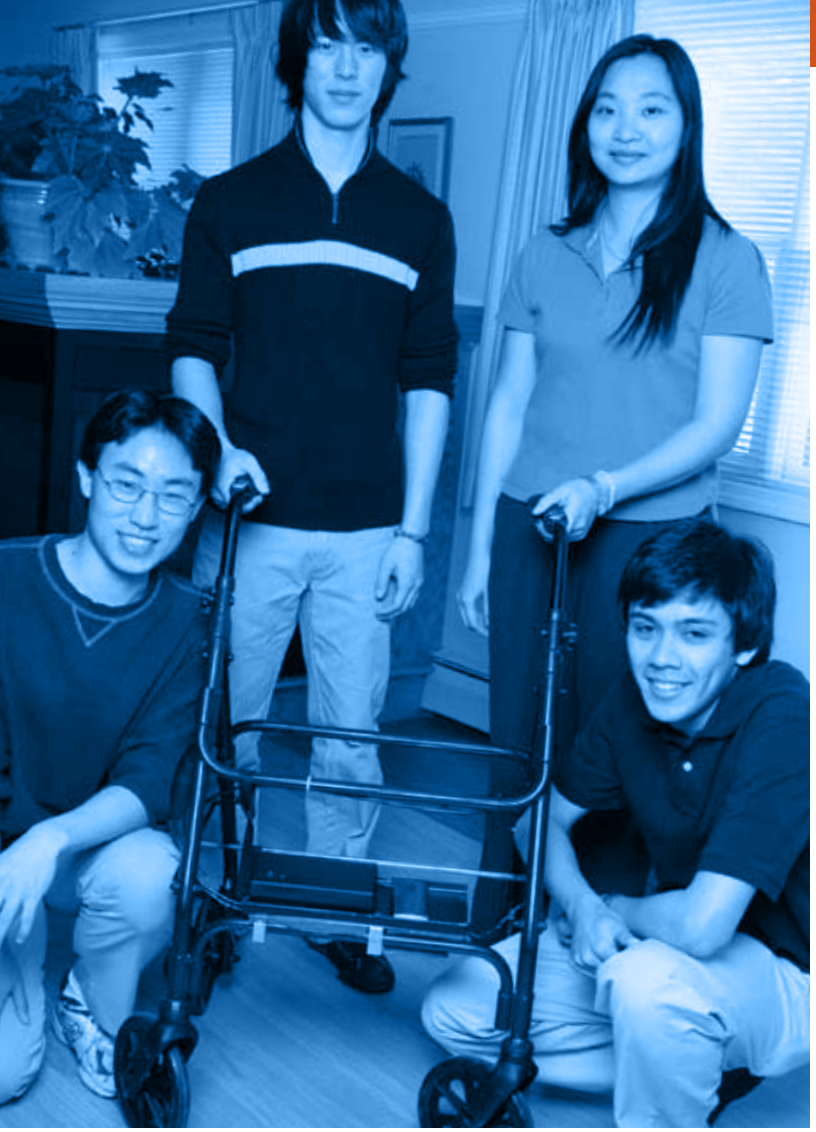


David Lipson

"Initially we thought we'd come up with a whole new walker, but it needed too much machining, so we decided to start with walkers already out there," she says. "We tried three-wheelers and four-wheelers—each costs around $100 at Wal-Mart—and found that the three-wheeler had a perfect place for us to add electronics. Now we're developing both models with the same technology. I think people will like it—they have electric wheelchairs, so why not?"

"It's simple, but not simple," says Lipson, the group's research adviser. "That's what's lovely about this project. There's no model of an augmented walker; it's a blank slate. It's a very constrained, challenging design problem."

Lipson goes on to explain that the Department of Biomedical Engineering itself is only three years old. "Mike Shuler [BME chair] is building this department with three goals: first, to grow the department into the top 10 among peer institutions; second, to integrate biomedical engineering education across scales—molecular, cellular, organ and tissue; and lastly, to develop whole body solutions where



Lindsay France/ University Photography

Affordability is a significant issue. Many people with mobility problems rely on Medicare, which currently covers 80 percent (typically about $50) of the cost of a non-rolling walker.

Students on the assisted walker team are (from left) Phillip Wang, Homer Chiang, team leader Sheryl Lau, and Suneth Attygalle.

students learn to develop practical applications. That's where I come in," he says. "I try to teach them that their ultimate teachers are not professors, but practitioners—doctors, nurses, physical therapists. Coming straight out of Cornell with the ability to engage with practitioners and clinicians about their needs will really distinguish them."

To get input from potential users of the assisted walker, students consulted with faculty at the other major educational institution in town, Ithaca College, which has a well respected physical therapy department, as well as the Ithaca College Gerontology Institute. The group met with Katherine Beissner, a professor of physical therapy who specializes in geriatrics. Beissner is also president of the board of directors of Ithacare, the agency that runs Longview, a senior living facility associated with Ithaca College. The walker team accompanied Beissner to Longview last October and interviewed walker users there about exactly what they would like to see changed.

The elders' complaints included the observations that walkers are hard to fold, are heavy, don't fit in the car, have too-small seats, and are difficult to maneuver through doors and hallways and in small spaces such as bathrooms. The Cornell team observed several other problems, such as the walkers' brake cords getting tangled and their wheels getting

"It's a very constrained, challenging design problem."

This walker will brake safely for users with low strength or impairment in their hands.

Lindsay France/University Photo

misaligned if struck from the side. Walkers appeared to either work well or fold well, but not both. The group spoke with a 103-year-old walker user who agreed to be videoed. Back in their lab in Kimball Hall, they watched her walking over a threshold forward and backward, as well as walking down a hall.

"Every time you add something to a person, it presents environmental hazards," says Beissner. "With walkers, there are lots of issues. The walker can 'get away' on an incline. The brakes can be hard to grip if you have arthritis, and brakes are very important for stability when going from standing to sitting or vice versa. Some models' wheels are so small they get stuck on things, like the edge of a rug. Or they turn when you back up and then won't go forward."

Beissner feels that elders will be receptive to better technology. "People I know are very interested in maintaining their mobility. I find them much more open to change than any stereotype suggests," she says.

As braking is consistently cited as a major problem, the team is tackling that first. According to Attygalle's project proposal, "the most rudimentary walker has four rigid posts, and the user lifts and plants the walker in front of them and walks towards it in an unnatural movement. ... Adding wheels to all four posts results in a walker that can match a person's gait; however, [this] makes the walker more difficult to control, since the walker can now move with its own momentum. Current four-wheeled walkers with brakes rely on the user to apply the brakes properly, using levers similar to bicycle brake levers."

The braking system the team is devising couldn't be more different from bicycle brakes. Instead of stiff, hard-to-grip levers, their walker has a single highly sensitive button. The button is a touch sensor that runs to a microprocessor (the system's brain), that sends information to a linear actuator (the system's muscle), that in turn pulls on a mechanical brake to make the wheels come to a complete stop. A mere touch is effective; this walker will brake safely for users with low strength or impairment in their hands.

Other design constraints include weight, cost, size, and battery life. Rolling walkers with brakes typically weigh between 8 and 20 pounds, and the team's goal is that the electronically enhanced model will not exceed that. Traditional (non-rolling) aluminum walkers weigh only about 3 to 5 pounds. The team's survey of residents at Longview suggests that people use the traditional walker for traveling because they can lift it into their cars, but prefer the enhanced mobility of the rolling walker when lifting is not necessary.

Rolling walkers typically cost between $100 and $250. Private insurance will generally pay two-thirds of the cost of a rolling walker. The team is working to keep the cost of the assisted walker below $400.

Affordability is a significant issue. Many people with mobility problems rely on Medicare, which currently covers 80 percent (typically about $50) of the cost of a non-rolling walker. Initially the market for an electrically assisted walker may be limited to those who can afford it out of pocket. Eventually, however, the walker may be included in a new Medicare category covering powered wheelchairs, which has higher spending limits.

In terms of size, the assisted walker will be narrower than a standard door frame and will collapse to fit in a car trunk or back seat. In terms of power, because a walker is typically used throughout the day, it should run at least one day on a single charge.

The team is aware of the importance this project might have in improving the lives of the elderly, a population that, by the middle of the 21st century, will approach 80 million people in the United States. "This is not a small market," says Attygalle. According to the group's research, medical costs resulting from falls by the elderly are expected to approach $32.4 billion by the year 2020.

In March, with the guidance of Beissner, the Cornell group took its walkers to Longview to get feedback from a group of current walker users.

Attygalle reports a thoroughly mixed reaction from those who tried out the walkers. "There was a huge range of opinion, from people who thought our walker was great to those who wanted to stick with the old one," he says. "It was definitely a lot different than when we use them. For starters, some of the elders had smaller hands, and they didn't like the grips or where the braking button was. We definitely saw more clearly the need for controlled, gradual braking—our system is all-stop or all-go. We realized we may need to incorporate two separate braking modes, one to slow down and one to stop completely."

"I definitely think that in the future walkers will be electrical," says Wang. "Baby boomers will be seeking more sophisticated machines that give better user mobility."

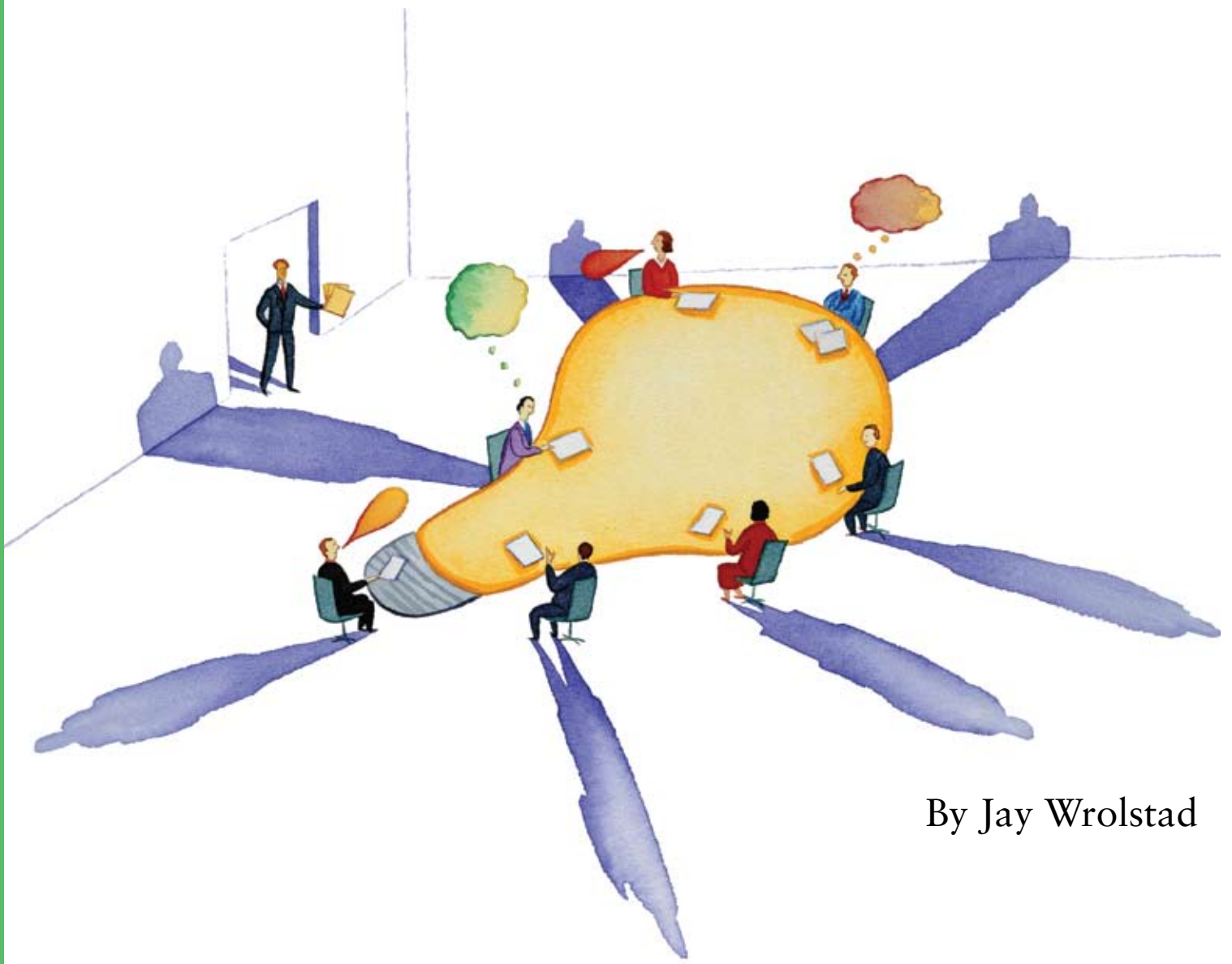
Wang adds that the project has been a great way to prepare for working in the biomedical industry. "The biggest challenge for me was figuring out where everybody else fits in, understanding what each person could contribute to the project," he says. "This is the first time we're really out of the classroom; there's so much creative freedom."

"The best part of this project for me," says Attygalle, "is that we as students get to define what the parameters are. All the decisions were made entirely by us. Also, I like that the scope of the project is something that will extend beyond the campus."

Although most of the team will graduate this spring, the project will continue. "We'll make up a suggestion list for next year's team," says Lau. "There's so much more we want to do—add better sensing, maybe ultrasound. If the wheels were motorized, they could mimic more exactly a natural walk. Basically, this project could go on indefinitely, adding or exchanging parts to suit a user's need."

More immediate goals must be addressed first, however. "Once we determine that the brakes are optimized, we can move on—when they are as reliable as possible and fit the widest range of user needs and constraints," says Chiang, the group's mechanical engineer. "For me, it's exciting to see the physical manifestation of our ideas; it's exciting to say, 'I made this with my hands.' And if it makes somebody's life easier, I'll be proud."

Innovators and



By Jay Wrolstad

Entrepreneurs

Students in business and engineering team up to help companies make strategic choices in new markets and new technologies.

It's only a short stroll from the Engineering Quad to Sage Hall, home of the Johnson Graduate School of Management, yet until recently they were two distinct educational realms; engineers developing new technologies, and business experts focusing on making money.

The folks on either side of Campus Road are increasingly finding common ground, though, through a program that combines Cornell's strengths in fostering innovation and putting best business practices to the test.

The Business of Science and Technology Initiative meets an increasing demand for business students who understand technological innovation and engineers who understand how work on the corporate lab bench translates into marketable products. It was founded in the summer of 2006 by the College of Engineering and the Johnson School.

The initiative joins graduate students from each school together in small teams to work on problems and opportunities identified by companies. The teams get hands-on experience under the tutelage of accomplished innovators, entrepreneurs, and faculty. It's an integrated approach that produces tangible results for businesses while training the next generation of innovators.

"Taking part in this initiative helps graduate research students to see, firsthand, that many new product lines are based directly on the research done in academia."

"We are establishing a link between engineer-scientists and entrepreneurs, based on a need at global corporations that have traditionally focused on specialization," says Eugene Fitzgerald, a visiting professor in the Department of Materials Science and Engineering and the Johnson School and co-founder of the initiative. "Now that focus is changing. The engineer-scientists are becoming business people, and business people are becoming more involved with engineering. These 'hybrid' individuals have a great value in the open-innovation environment."

According to Fitzgerald, who has worked as a scientist at Bell Labs, industry needs more employees knowledgeable in complementary areas. "For the students this is an opportunity to gain the type of experience they need in finding a job at a corporation," he says.

That's exactly why applied physics Ph.D. student John Mannion enrolled in BSTI. He says students from both schools benefit by stepping out of the classroom or the lab and working to address a problem of immediate concern in industry.

"Taking part in this initiative helps graduate research students to see, firsthand, that many new product lines are based directly on the research done in academia," he says. "I think, having seen this, students will turn to work on their dissertations with a stronger sense of purpose."

Working with MBA candidates has given Mannion an appreciation of their ability to quickly identify and evaluate markets for technological innovations. "The two disciplines do go hand in hand," he says. "As our project has progressed, there has been a valuable exchange of knowledge, with us engineers giving the MBAs a choice of technologies for a market, and with them giving us a choice of markets that they have identified as being the most profitable. For our team, identifying opportunities for the client to make money has been a highly iterative process."

Cornell is ideally suited for this endeavor, according to Michael Spencer, professor of electrical and computer engineering and associate dean for research in the College of Engineering. "Here we have a tradition of multidisciplinary endeavors without boundaries," he says, "so there is a discussion with multiple points of view on specific technological issues."

Such collaboration is critical in the long and involved process of moving from that "Eureka!" moment of discovery to bringing a product to market. BSTI director and co-founder Andreas Wankerl explains that innovation does not occur as a linear progression, from research to invention and from invention to commercialization, but rather as a non-linear and complex process between supply and demand.

"Innovation is a complex, iterative learning process—on the market side and on the engineering and science side," he says. "In order to come up with a very complex solution, you can't take a linear approach because there are too many pieces of the puzzle."

And completing that puzzle is a lot easier when engineers and business people like chief technology officers interact at every step along the way. A well trained engineer knows how to conduct research and how to develop practical solutions to practical problems, but may not consider the business parameters of cost and time in developing a product, Wankerl says.

Finding corporations to participate in the program has been a challenge, although most corporations are now more receptive to help from the outside than they have been. "There is a high level of uncertainty, and we have to establish a good working relationship on the business side as well as the science side," says Wankerl. Typically a BSTI project involves a technology that a company has, or is developing, but needs some help getting to market.

The projects are open-ended, as initially there is no way to know whether a particular technology will pan out, which allows the team to draw on a variety of resources. "Creative people have to continually check against reality, asking 'Can this work?'" Wankerl says. "We can let the company know that a particular project is not working—and won't work—and here's why from an engineering perspective. Ninety percent of experiments fail, but it is the learning process from failures that make the ultimate experiment succeed."

"Innovation is a complex, iterative learning process—on the market side and on the engineering and science side."

As an example of this process, Fitzgerald offers a theoretical company that is exploring new biomedical devices. "The traditional approach is to collaborate with a research university, like Cornell, to explore what is being done in the field. With our initiative, we go to the company to help them understand the market for a particular product in the future and to establish a timeline for developing that product and meeting the anticipated demand," he explains. "We ask them to tell us, 'What is important to you?' Then we conduct research on a device they want to sell, as well as the market for that technology."

Once given the nod, the Cornell BSTI team delves into the project in more detail, perhaps building a prototype device, or suggesting that a company may want to reconsider its plans if the market for a product or technology is not apparent. "The idea is to answer their questions in a timely manner and provide a give-and-take between our team and their people."

Students have worked on two industry-related projects this year and while the details are confidential, one involves biotechnology research by a well known global corporation, and the other concerns electronics applications.

Every project includes an engineering professor, and possibly a larger number of instructors. Senior technical officers at the client company are also involved in every step of the process, offering their input and providing direction when needed.

Successful companies are always brainstorming new

uses, and new markets, for their technologies, winnowing hundreds of possible ideas down to a few viable products. Corporate culture can sometimes stifle the kind of outside-the-box thinking that produces the next big innovation, but Spencer says that's not a problem for BSTI students.

"Companies are careful not to be too restrictive with us; they see this as an interesting experiment," he says. "A couple of months into a project, if a student team can tell the company something they have not considered about a market or technology area that the company knows well, that is quite an accomplishment. That creates real value."

Richard Shafer, associate dean for corporate relations at the Johnson School, suggests that businesses see BSTI as way to improve their standing in a highly competitive atmosphere. "They have to grow fast, and they know their current research and development process is not pumping out enough new products and services fast enough on a global basis," he says. "So they have to know where the innovation is coming from. The idea of innovating the innovation process is what this is all about. Then we can evaluate which technologies make the most sense for a company."

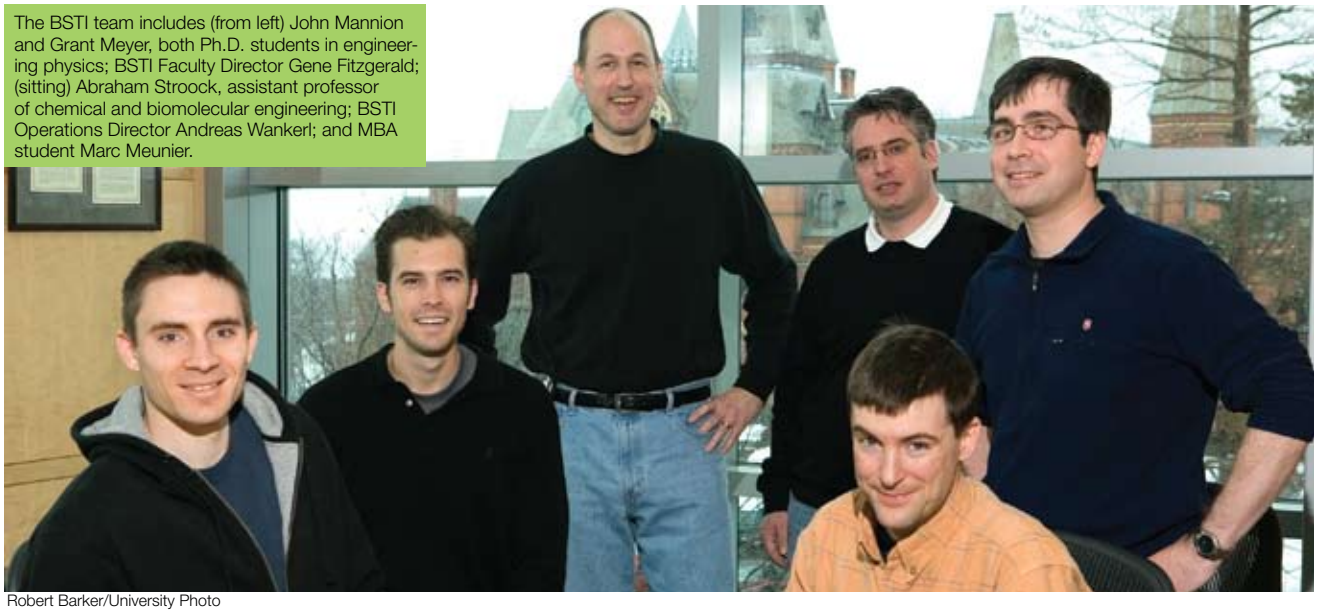
That ability to anticipate which products will sell, and how to speed the innovation process, is what makes BSTI particularly valuable. Spencer notes that Cornell students have the talent to "see around corners" and can get from point A to point B when the path is not laid out in front of them.

"A company may have the wherewithal to invest and make ideas grow, but not know how to do innovation well and consequently miss many opportunities," he says. "A particular strength of this initiative is that engineers are talking to business school students at an earlier point in their careers, and are learning the terms that are important in the business world. Engineers typically have no sense of market and market urgency."

Looking ahead, Fitzgerald and Wankerl want to reach beyond the Cornell campus and involve more students at other universities that will initiate additional corporate projects. MIT, which like Cornell has strong business and engineering schools, has been brought into the fold through the efforts of Fitzgerald, a professor in the engineering school there. BSTI would serve as the primary contact point for corporate partners when the model is expanded.

"It's exciting for me to provide engineering students with this type of path," Fitzgerald says. "And the connection with MIT will enable us to establish teams that work across educational institutions."

Ph.D. student Mannion is confident that the experience gained through BSTI will serve him well when he pursues a career in industry. "The program is a model, really. The goal is to demonstrate that students with knowledge sets based in different disciplines can work together to quickly and efficiently answer questions of commercial relevance," he says. "In addition, those who plan to go into industry derive benefits through working on a BSTI project. They get a feel for the industrial lab setting, and they develop a more complete picture of the innovation process."



The BSTI team includes (from left) John Mannion and Grant Meyer, both Ph.D. students in engineering physics; BSTI Faculty Director Gene Fitzgerald; (sitting) Abraham Stroock, assistant professor of chemical and biomolecular engineering; BSTI Operations Director Andreas Wankerl; and MBA student Marc Meunier.

Robert Barker/University Photo

SPICING UP THE CLASSROOM

Professor of the Year shares his thoughts on teaching and research.

Charles Williamson, professor of mechanical and aerospace engineering, is the 2006 New York State Professor of the Year.

Robert Barker/Cornell University Photography

Charles H.K. Williamson, professor of mechanical and aerospace engineering, was named New York state's top professor for 2006 by the Carnegie Foundation for the Advancement of Teaching and the Council for Advancement and Support of Education.

Williamson received the New York State Professor of the Year award at a ceremony in Washington, D.C., in November, along with winners from 42 other states, the District of Columbia ,and Guam.

An expert in fluid dynamics, Williamson has research interests that include problems of vortex dynamics and instabilities, vortex-induced vibration, aircraft wake vortices, vortex pair instabilities, and ocean engineering. He also serves as director of the Fluid Dynamics Research Laboratories.

Williamson, who earned his bachelor's degree in naval architecture from Southampton University in England and his Ph.D. in fluid mechanics from Cambridge University, has won numerous teaching awards since he joined the faculty in 1990, including the 1994 W.M. Keck Foundation Award for engineering teaching excellence, as well as the 1999 Weiss Presidential Fellowship from Cornell. He has worked with 152 student researchers in his lab; his papers have been cited more than 2,500 times.

Cornell University Photography

Williamson works with a student in the lab.

> "Cornell has an incredible program of putting undergrads in research labs."

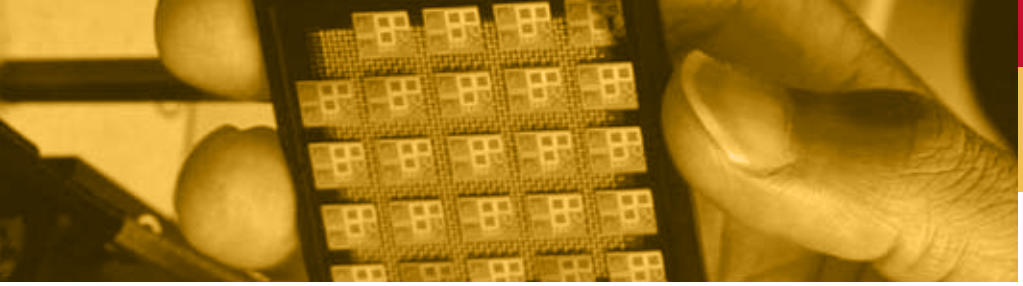
In March, Williamson shared his thoughts on teaching with other faculty members in the campus Faculty Seminar Series, co-sponsored by the Center for Learning and Teaching and the Vice Provost for Undergraduate Education.

"If you have the attitude: 'I can have fun with anything,' students will be receptive. That's my theory," he said, explaining how he bridges the gap between the classroom and the research lab for undergraduate students.

In his talk, "Synergy Between Research and Teaching: Fun With Fluid Dynamics," Williamson emphasized that demonstrations are essential to "spicing up the classroom." He showed several favorites from his lectures on fluid mechanics, including rolling pens off a table so that they flew upwards, blowing enormous smoke rings, and making toilet paper rolls fly in spirals over the audience. "Students come in thinking we'll do just book stuff, but I've got all these little things waiting for them, with the theory behind it all. They think it's all spontaneous, but in fact everything is choreographed."

But teaching, for Williamson, goes beyond the classroom. "Cornell has an incredible program of putting undergrads in research labs, and this is a chance for faculty to mentor students way, way, way over and above what you can do in class. And we've got great students here—you've got to admit, it's one of the best things about being at Cornell," he said.

—Adapted from stories by Anne Ju and Melissa Rice of the Cornell Chronicle



IMAGING SCIENCE

To better her understanding of nacre, the iridescent substance found in seashells, Cornell engineering graduate student Ellen Keene used a scanning electron microscope to study crystals of calcium carbonate, nacre's fundamental material.

By capturing an image of two strikingly different polymorphs, or crystalline patterns, of calcium carbonate on the edge of a broken silicon wafer, Keene also won herself a first-place award in the National Science Foundation-funded Cornell Center for Materials Research (CCMR) fourth microscopy imaging contest. Held periodically throughout the academic year, the contests solicit often stunning and always interesting images taken on CCMR equipment, including electron and optical microscopes.

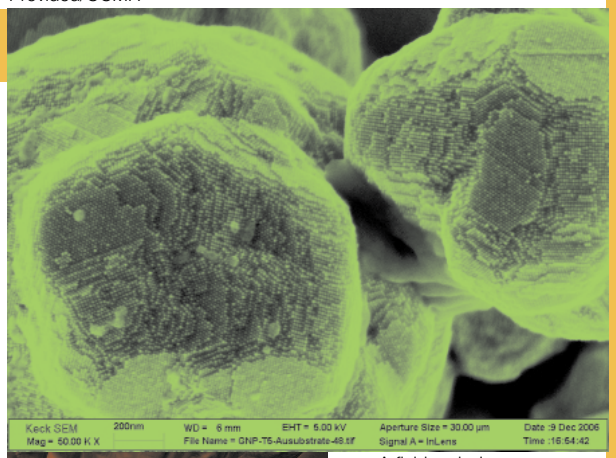
Other first-place winners were Wenlong Cheng, for an image of gold nanoparticles manipulated with DNA; James Loudon, who captured a lattice-like pattern in manganite (MnO3); and Matthew Lloyd, for his image of thin films of organic molecules following exposure to a solvent vapor.

Choosing from 25 submissions, faculty judges also picked a handful of honorable mention winners in such categories as "most unusual," "most artistic," and "best caption."

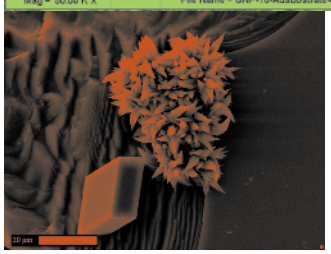
The idea for the competition came about two years ago, when Mick Thomas, a facility manager at CCMR who runs one of the microscopy labs, noticed that students were taking remarkable microscopic images, but many were never published.

"I thought it would be good if we could create a venue where students could showcase their work, which might not get into print because it's a steppingstone toward a final step in their research," Thomas said. "Or maybe it's a brilliant image, but there just wasn't room in the journal."

Provided/CCMR



A field emission scanning electron microscope allowed Wenlong Cheng, who studies biological and environmental engineering with Professor Dan Luo, to show gold nanoparticles assembled using DNA.



Provided/CCMR

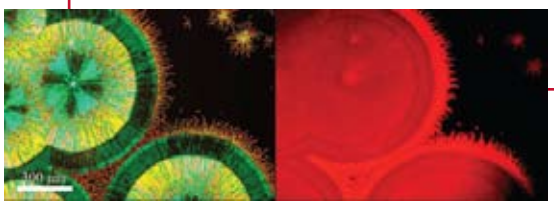
Using a scanning electron microscope, materials science and engineering student Ellen Keene saw two patterns of calcium carbonate, the fundamental material of nacre, or mother-of-pearl. Keene's research group tries to mimic the growth of nacre.

The response to the contest so far has been positive, according to CCMR Associate Director Helene Schember. For the first time, this latest round of submissions included unsolicited videos, such as honorable-mention recipient Thiti Taychatanapat's capture of disappearing gold particles on gold wires. Because the judges were unprepared for videos, they likely will form a new category for future contests.

"We were very pleased—the students are ahead of us," Schember said.

Winners and advisers were treated to pizza at an awards ceremony Feb. 27. They received certificates from CCMR Director Melissa Hines, and first-place winners also took home cash prizes.

—Anne Ju, Cornell Chronicle



Provided/CCMR

Materials science and engineering student Matthew Lloyd used a light microscope to capture images of organic semiconducting material: anthradithiophene, and a buckminsterfullerene derivative.

SEE ALL OF THE CONTEST IMAGES AT WWW.CCMR.CORNELL.EDU/FACILITIES/WINNERS07FEB

University Photography

FRENCH CONNECTION

Philip Protter, professor of operations research and information engineering, has been named to a Fulbright-Tocqueville Distinguished Chair for the 2007–08 academic year.

Part of the international Fulbright Scholar Program, the Fulbright-Tocqueville chair promotes collaborative research between France and the United States. During the fall 2007 semester, Protter will teach two courses at the University of Paris-Dauphine and give three plenary lectures to general audiences in Paris. He will return to Cornell in the spring.

Currently director of Cornell's Financial Engineering Program, Protter joined the Cornell faculty in 2000 and specializes in theoretical and applied probability. His research interests also include mathematical finance theory (including asset pricing, liquidity risk, and credit risk), stochastic numerical analysis, stochastic analysis and its applications, weak convergence, Markov process theory, and filtering theory.

—Anne Ju, Cornell Chronicle

SCIENCE IN ACTION

Jason Koski/University Photography

Arojit Saha '07 helps Mackenzie Mansfield of Girl Scout Troop 127, Newfield, learn about different types of engineers by exploring the engineergirl.org Web site.

From building robotic submarines to designing communication devices, engineering career possibilities were seemingly endless at a science workshop for Girl Scouts, hosted by a student group March 10.

The Cornell University Autonomous Underwater Vehicle (CUAUV) team, a student-run club, invited three local scout troops to its first-ever outreach event, Science in Action.

"We wanted to reach out to the community and teach girls about engineering opportunities," said Jackie Klein, graduate student in the Cornell Institute for Public Affairs and public relations team leader for CUAUV.

By the end of the day, the troops had completed five projects, earning Science in Action merit badges while discovering how engineers apply science to solve ordinary and extraordinary problems.

At the communication project, the Girl Scouts learned about the origins of the Internet and cellular phones. They then broke into pairs and constructed their own phones out of cups and string. The girls then moved on to bridge building, working together on an online activity to construct appropriate bridges around a small city.

Next was a tour of the CUAUV lab, where the Cornell team designs and constructs robotic submarines, followed by Engineering 101, an online scavenger hunt to learn more about what it means to be an engineer.

Emergency Science featured a volunteer firefighter who demonstrated the clothing and equipment that firefighters use to protect themselves and discussed how technology is used to save lives.

After completing all five projects, the Girl Scouts finished their day with a presentation from Sheila Hemami, professor of electrical and computer engineering at Cornell.

"We're trying to get a well-rounded experience," said Kittie Hollander, co-troop leader for Troop 127. "We want the girls to know what's available to them."

—Ryan Anderson, Cornell Chronicle

LIFETIME CONTRIBUTIONS

Charles Harrington Photography

Francis Moon

Francis C. Moon, the Joseph C. Ford Professor of Mechanical and Aerospace Engineering at Cornell, has won the 2007 Lyapunov Award from the American Society of Mechanical Engineers.

The Lyapunov Award is given by the Technical Committee on Multibody Systems and Nonlinear Dynamics, which is part of the ASME Design Engineering Division. It recognizes lifetime contributions to the field of applied nonlinear dynamics.

Beginning in the late 1970s, Moon, along with colleagues in the Department of Theoretical and Applied Mechanics, helped establish Cornell as one of the leading centers for the study of chaos theory, especially its application to mechanical systems.

He and his students developed experimental methods to test some of the new mathematical ideas in chaotic dynamics and fractals. Moon published several popular books on chaos, including "Chaotic Vibrations and Chaotic and Fractal Dynamics." His most recent book, "The Machines of Leonardo da Vinci and Franz Reuleaux," will be published this spring.

The ASME award is named for the 19th-century Russian applied mathematician Aleksandr Lyapunov (1857–1918), who established basic ideas about stability in dynamic systems.

Moon will receive the award at ASME's Sixth International Conference on Multibody Systems, Nonlinear Dynamics, and Control in Las Vegas, Sept. 4–7.

Moon, who teaches dynamics and robotics, has taught in the Sibley School of Mechanical and Aerospace Engineering since 1987 and served as its director from 1987 to 1992. He joined the Cornell faculty in 1975, and also served seven years as chair of the Department of Theoretical and Applied Mechanics.

For the past decade, Moon has served as curator of Cornell's collection of Reuleaux Kinematic Models. He has written several papers on 19th-century kinematics and dynamics of machines.

—Anne Ju, Cornell Chronicle

SCOPE AND STYLE

Steve Strogatz, Cornell professor of theoretical and applied mechanics and director of the Center for Applied Mathematics, is the 2007 recipient of the Joint Policy Board for Mathematics (JPBM) Communications Award. The award cites Strogatz's ability to tweak the popular imagination with novel research, engaging writing, and a flair for finding new answers to an old question: What does complex math have to do with real life?

The award was presented Jan. 6 at the Joint Mathematics Meetings in New Orleans.

Strogatz's recent research topics include: the social networking phenomenon known as "six degrees of separation," circadian rhythms in humans, blinking patterns in fireflies, and the swaying of the Millennium Bridge. His 2003 book "Sync: the Emerging Science of Spontaneous Order" describes the order behind such phenomena as traffic jams, firing neurons, and solar system dynamics. And for fun, Strogatz plays chess (last year beating a visiting grandmaster).

The award "recognizes a person from within the mathematical sciences community who made a consistent effort to reach out to a wider audience." The citation states, "Strogatz has made significant contact with the wider scientific community. The style of 'Sync' and its sales indicate that it is intended for and has reached an even wider audience. The volume of this work is impressive, but the quality and breadth are spectacular as well."

The JPBM represents the American Mathematical Society, the American Statistical Association, the Mathematical Association of America and the Society for Industrial and Applied Mathematics.

—Lauren Gold, Cornell Chronicle

Cornell University Photography

Steve Strogatz

TARGET: 2015

Cornell's College of Engineering is widely recognized as one of the world's best research facilities, but equally important to the college's administrators is a vision it hopes to make a reality by 2015: to become "a diverse community of exceptional faculty, students, and staff"—words taken straight from the college's 10-year strategic plan.

Transforming the engineering college into a place where women and racial minorities are well represented among the traditionally white male majority has its challenges, say college leaders. But, they believe, the rewards are well worth the effort.

"We've made progress, but we feel that there's so much more to be done," said Zellman Warhaft, the college's associate dean for diversity.

The strategic plan describes the following diversity goals:

- Increase the percentage of undergraduate women to at least 35 percent, from 25 percent today, and of underrepresented minority students to at least 10 percent, from 6 percent;
- Increase the percentage of women graduate students to at least 30 percent, from 7 percent, and of underrepresented minority graduate students to 7 percent, from 4 percent;
- Increase the percentage of women faculty members to at least 20 percent, from 11 percent, and of underrepresented minority faculty members to at least 7 percent, from 4 percent.

Among ongoing efforts to increase faculty diversity is the two-year-old Faculty Recruiting Diversity Committee, which Warhaft heads. A small group of senior engineering faculty helps university search committees in the search process by advising on best practices in both hiring and mentoring new faculty, Warhaft explained.

The college administers a number of programs for diversity, many through Diversity Programs in Engineering. DiOnetta Jones has been its director since 2005, when the position was created to support recruitment and retention of diverse students and faculty, and to "enhance the climate" of a diverse campus community.

One of the most important steps to achieving diversity, in Warhaft's mind, is to make the concept a familiar one to the engineering community.

"One of the primary objectives is to make the faculty and the students conscious of the importance of diversity and make them sensitive to differences," Warhaft said.

—Anne Ju, Cornell Chronicle

Cornell University Photography

The college's strategic plan outlines goals to increase the number of women and underrepresented minorities in Engineering.

HIGHEST DISTINCTION

Cornell University Photography

Harold Craighead

Cornell University Photography

Éva Tardos

Two members of Cornell's engineering faculty—Harold Craighead, the Charles W. Lake Jr. Professor of Engineering, and Éva Tardos, professor and chair of the Department of Computer Science—are among 64 new members elected to the National Academy of Engineering.

Election to the academy is among the highest professional distinctions accorded to engineering faculty members.

"These individuals have earned this prestigious honor by virtue of their impact on their field," said Kent Fuchs, the Joseph Silbert Dean of Engineering. "To have faculty members elected to the academy for a second straight year is a source of pride for the college and the entire university." Last year, Toby Berger, the Irwin and Joan Jacobs Professor of Engineering emeritus, and Jean-Yves Parlange, professor of biological and environmental engineering, were elected.

According to the academy, Craighead, director of Cornell's Nanobiotechnology Center, was selected for "contributions to the fabrication and exploitation of nanostructures for electronic, optical, mechanical and biological applications." He has been a pioneer in nanofabrication methods and using nanostructures as tools in biological research. His research group has created devices that can detect and identify single bacteria and viruses, nanoscale gas sensors, and nanofluidic devices that can separate, count, and analyze individual DNA molecules.

Tardos was chosen for "contributions to the design and analysis of efficient algorithms for network problems." Her research focuses on "optimization," in which a computer is asked to find the most efficient way to organize a large number of elements. She has developed approaches that approximate ideal solutions and prevent the computer from becoming lost in unsolvable problems. The work has applications in the design, maintenance, and management of communication networks and problems that arise from vision. Her recent work focuses on algorithmic game theory, network games, and the price of anarchy.

—Bill Steele, Cornell Chronicle

AAAS HONORS

Cornell University Photography

Michael Shuler

Michael Shuler, the S.B. Eckert Professor of Chemical and Biomolecular Engineering and the J. and M. McCormick Chair of Biomedical Engineering, was one of five members of the Cornell faculty recently named fellows of the American Association for the Advancement of Science (AAAS), the world's largest general scientific society and publisher of the journal *Science*. The researchers were recognized at the annual AAAS meeting, held in San Francisco in February.

Shuler, who received his Ph.D. from the University of Minnesota in 1973, was named an AAAS engineering fellow for his work on bioprocess engineering, particularly Taxol production from plant cell culture, in vitro toxicology, single-cell models, and heterologous protein production. His research interests include applying chemical reaction engineering principles to biological systems and investigating targeted drug delivery to multidrug-resistant cancer cells.

Other Cornell faculty members named as AAAS Fellows include Hector Abruña, the E.M. Chamot Professor of Chemistry and Chemical Biology and department chair; Barbara Baird, professor of chemistry and chemical biology; Geoffrey William Coates, professor of chemistry and chemical biology; and Mariana Wolfner, professor of molecular biology and genetics.

—Lauren Gold, Cornell Chronicle

SPOUSES IN SYNCH

Hod and Michal Lipson bring laptops along to lunch at Hope's Way in Triphammer Mall, where they trade ideas across their separate disciplines.

Hod and Michal Lipson have synchronized their careers. And that's not a metaphor.

"We have to keep working to stay together," Hod says. "A dual career is unstable. The moment one person gets ahead they accelerate. The other one stays more and more behind, the gap opens and it's irrecoverable."

From the time they met and married, Hod and Michal planned to stay together in everything they did. They timed their education and postdoctoral research to stay in step. They applied for faculty positions "synchronously," as engineers would put it. And they screened their offers to find the school that really wanted them both. That was Cornell, where in 2001 Hod became assistant professor of mechanical and aerospace engineering and Michal, assistant professor of electrical and computer engineering.

"Cornell is one of the few places where neither of us had to compromise," Michal recalls. "Other places were better for me and worse for Hod or the other way around. We wanted to be appreciated independently."

Synchronicity started long before they met. Both were born in the same neighborhood in Haifa, Israel; both were children of physicists, raised to value education and love science. Both had parents on the faculty of Technion, the prestigious Israel Institute of Technology. But when Michal was 8 years old, her family moved to Brazil.

Ten years later, Hod, then 21 and about to graduate from Technion, planned a trip to South America. Michal, then 18, was visiting Israel. "I heard there was this woman from Brazil, and I thought she could tell me something about South America," Hod recalls. "Things followed. I forgot all about the trip."

After his last final, Hod followed Michal back to Brazil. Five months later they were married and back at Technion. Michal pursued a bachelor's degree in physics at Technion, while Hod completed his mandatory military service in the Israeli navy. Michal, technically Brazilian, was exempt, which allowed the couple to get in phase.

After the navy Hod returned to Technion. "I was a year behind him, doing a master's when he started his Ph.D.," Michal explains. "When he finished his Ph.D., he waited six months for me to finish."

Faculty positions are hard to come by in such a small country. The unwritten rule was that you first had to do a postdoc in the United States. Michal landed a job at the Massachusetts Institute of Technology, working with light-emitting silicon. Hod got a joint appointment at MIT and Brandeis University.

Thoughts of returning to Israel were quickly set aside. While Technion has some of the greatest scientific minds, the resources available in the United States were eye-opening. Michal recalls asking a professor: "What material should I use for this?" He opened the periodic table of the elements and told her anything was possible. "In other parts of the world they say, 'These are the tools you have, what questions can you answer?'" Hod says.

And Michal realized that they could do work that would have an impact. "We saw really quickly that people were changing the world," she notes.

Michal now works with photonic circuits, where beams of light flitting through tiny waveguides on a chip replace electrons in wires. Hod works in "evolutionary robotics." In computer science, "evolution" is about telling a computer what you want and letting it try different approaches until one emerges as the most successful.

With two careers and now two sons, ages 9 and 2, they say there is no time for hobbies. "We put the kids to bed and go downstairs and work together. When the kids are off to Hebrew school or with a babysitter, we go off to the coffee shop; we both bring our laptops and work," Michal says.

But, she adds, "We are working, but we are holding hands. We are very lucky."

—Bill Steele, Cornell Chronicle

Lang Tong

NETWORKED SYSTEMS

Electrical and computer engineering professor Lang Tong has received a $50,000 university research grant from Lockheed Martin. Representatives from the company were on campus in December to officially award him the grant.

Tong will use the money to support his ongoing research project, developing theory and applications of networked autonomous systems.

Tong, who joined the Cornell faculty in 1998, was also named the Irwin and Joan Jacobs Professor in Engineering in early November, replacing Toby Berger, who had held the chair since its endowment in 1997. Berger retired from Cornell after the fall 2005 semester.

Tong's research areas include statistical and signal processing, communication systems, and wireless networks. His group is investigating various practical problems that arise from broadband wireless systems, mobile ad hoc networks, and large-scale sensor networks.

Irwin Jacobs '54, BEE '56, is a founder of Qualcomm. He and his wife, Joan '54, have been major contributors to Cornell, most recently through a $30 million gift for university scholarships and fellowship funds for ECE.

—Anne Ju, Cornell Chronicle

HOMETOWN HERO

An alumnus is helping to bridge the education gap between rich and poor schools.

TEACHING FOR AMERICA

Provided

Keim teaching in his Oakland classroom.

Will Keim '04 EP could be making a bundle; instead, he's making a difference. As a graduate of the nation's top-ranked engineering physics program, Keim could have had a high starting salary, or acceptance into a graduate program at one of the country's leading research institutions. What he chose, however, was a two-year commitment to teach science to high school students in Oakland, Calif., with Teach For America.

Both of Keim's parents are teachers, his mother in elementary school and his father at a community college, so Keim has teaching in his blood, but he was also drawn to Teach for America's mission to eliminate educational inequality. "I've always wanted to do something where I felt I was making a difference and having an immediate impact," says Keim, now a Teach For America alumnus in his third year teaching at Oakland Technical High School.

Keim is not alone. Teach for America has been one of the top 10 employers of Cornell graduates for the past several years. The organization is very selective, targeting top-ranked schools like Cornell, Yale, and Duke. They want the best and it takes more than smarts to break through to the students they are trying to reach. The organization looks for recruits who won't give up when the going gets tough. Of 19,000 applicants in 2006, Teach For America accepted 2,400, making it one of the top employers of new graduates nationally.

Professor Frank Wise, with whom Keim had done undergraduate research, was surprised when Keim told him that he was joining Teach for America. "There's not much money in it. No prestige. His friends are all going to law school, medical school, graduate programs," he says. "They go through a lot and sacrifice a lot of earning potential, so these kids deserve a lot of credit."

During the two years Keim was a Teach for America member, he made trips back to Cornell to tell students in Wise's classes and others about the program. Members are paid directly by the school districts for which they work and generally receive the same salaries and health benefits as other beginning teachers, ranging from $25,000 to $44,000. Because TFA is a member of AmeriCorps, members can also get a break on their student loans during their two years of service, plus a stipend of $4,725 each year.

Like many members, Keim used his stipend to enroll in teacher certification courses, a requirement for all uncertified teachers. He had considered staying at Cornell to earn his certification, but found Teach for America's guarantee of a teaching position and express ticket to the classroom preferable to paying for a fifth year of tuition. But he did have to endure a kind of teacher boot camp—five weeks of intense training over the summer, including supervised teaching.

Oakland Tech Assistant Principal Tobi Page has worked with several Teach for America members and found them all to be excellent teachers. She says it depends a lot on the individual and how hard they want to work. Keim regularly works 12- and 14-hour days, picking up one student who does not have transportation to school in the morning and working into the evening and on weekends as the school's staff professional development chair, assistant baseball coach, and Saturday school teacher. "He's an exceptional person and a wonderful teacher," says Page. "He makes science come alive. The students love his class."

Keim says some friends have had a hard time understanding his choice to continue teaching. "Even now, people are like, 'You're teaching? What?' But I'm very happy with what I'm doing," he says. "I'm not stuck here. I'm choosing to stay here."

Keim doesn't plan on spending his entire career as a teacher, but he does plan on remaining in education, perhaps as an administrator or as a staff member for Teach for America. "I enjoy it and believe very strongly in what I'm doing and want to find a way to just broaden the effect that I can have," he says.

—Robert Emro

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