FALL
09

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CORNELL ENGINEERING

MAGAZINE

CORNELL'S 100+ MPG TEAM DRIVING FOR *Sustainability*

contents

DEPARTMENTS

Features

Stimulus money will fuel energy research and add jobs

Cornell researchers have won federal stimulus funding for three projects that will help meet the nation's future energy needs, with additional state support for one project. The proposals are the first to be approved among dozens submitted by the university for the federal aid.

The funding is expected to support at least 30 new graduate students and postdoctoral researchers, and according to the Office of the Vice Provost for Research, each new Cornell researcher generates two or three support jobs in the surrounding community.

At the top of the recipient list is the Center for Nanostructured Interfaces for Energy Generation, Conversion, and Storage, to be directed by Héctor D. Abruña, the E.M. Chamot Professor of Chemistry and Chemical Biology and co-director of the Cornell Fuel Cell Institute. The goal of the center is to discover and design materials that will dramatically enhance the performance of fuel cells, batteries, photovoltaics, and photo-electrochemical cells.

"The proposal we put forth was a great collective effort, and the Department of Energy recognized in it Cornell's strengths in materials design, characterization and modeling, and the close-coupling of the various components of the proposed work. This is great news," said Abruña. The proposal team includes 14 faculty members from five departments and two colleges. The center will receive $17.5 million over five years, according to Paul Mutolo, associate director of the Fuel Cell Institute. Additional funding of $500,000 has been committed by the office of New York state Gov. David Paterson, and the New York State Energy Research and Development Authority will provide a one-time $250,000 contribution. The Cornell Center for a Sustainable Future, a key partner in developing the proposal, will provide additional support.

A dozen engineering faculty members are involved in the center. Their research will include an expanded search for better catalysts for fuel cells, work already in progress at the Fuel Cell Institute, and the development of better materials for electrodes in lithium-ion batteries to increase the amount of energy the batteries can store per unit of weight, which is essential for viable electric cars and will enhance wind and solar electricity systems.

The new center will be one of 46 Energy Frontier Research Centers (EFRC) created by the U.S. Department of Energy's Office of Basic Energy Sciences. Several of these new centers, including the one at Cornell, will be funded by President Barack Obama's economic stimulus package.

Cornell also is collaborating with other institutions in two other EFRCs.

J.C. Séamus Davis, the James Gilbert White Distinguished Professor in the Physical Sciences, who holds a joint faculty appointment at Brookhaven National Laboratory, will lead a Center for Emergent Superconductivity involving Cornell, Brookhaven, Argonne National Laboratory, and the University of Illinois. The center aims to move superconductor research from theoretical to practical. Some materials can superconduct—conduct electricity without heating or energy loss—at temperatures up to around 150 degrees above absolute zero (-125 Celsius). But superconductors that need even less cooling could lead to more efficient motors and generators, Davis said. One possibility, he suggested, would be lightweight yet more powerful generators for wind-power towers.

UNIVERSITY PHOTOGRAPHY

Stephen Pope

The research will include an expanded search for better catalysts for fuel cells, work already in progress at the Fuel Cell Institute, and the development of better materials for electrodes in lithium-ion batteries to increase the amount of energy the batteries can store per unit of weight, which is essential for viable electric cars and will enhance wind and solar electricity systems.

Stephen Pope, the Sibley College Professor of Mechanical and Aerospace Engineering, will participate along with scientists at six other universities and institutions in the Energy Frontier Research Center for Combustion Science, directed by Chung K. Law of Princeton University. The researchers will create computer models of the combustion process, verified by experiment, in order to design novel, more efficient engines for cars and trucks, including engines using alternative fuels.

Pope's expertise is in the modeling of turbulence and its interaction with chemical reactions, and he will focus on the mixing of fuel, air, and recirculated exhaust in combustion chambers. "In this center Cornell is at the end of the food chain and others will be feeding into us [with models of the chemical reactions at the atomic scale]," Pope explained. "The goal is to create better tools that can be used in engine design." Cornell's share of the institute's funding will be up to $1.25 million over five years, he said.

—*Bill Steele*

New student team aims to create biomachines that destroy pollutants, cancer cells

Microscopic, living machines that sense toxins in the air or deliver drugs in the body—the stuff of science fiction? A new Cornell student project team is working to make such things the stuff of reality.

The Cornell International Genetically Engineered Machines (iGEM) team, formed last year, uses biological, not mechanical, components to make machines. Their goal is to enter the annual competition at the Massachusetts Institute of Technology that convenes institutions from all over the world to design, create, and demonstrate such machines.

This field is called synthetic biology, a discipline so new that many large research institutions don't offer specific programs to study it.

Reminiscent of when "nanotechnology" was barely a household term, synthetic biology is the design and engineering of complex biological systems that don't occur naturally, using DNA or other biological materials as "biobricks." Synthetic biologists bioengineer microorganisms that can perform such tasks as producing pharmaceuticals, detecting toxins, breaking down pollutants, or repairing defective genes.

"A lot of students were looking for a project team in the bio-related disciplines, which didn't exist at Cornell," said Naweed Paya '09 ECE, who co-founded the team last fall with Koonal Bharadwaj '09 BEE. Other majors represented on the team include biology, chemical engineering, and materials science.

The team attended the 2008 iGEM competition, which featured more than 80 teams, to observe the other schools and collect ideas.

Last spring, the team brainstormed ideas for its entry into MIT's sixth competition, to be held in November. Among the possibilities they considered were using bacteria as an anti-tumor agent or to insert antioxidants found in berries or spinach into such food-producing cells as yeast or bacteria that produce cheese.

The team chose to create a low-cost biosensor by using a bacteria's natural system of regulating metal ions to measure levels of toxic cadmium in drinking water. They worked on the project over the summer and are close to completing it, they said.

The students, whose faculty advisers are Carl Batt, the Liberty Hyde Bailey Professor of Food Science, and Maki Inada, senior research associate in molecular biology and genetics, are researching whether any of their ideas have been tried before. They spend Sunday afternoons presenting their findings to each other.

Meanwhile, the search is on for team funding. While they've received a small grant from the College of Engineering, the students are looking for alumni, companies, or other donors who can support them longer term.

"It's kind of like we're reinventing the wheel," said Alyssa Henning '11 BEE, who added that what drew her to iGEM was the opportunity to explore uncharted territory. "What we are doing in any of these projects really hasn't been done before."

—*Anne Ju*

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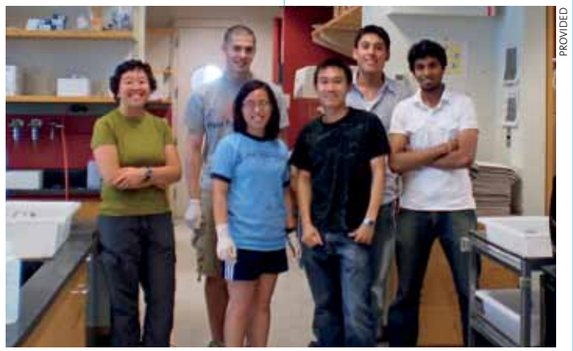

Members of the Cornell iGEM team, from left to right: faculty adviser Maki Inada, Matthew Hall '10 BEE, Alyssa Henning '11 BEE, Xing Xiong '10 Chem, Bernard Cammarata '11 BEE, and Malinka Walaliyadde '11 MSE.

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New lab working to make biofuel sustainable

JASON KOSKI/UNIVERSITY PHOTOGRAPHY

Larry Walker, professor of biological and environmental engineering, right, and Steve Kresovich, vice provost for the life sciences, second from left, examine a bag of sorghum with a group of students.

Cornell researchers moved into the new $6 million Biofuels Research Laboratory earlier this year. Inside the 11,000-square-foot facility, Larry Walker, professor of biological and environmental engineering, and a group of engineers, scientists, and students from across the university are examining sustainable and economical biofuel production.

"Under a single roof, we can perform all the major steps required to make biofuel," said Walker, director of the Cornell-based Northeast Sun Grant Institute of Excellence. "Other schools have bits and pieces of the process or specialize in pretreatment, chemical conversion, or cell wall analysis. In this lab, we can do it all."

In January, researchers from the College of Agriculture and Life Sciences and the College of Engineering began using the space, which was funded by a $10 million grant from the Empire State Development Corp. and replaces an agricultural engineering power and machinery lab in Riley-Robb Hall. The Cornell team focuses on the creation of cellulosic ethanol—a process that frees sugars from perennial grasses and woody biomass and biologically converts them into fuel.

"The highlight of the new lab is that multiple departments and multiple colleges are using it," Walker said. "That's been the underlying philosophy from the very beginning."

Unlike corn ethanol, which grew popular in recent years as gas prices climbed, cellulosic ethanol is derived from such nonfood crops as switchgrass, sorghum, and willow, so it has little effect on food prices. What's more, most of the feedstocks used in the biofuels lab can thrive on marginal lands that would go unused. Cellulosic ethanol, therefore, holds greater long-term promise than corn ethanol.

Walker has no doubt that the technology already exists to turn a bale of switchgrass into a barrel of biofuel. But, he said, the challenge is to generate the fuel in a way that's efficient, cost-effective for producers and consumers, and sustainable. Solving the problem requires a systemic analysis of biofuel production—from using sophisticated microscopes to study enzymatic processes at the nanoscale to transforming plant sugars into ethanol in a 150-liter fermentation reactor.

"The highlight of the new lab is that multiple departments and multiple colleges are using it," Walker said. "That's been the underlying philosophy from the very beginning."

The lab is arrayed like a factory. At its north end, large bales of raw material are unloaded. The biomass is then size-reduced and pretreated by thermochemical reactors that liberate some sugars and make the remaining solids easier to break down. From there, the feedstocks move south through the lab and undergo enzymatic conversion, which captures the remaining simple sugars. All of the sugars are then fermented into ethanol, butanol, and other biofuels. Cornell researchers study every step to determine how to better engineer the processes for converting plants into bioenergy.

For example, plant geneticist Stephen Kresovich, Cornell's vice provost for the life sciences, plans to examine the genetic and phenotypic diversity of select grasses in the lab. These studies promise to help researchers identify and create specific varieties of sorghum and other plant material best suited for biofuel conversion.

"[The lab] provides Cornell faculty and students the opportunity to strategically understand the genetic mechanisms that affect plant composition and yield," Kresovich said. "It will take this level of collaboration to make biofuels development a reality in New York and beyond."

The lab features numerous energy-saving features, including sensors to extinguish lights and limit ventilation in unoccupied rooms. It's currently under review by the U.S. Green Building Council for certification as an eco-friendly structure.

—Ted Boscia, College of Agriculture and Life Sciences

Cornell MineSweeper team wins high marks

Gil Lee '11 ECE, Steven Liu '11 ME, Hamzah Sikander '08 ECE, M.Eng. '09 SysEng, and Greg Meess '09 ME competed in Michigan.

An autonomous, lightweight robot created by Cornell students for detecting land mines placed third out of 53 student teams in the design portion of the Intelligent Ground Vehicle Competition, held in Michigan June 5–8.

The robot, Nero, was the latest model conceived and built by the Cornell MineSweeper Team, comprising more than 30 engineering students from several disciplines. Founded in 2006, the team, which had never competed before, plans to continue entering competitions, but its purpose is ultimately humanitarian.

"The chief purpose of our project is definitely to save lives," said Cam Salzberger '11 ME, co-leader of the team for 2009–10. "Our robot will make the act of mine sweeping far safer and, therefore, faster."

The challenge is to make a device reliable enough to assist civilian operations with clearing fields of explosives that can maim or kill when stepped on. Used in warfare to secure borders or restrict enemy movement, anti-personnel land mines have been banned by 156 countries so far, according to the International Campaign to Ban Land mines—and the U.S. is not one of them. Their use continues to be a humanitarian issue around the world.

"We can help the people of affected countries by raising awareness, removing land mines, and helping the victims," said Barrett Ames '12, team co-leader. "The robot is just one piece of this puzzle."

The team, honored with the Albert R. George Student Team Award from the Cornell Engineering Alumni Association in 2008, entered only the design portion of the competition, which also included categories for navigation and autonomy. Nero received high marks for such components as its drive train and the software that controls it. The judges also ruled on the engineering process the students described in their reports and work assignments.

"IGVC was a competition to benchmark competency for the team and also the basics of how robotics should be done," said founding member Hamzah Sikander '08 ECE, M.Eng. '09 SysEng.

Nero is the successor to the team's first robot, Gladiator, which suffered from faulty engineering and generally didn't work, Sikander said. Learning from their mistakes, the students built Nero using a more systems-based approach, integrating electrical, mechanical, and computer components from the start, Sikander said.

In the upcoming year, the team will likely re-enter Nero in the competition with a new, more stable chassis, according to Salzberger.

The team will also work on an entirely new robot specific to mine detection and will likely shift to a remote-controlled platform, as opposed to an autonomous one.

"The goal is to test the robot in facilities specific to this purpose by [next] summer and actually test the robot in affected countries in the near future," Salzberger said.

—Anne Ju

Greg Meess '09 ME, left, and Gil Lee '11 prepare to test code for Nero, the Cornell MineSweeper Team's entry at the Intelligent Ground Vehicle Competition, June 5–8.

BME grad students helping science teachers

Why do your fingers turn blue when they're cold? Words like "oxygenation" and "hemoglobin" might make a sixth-grader lose interest—unless experiments with red dye and an arm cuff make the concepts come alive.

Ten Cornell graduate students will spend the school year helping middle school and high school teachers in rural outlying districts teach science in fun, innovative ways, supported by a five-year, $3 million National Science Foundation grant to Cornell. The researchers will target schools that "lack resources and do not currently benefit from extensive outreach efforts from universities," according to the project proposal.

The program will allow the graduate fellows to make the "critical transition from student to scientist," the proposal continues, by creating outreach materials related to their own research that make sense to both teachers and young students.

"This grant will provide our graduate fellows an unusual opportunity to learn to communicate science concepts more effectively," said principal investigator Michael Shuler, the James M. and Marsha McCormick Chair of Biomedical Engineering. "We expect that this process will enrich the education of the graduate fellows, the teachers, and middle school and high school students."

In July, the fellows and their advisers began working with teachers in Binghamton, Elmira, Trumansburg, Groton, South Seneca, Newark Valley, and Dryden developing inquiry-driven science education activities for the upcoming school year. Summer work included a small research project for the teachers.

The project will also help teachers focus on inter-disciplinary ways of teaching science, moving away from the traditional hard lines drawn between such fields as chemistry, physics, and biology.

Project leaders include Shuler, and co-PIs Chris B. Shaffer, assistant professor of biomedical engineering, and Shivaun Archer, senior lecturer in biomedical engineering. The participating graduate students are Vishal Tandon, Jeisa Pelet, John Nguyen, Evan Spiegel, Luke Landherr, John Huynh, Jeff Ballyns, Philip Buskohl, Alyse Portnoff, and Jennifer Weiser.

—Anne Ju

PROVIDED/KEVIN DILLEY

BME graduate student John Huynh (right) analyzes a chemical reaction with Waverly High School teacher Stacey Coston.

"This grant will provide our graduate fellows an unusual opportunity to learn to communicate science concepts more effectively."

PROVIDED/KEVIN DILLEY

Shivaun Archer, BME senior lecturer (left), helps Binghamton High School teacher Carolyn Wilczynski develop an outreach lesson plan around investigating evidence of a chemical reaction.

PROVIDED/KEVIN DILLEY

BME graduate student John Nguyen develops an inquiry-based activity with Eagle Hill Middle School teacher Jacaranda Henkel.

Read more on these and other stories at
www.engineering.cornell.edu/news

Improved air quality during Beijing Olympics could inform pollution-curbing policies

The air in Beijing during the 2008 Olympics was cleaner than the previous year's, due to aggressive efforts by the Chinese government to curtail traffic, increase emissions standards, and halt construction in preparation for the games, according to a Cornell study.

Led by Max Zhang, assistant professor of mechanical and aerospace engineering, the study indicates that such measures as regulating traffic density and encouraging public transportation can have a significant impact on local air quality.

"We hope our study can help or advise local regulators and policymakers to adopt long-term sustainable emission controls to improve air quality," Zhang said. "That's our mission."

Published online July 11 in the journal *Atmospheric Environment*, the study was based on air quality readings before, during, and after the Olympics. Leading up to the Olympics, the Chinese government barred more than 300,000 heavy-emission vehicles—mostly trucks—from the roads. The city also implemented rules in which only some people were allowed to drive on certain days based on their license plate numbers. As a result, close to 2 million vehicles were pulled from the roads. Other mandates involved halting construction and decreasing the use of coal in favor of natural gas for electricity.

In 2007 and 2008, the researchers collected air quality data from equipment installed at two elevations on a building in the heart of Beijing.

They also tracked emissions from vehicles in different areas of the city by following randomly selected cars and trucks in a minivan equipped with sensitive instruments for detecting carbon particles, including carbon monoxide, carbon dioxide, and black carbon, or soot.

Among the researchers' conclusions: Black carbon pollution is significantly greater at ground level than at higher elevations, and diesel trucks are a major source of black carbon emission during the summer in Beijing. These particles are not only harmful to the lungs but are also known to be a global warming compound, Zhang said.

The researchers found that car emissions of black carbon were down 33 percent in 2008 compared with their 2007 readings. Carbon dioxide decreased 47 percent, and ultrafine carbon-based particles—those that measure less than 100 nanometers—decreased 78 percent.

PROVIDED

Above, a view of northwest Beijing on a smoggy day and, below, on a clear day.

PROVIDED

The sharp drops were most likely due to a new emission standard implemented in Beijing in 2008, in which all new registered vehicles as well as gasoline and diesel fuel engines were required to achieve emissions standards equivalent to European Union regulations. A similar standard was mandated starting in June 2008 for 20,000 buses and 66,000 taxies.

Improved fuel quality probably enhanced the performance of engines and catalytic converters, the researchers reported.

"We are showing what the city can do if they are determined to improve air quality," Zhang said.

The study, whose first author was graduate student Xing Wang, was funded by the U.S. Environmental Protection Agency and Cornell's Jeffrey Sean Lehman Fund for Scholarly Exchange with China.

—*Anne Ju*

Cornell's robotic submarine wins international competition

PROVIDED

The Autonomous Underwater Vehicle team's submarine, Nova, dodged barbed wire, fired torpedoes, and retrieved a pinging briefcase during the competition.

For the Cornell University Autonomous Underwater Vehicle team, months of meticulous testing, refining, and retesting has paid off: With a flawless 11.5-minute run through a complex course of underwater tasks in the final round, the team's autonomous submarine beat the competition and earned first place in the 12th annual Association for Unmanned Vehicle Systems International/Office of Naval Research (AUVSI/ONR) competition in San Diego Aug. 2.

The win earned the CUAUV team $10,000.

The Cornell undergraduates—32 in all, 12 of whom traveled to the competition—competed against 29 other teams in the five-day competition.

The team's new vehicle, Nova, was the only sub to complete every element of the course, which included dodging barbed wire, firing torpedoes, and retrieving a pinging briefcase.

"We had a very, very reliable system from day one," said team leader Erin Fischell '10 ME.

That reliability came from work that started with planning and designing last fall, then moved into hours upon hours of pool testing starting May 10. "We had pool tests nearly every day this summer, getting practice and identifying the problems we would encounter," she said.

The team also benefited from a strong team memory.

"[The Cornell] team has been doing this 10 years," Fischell said, and each year's team has paid particular attention to lessons learned by predecessors.

That attention paid off at the competition. "We brought backups for every part we made ourselves, but we never had to use any of them," Fischell said. "We made this vehicle reliable and usable enough that we never had to open it up.

"We had an amazing team this year," she added. "Everyone did wonderfully. I'm very proud of what we did."

In the coming year, the team will prepare for next year's competition, test new ideas, recruit new members, and improve its infrastructure.

The team is already working on new challenges, including possibly building a vehicle to search for a shipwreck in Cayuga Lake, at the request of the Ithaca/Tompkins County Convention and Visitors Bureau.

In its 10 years in the AUVSI/ONR competition, the Cornell team has earned several wins (most recently in 2003) and runner-up prizes, including first place in the design and implementation award for six consecutive years. The team has made it to the finals nine times; last year's entry came in seventh overall.

—*Lauren Gold*

PROVIDED

Members of Cornell's Autonomous Underwater Vehicle team celebrate after their submarine, Nova, was the only entrant to complete every element of the course. In the back row, from left: Nick Elser '10, Arseney Romanenko '11, Andrew Rzeznik '12, Brian Mittereder '11 ME, Kenny Bongort '11 CS. Front row: J.B. Rajsky '11 ME, Kirill Kalinichev '10 ECE, Greg Malysa '11 ECE, James Mwaura '10 ECE, Tom Jackson '12, Erin Fischell '10 ME, Tracy Cheung '10 OR.

Huttenlocher CIS dean

PROVIDED

Daniel Huttenlocher

Daniel P. Huttenlocher, Cornell's John P. and Rilla Neafsey Professor of Computing, Information Science, and Business, is the university's new dean of the Faculty of Computing and Information Science (CIS). He succeeds Robert L. Constable, who stepped down June 30, when his second five-year term concluded.

President David Skorton said: "I am very pleased that Dan Huttenlocher will be bringing his vision and expertise to the position of dean of CIS. He has the strong support of the faculty and of Provost Fuchs and myself."

CIS is an interdisciplinary program that stretches across campus with more than 50 affiliated faculty members. CIS has three main components, comprising faculty from the Department of Computer Science, the Information Science program, and the Department of Statistical Science, in addition to faculty members with joint appointments across the university.

"I am excited by the opportunity to lead such an academically outstanding group," Huttenlocher said. "Building on Cornell's long-standing strengths in computer science and statistics, we have also created one of the nation's leading information science programs in the past few years. The vibrancy and growth of all three of these areas provides us with a broad range of exciting new opportunities for education and research—both on fundamental scientific questions and on issues of substantial importance to our increasingly information-soaked society."

—*Cornell Chronicle*

Warner honored with PECASE award

UNIVERSITY PHOTOGRAPHY

Derek Warner

Derek Warner, assistant professor of civil and environmental engineering, is one of two Cornell recipients of the Presidential Early Career Award for Scientists and Engineers (PECASE), along with Jiwoong Park, assistant professor of chemistry and chemical biology.

Established in 1996, the PECASE program honors outstanding researchers near the beginning of their careers, providing recognition of their potential for leadership. Awardees are nominated by the National Science Foundation, NASA and several federal departments including defense, energy, and agriculture. The award is the highest honor bestowed by the U.S. government on early career scientists and engineers.

Warner, nominated by the Department of Defense, works on fracture modeling of aluminum and other metals, with the goal of better informing engineers about how such materials fail. The awarded work is intended to aid in the assessment of ship hull structures.

Warner's $1 million, five-year PECASE award will allow him to study the effects of harsh chemical environments, such as the ocean, on mechanical behavior. The work will involve using atomic-level simulation and analysis techniques to develop physics-based models of mechanical behavior in corrosive environments.

—*Anne Ju*

DRIVING FOR SUSTAINABILITY

Cornell 100+ mpg team members (from left to right): Katarina Chang '11 ME, James Watt '10 ME, Bill LaCava '09 ME, Matt Robison '10 OR, Jon Goldsmith '11, Ted Widger '09 ME, Fred Lenihan '10 ME, and Robert Moore '12

LINDSAY FRANCE/UNIVERSITY PHOTOGRAPHY

CORNELL'S 100+ MPG TEAM DESIGNING SUPER-EFFICIENT, FOUR-PASSENGER HYBRID CAR

By Lauren Cahoon

PHOTOS BY LINDSAY FRANCE/UNIVERSITY PHOTOGRAPHY

(From left to right) Matt Robison '10 OR, Andrew Gifft '09 ECE, and Ted Widger '09 ME discuss the wiring harness for the diesel engine.

The UQM controller regulates power to the UQM 125 electric drive motor.

A frigid Saturday morning in February is a time when most college kids lie dormant in their beds. Yet deep in the bowels of Upson Hall, a handful of students are hard at work. The engineering lab is cluttered with scraps of metal, heavy-duty tools, and carcasses of deconstructed machines. Two students, wearing bulky welder's masks, kneel next to the metal skeleton of a car and spray a blinding shower of sparks as they slowly guide the welding torch along the metal frame. Through the swinging double doors of the laboratory, Master of Engineering student William "Trey" Riddle '09 ME and another student survey a white board covered in notes, calculations, and to-do lists. They're reviewing the latest step in building a car that can get the equivalent of 100 miles per gallon of gas. It must be able to go at least 200 miles—city and highway—before refueling, accelerate from 0 to 60 mph in less than 15 seconds, and carry four passengers comfortably.

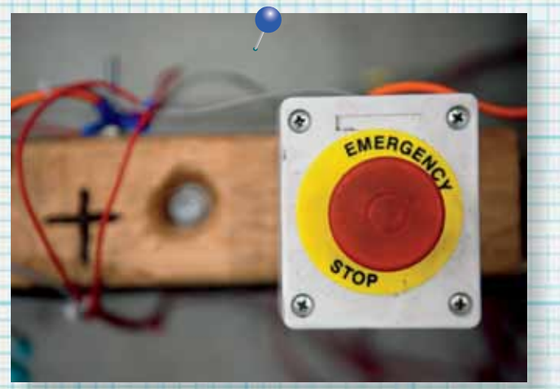
These Cornell students are one of only two university teams in the Progressive Automotive X Prize challenge, an international competition that challenges the world's innovative engineers and entrepreneurs to think beyond the gas pump. The Cornell team is up against some stiff competition—heavy hitters Tesla and Tata Motors are also in the race.

The X Prize Foundation awards $10 million or more to competitors that achieve its challenges. The concept is modeled on the 1919 Orteig Prize, which offered $25,000 for the first non-stop trans-Atlantic flight. Charles Lindbergh won that contest in 1927 and changed the aviation industry forever. The hope is that the Auto X Prize will drive the same kind of advances in the auto industry. An X prize has already motivated the creation of a civilian-built aircraft capable of carrying three people into space. Other ongoing X prizes include the Google Lunar X Prize, in which privately funded teams are competing to put a robot on the moon, and the Archon Genomic X Prize, which drives teams to find better, faster, and cheaper ways of sequencing the human genome.

Johnson School student Phil Bell put Cornell University in the running for the Auto X Prize in 2006, when he and a few other students got involved. By the fall of 2007, the team had grown to about 60. Now more than 90 members strong, the crew has gained confidence and momentum as they prepare for a competitor showcase this year and the race itself in the summer of 2010.

To test its concepts for a hybrid electric vehicle, the team added a 600-pound battery pack to a Geo Metro. Last year, the team entered this "mule" car in the 2008 Green Grand Prix in Watkins Glen, N.Y., discovering what aspects of the car worked, and what needed to be tweaked. "I think the Green Grand Prix largely helped us to see how important manufacturing issues are," says team president Riddle. "We learned how sloppy wiring can cause a problem. We had loose wires that caused us to have to stop and fix them."

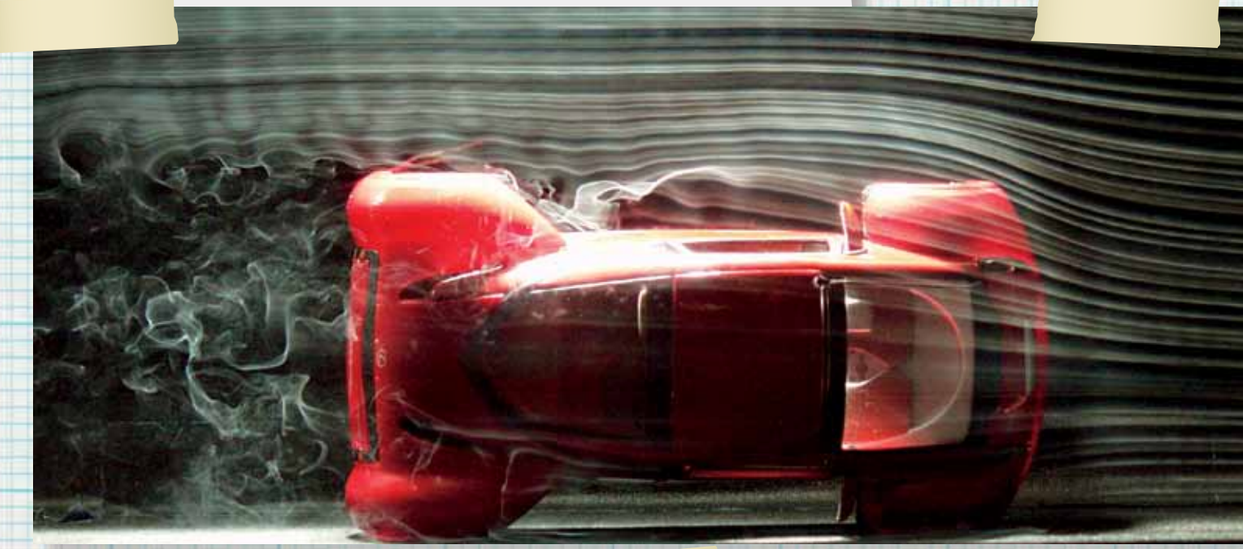
By January 2009, the team was ready to build the entry car. They began with its aerodynamics. "I think sometimes we forget that we're building a race car," Riddle told his teammates at a weekly meeting. "On the outside it may look like a small passenger car, but inside, it's got the heart of a beast," he joked. At the time, the "beast" looked to be just that—a hulking metal skeleton welded together from scavenged or purchased vehicles. For the chassis, the team had managed to acquire a Subaru Sambar—a Japanese minitruck with a strikingly narrow frame. They wanted this slim-framed auto for its aerodynamic qualities. To this, they would attach a body based on a narrowed Honda Civic. When welded together, the two parts will create a chimera car with optimal aerodynamics for reducing drag and maximizing fuel efficiency. The team also worked on upgrading their heavy, less-efficient lead-acid batteries to lighter lithium-ion batteries, which will weigh 300 to 375 pounds. In the meantime, the design subgroup has created computer and clay models of what the finished automobile will look like: sleek, bullet-like, and cherry-red—the very picture of a modern hot-rod.



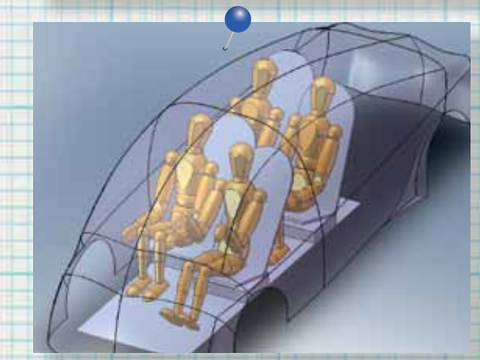
The car has an emergency power cutoff switch in case of a controls failure.

The AC55 Azure Dynamics generator charges the batteries from the diesel engine.

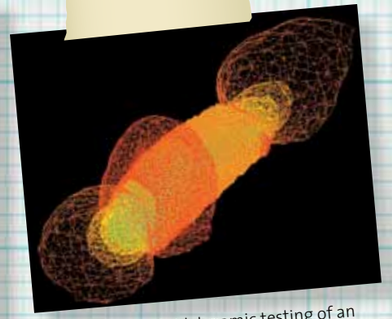
"On the outside it may look like a small passenger car, but inside, it's got the heart of a beast."
—Trey Riddle, team president



Early wind tunnel testing with a toy car helped the team determine the best shape to reduce drag.



This early body shell design was changed to reduce aerodynamic drag and frontal area.



Computational fluid dynamic testing of an early computer model of the car demonstrated the feasibility of the team's low-drag design.

The car has temporary T-bar steering until the students can install the custom rack and pinion steering.

The VW 1.4L TDi, originally manufactured for a VW Polo, was imported from Germany.

Building the car might sound simple, but in reality is full of trips back to the drawing board. For example, the group hit a snag when trying to perfect their vehicle's Static Stability Factor (SSF), which measures the car's top-heaviness by dividing half the car's track width by its center of gravity. The lower the SSF, the higher chance the vehicle may roll over. The average SSF for passenger cars is 1.4, while trucks and vans have an average of 1.17 and 1.12, respectively. In simulations, the team had placed the car's batteries high up in the car—making it too top-heavy. The team was asked to hit the books and figure out a way to solve the problem. After revising its calculations and designs, the team opted to put the bulk of the batteries underneath the rear passenger seats, and slightly changed the placement of the engine, which brought the SSF back up to a safe number.

The high-profile nature of the Automotive X Prize has garnered the Cornell team both national and even international media attention, including coverage and sponsorship by *Popular Mechanics*. The attention is "a mixed bag," says Riddle. "Nothing ever ends up absolutely correct. But the more people know about us, the better." Indeed, while the Cornell students have managed so far to get various car parts from donations and scrap-hunting, Riddle notes that the team needs more donations of money and equipment to finish building the car and travel to competitions.

While neither the team nor Cornell will go on to mass-produce the car, the competition requires entrants to design a vehicle that can be easily produced and reasonably priced—after all, the overarching goal of the Automotive X Prize is to change the face of the automotive industry. Riddle says that if their design turns out to be successful and competitive, they would hand production off to a major auto manufacturer.

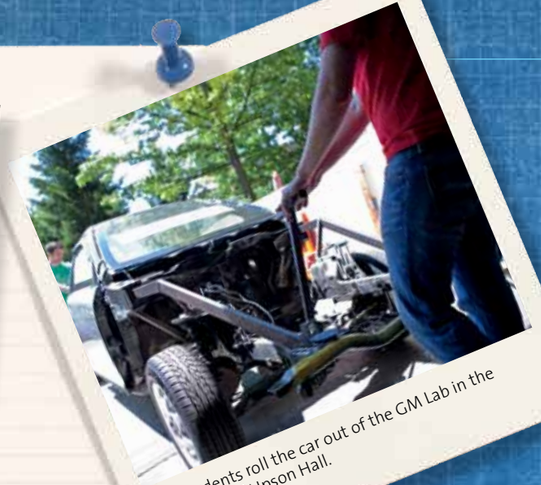
It's 4:30 on a rainy Thursday afternoon, and most students are in a hurry to leave campus and classes behind. The 90-or-so members of the 100+ MPG team, however, are filing into the basement auditorium of Hollister Hall for their all-hands meeting where they will review the week's work and plan. Riddle takes the floor with a PowerPoint presentation projected behind him to announce the Hard Workers of the Week—students who have put in extra effort to work on the car. "Will all Hard Workers stand up so I can toss your rewards to you?" Riddle says. The winners obligingly rise and attempt to catch the large, plastic-wrapped cookie that Riddle hurls at them. While the students joke back and forth during the meeting, they mean business. Building a 100-mpg car requires serious organization, with the team divided into electrical, mechanical, structural, and design subgroups. Others are in charge of information management, business administration, and business planning. Keeping all these teams up-to-date and on the same page "is definitely a challenge," says Riddle. "Everyone's working different schedules, so we have to be clear on communication." Riddle notes that these are all students with full course-loads who must find time between homework and classes to work on the car. At this stage, Riddle says the car's design is 90 percent done, with the remaining touches required for actual on-the-road testing to be finished up during the beginning of the fall semester.

Albert George, the John F. Carr Professor of Mechanical Engineering, advises the team on engineering and management solutions with John Callister, a senior lecturer with joint appointments in Mechanical and Aerospace Engineering and Operations Research and Information Engineering who is the Harvey Kinzelberg Director of Entrepreneurship in Engineering, and Electrical and Computer Engineering senior lecturer Bruce Land. According to George, the team's challenges are staying on schedule and updating new members while developing accurate simulations of the car to test its reliability. However, thanks to the smart and strongly motivated students, George believes the team will do "very well" in the competition.

Riddle agrees. "We are a top contender for winning the prize, undoubtedly," says Riddle. "Ultimately, we have designed the vehicle based on the competition rules. We didn't just get the best batteries or just get the best engine; we've optimized the entire car."

A rendering shows the final design of Cornell's Automotive X Prize car.

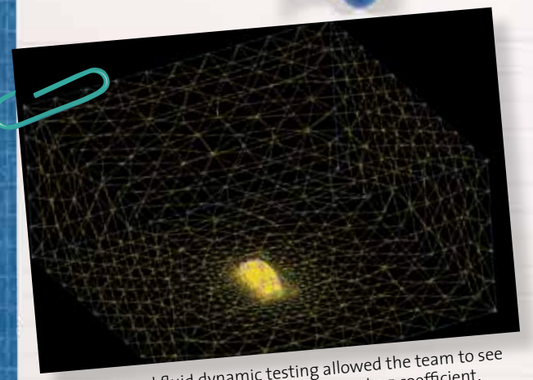
MATT ROBISON.



The students roll the car out of the GM Lab in the basement of Upson Hall.

The car's rear suspension is from a Subaru Sambar.

The high-profile nature of the Automotive X Prize has garnered the Cornell team both national and even international media attention, including coverage and sponsorship by Popular Mechanics**.**



Computational fluid dynamic testing allowed the team to see air flow around the model and predict the drag coefficient.

The summer team leaders were (from left to right): Matt Robison '10 OR, James Watt '10, Ted Widger '09 ME, Bill LaCava '09 ME, and Andrew Gifft '09 ECE (not pictured).

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Allison Danner '09 CE and EnvE chose a double major so she could study environmental engineering and have an ABET-accredited engineering degree.

Green with EnvE

Cornell's newly accredited environmental engineering program prepares students from two colleges to solve the planet's most important problems

By Michael Gillis

Allison Danner '09 CE and EnvE spent much of her youth hiking, camping, and trekking to the beaches of the Olympic Peninsula in her home state of Washington. Those experiences fostered an appreciation for the natural world that persists today.

But over the years, she realized the natural splendor she enjoyed so much was at risk.

"As I got a little older I started realizing that there were some environmental problems out there and I wanted to learn more about them and maybe help fix them," she says. "I also enjoyed math and science in school and wanted to be able to use those skills in the career I chose."

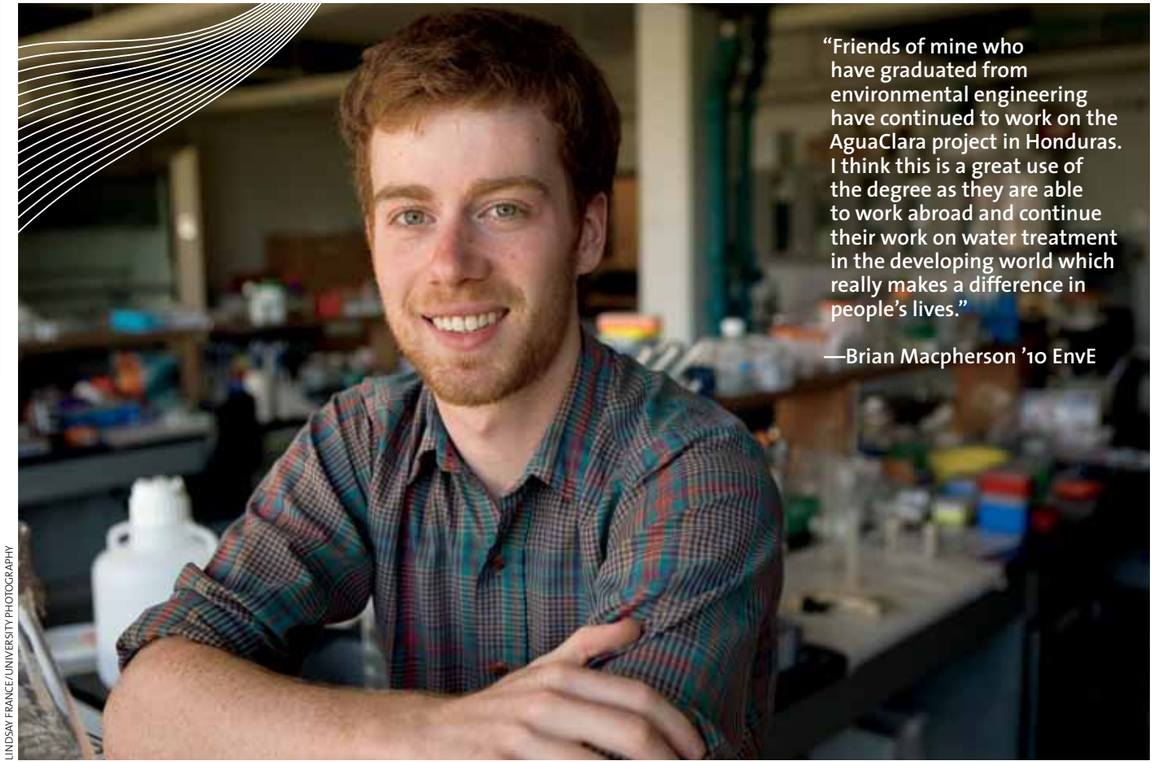
That realization led her to pursue a second major in environmental engineering.

"I specifically chose environmental engineering over other environmental majors at Cornell because I wanted to learn both the science to understand the natural world and the environmental issues we face, as well as the technical skills to be able to find solutions to the problems," she says.

Brian Macpherson '10 EnvE was attracted to environmental engineering for many of the same reasons, but he also appreciates that his choice is timed perfectly with accreditation of the degree. ABET Inc., previously known as the Accreditation Board for Engineering and Technology, accredited the program in August, certifying that it meets the most rigorous standards of quality and education. The accreditation spans May 2007 to September 2011. EnvE majors who graduated in 2007 or 2008 have accredited degrees retroactively.

That allows students to dedicate their time and energy solely to an environmental engineering degree, according to Beth Ahner, associate professor and associate chair in the Department of Biological and Environmental Engineering. Administratively the department is in the College of Agriculture and Life Sciences, but its academic program is within the College of Engineering.

"For the last several years, students wanting to major in environmental engineering have been constrained by the need to double major (in an accredited program) if they wanted to begin the process of becoming a professional engineer in the semester prior to graduation by taking the fundamentals of engineering exam," Ahner says. "Students graduating from a program that is not accredited have to work for a number of years to qualify for this exam. It is advantageous for environmental engineers to be licensed P.E.s when seeking work in environmental consulting firms and for the government."



LINDSAY FRANCE/UNIVERSITY PHOTOGRAPHY

Brian Macpherson '10 EnvE will be among the first to graduate from Cornell with an ABET-accredited environmental engineering degree.

Engineering history

Cornell created the environmental engineering major in 2002 after years of planning and building the curriculum, according to Leonard Lion, who was interim director of the School of Civil and Environmental Engineering until July 1. Cornell then began the process of seeking ABET accreditation, which culminated with a visit to the campus last year by ABET to evaluate the program and, shortly thereafter, a list of recommended changes, which Lion says were easily realized.

But even before the formal major was created, Lion points out that students were still graduating as environmental engineers. The actual degree may have been civil or biological engineering, but students interested in the environmental elements of engineering were allowed to focus their studies on that discipline.

"The title of the major didn't reflect, necessarily, that strong environmental component," Lion says. "At one point we created a formal concentration in environmental engineering that became a transcript notation indicating that, in the course of getting their civil engineering degree, students had focused on environmental material. The environmental concentration required a set of courses that was compatible with getting an accredited degree in civil engineering but was still focused much more on the environment."

The concentration required students to take courses in what is now the Department of Biological and Environmental Engineering, which had its own environmental concentration. "We had two differently named majors, both of which had a concentration related to the environment, and both were requiring each other's courses," Lion says. "We operated in parallel like that, benefiting from each other's offerings for quite a few years."

In the 1990s, the two units hammered out the details, bridging common courses and curriculum, leading to the formal creation of the environmental engineering major, which is now offered in both colleges.

"It is a marriage of two different cultures," Lion says. "The major is the same, though, no matter how you come into it. What makes us very different is the breadth of expertise here, which comes from the fact that we had a group of faculty looking at environmental engineering through the lens of the civil engineering profession, where design of municipal water and wastewater treatment systems and hazardous waste site remediation are important activities, and another group of faculty looking at environmental engineering more from the focus of agricultural and natural systems."

A tale of two schools

Although offering the major in two colleges is unusual, it makes sense considering that environmental engineering intersects with both civil and biological engineering, says Tina Hu '09 CE and EnvE.

Hu says she migrated from mechanical engineering to environmental engineering out of a desire to recycle waste into a reusable resource. To tackle that task, Hu says she needs to understand both civil and biological systems.

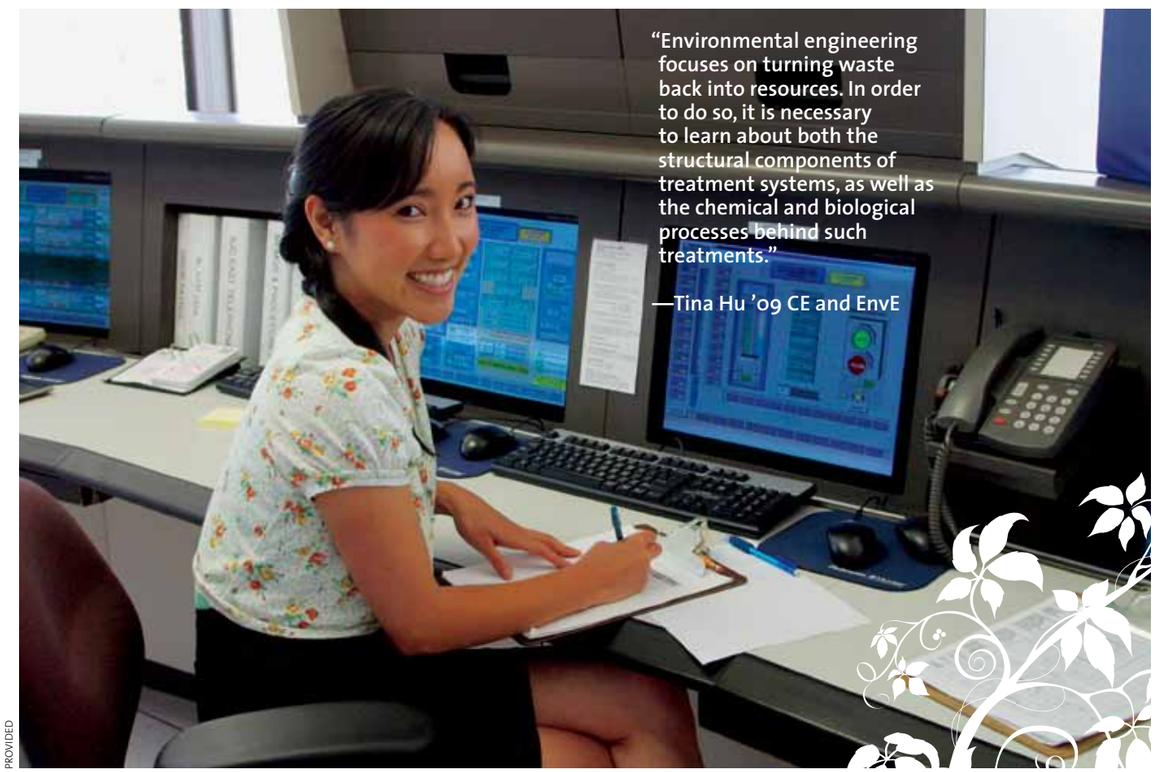
"Environmental engineering focuses on turning waste back into resources." she says. "In order to do so, it is necessary to learn about both the structural components of treatment systems, as well as the chemical and biological processes behind such treatments. Both civil and biological engineering are equally important to environmental engineering, and thus environmental should not merely be linked to one or the other. Having a specialized degree in environmental engineering allows students to be more thorough with their course work."

Danner concurs. "A specialized environmental degree allows students to take more of the types of classes they are interested in, and to focus on subjects that are most applicable to jobs in environmental engineering," she says. "Environmental concentrations are also available in other majors, but if you do those you might have to take classes that may not be very useful. I considered doing both BEE and CEE but chose environmental engineering because of this flexibility. The environmental engineering major still has all the core engineering courses for learning the technical skills engineers need, but without courses that are not as applicable to environmental topics. For example, I have actually taken most of the core civil engineering courses, but doing environmental engineering allowed me to avoid structural engineering courses that I just am not interested in."

Green jobs continue to sprout

Environmental engineers are frequently called upon to strike a balance between the needs of the industrialized world and dwindling natural resources. They tap into a wide spectrum of science, from the biological and chemical to economics and hydrology, to help improve wastewater treatment, scrub contaminants from natural aquatic systems, or create more efficient environmental and water resource systems.

Leslie Blythe '81 CE, president of B&G Environmental Inc. in Atlanta, Ga., understands as well as anyone the need for



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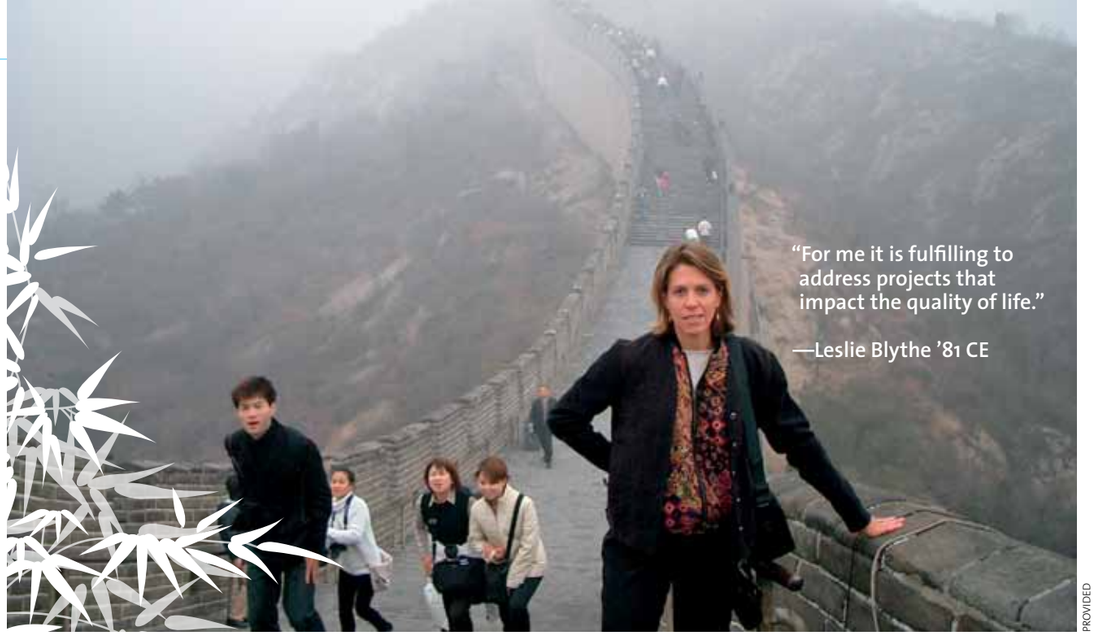
Tina Hu '09 CE and EnvE did a summer internship at the Los Angeles County Sanitation Districts working with wastewater and solid waste management.



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Leslie Blythe '81 CE, president of B&G Environmental Inc. in Atlanta, Ga., was the project manager for a study tour for government managers from the water and energy ministries of Uganda. The group visited selected water resources and power facilities in the U.S. and China.

engineers specializing in the environment. Her firm deals with hazardous waste and she sees nothing but growth in the years to come.

"Given the large number of contaminated industrial and military sites and ever scarcer resources, I think there will continue to be a growing demand for environmental engineers," Blythe says. And like many of the students looking to graduate into careers as environmental engineers, Blythe appreciates that her work is for a greater good. "For me, it is fulfilling to address projects that impact the quality of life," she says. "As an added benefit, I have had great flexibility having my own business."

Blythe, who serves on the advisory council for the School of Civil and Environmental Engineering, says she is an example of how the system used to work.

"My specific degree is in civil engineering, which was most applicable for Cornell environmental engineering students 30 years ago," she says in an e-mail. "As a result, I took the typical civil distributional requirements (structures, transportation). Despite great Cornell faculty in these areas, some of whom I still keep in touch with, it would have more beneficial for me to have taken more environmental courses."

Lion agrees that environmental engineering is now a hot commodity.

"Most of the world's population, outside of Europe and North America, needs basic infrastructure for water supply and wastewater treatment," he says. "That's why it's a growth industry."

Engineering jobs are already among the hardest to fill and the most lucrative, a statistic that has spiked as the government funnels billions of dollars of stimulus cash into projects coast to coast.

Forbes recently ranked environmental engineers as one of the top "green" jobs with prospects of earning a six-figure salary.

Regardless of earning potential, environmental engineering students say they are driven by the need to help.

"Friends of mine who have graduated from environmental engineering have continued to work on the AguaClara project in Honduras," says Macpherson. AguaClara is a Cornell student group that aims to improve drinking water in Third World countries, using local resources, science, and research. "I think this is a great use of the degree as they are able to work abroad and continue their work on water treatment in the developing world which really makes a difference in people's lives."

For Hu, it's a matter of engineering a better world.

"With my degree, I'm looking to find larger scale solutions to the impending environmental problems the world faces," Hu says. "Everyone is affected every day by the wastes generated and the amount of usable water there is whether they realize it or not. I look forward to trying to solve such problems in the most efficient, environmentally friendly way possible."

Tony Nekut stands in a test plot of saplings being grown for biomass energy at the Cayuga Nature Center.

LINDSAY FRANCE/UNIVERSITY PHOTOGRAPHY

Burning Questions

TONY NEKUT '72 EP, PH.D. '78 AP, MENTORS STUDENTS ON A BIOMASS ENERGY PROJECT.

By Sharon Tregaskis

Standing in the dappled shade of a half-dozen oak saplings on the 120-acre Cayuga Nature Center property six miles from downtown Ithaca, Tony Nekut '72 EP, Ph.D. '78 AP, considers a nook behind the main building, a one-time tuberculosis sanatorium. Today, the 10,000-square-foot lodge on the west side of Cayuga Lake houses summer camps and year-round environmental education events. It's a terrific facility in summer, with a view across West Hill to Cayuga Lake. But in winter, heating the drafty, Depression-Era facility with a trio of inefficient, propane-powered boilers in the basement costs close to $20,000, a significant chunk of the nonprofit's annual budget.

Thanks to Nekut, sometime this fall a steel shipping container housing a European-designed, wood-fueled boiler will arrive on site to slash that number. The new system won't be much to look at—just a big, metallic box with a few pipes connecting it to the building's heating system—in fact, it won't even be visible from the main entrance. Yet Nekut, a member of the center's advisory council and mastermind of the installation, expects the new system to draw visitors from throughout the state. "The idea is to provide people who would buy this kind of [commercial heating system]—schools, for example—a place to go to see how it works," he says of the nearly $200,000 pilot project, funded in part by the New York State Energy Research and Development Authority (NYSERDA). "The other side of it is to set up forest management on enough acreage to give the public an idea of what good management looks like."

Heating the Depression-Era facility with a trio of ancient, propane-powered boilers in the basement costs close to $20,000, a significant chunk of the nonprofit's annual budget. Sometime this fall, a European-designed, wood-fueled boiler will slash that number.

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"We're running out of cheap and easy fossil fuels at the same time the climate is screaming out for help."

—Tony Nekut

More than 18 million acres of woodlots and forests blanket New York State in a sea of green, providing paper pulp and timber, wildlife habitat, countless ecological services, and soothing year-round recreation destinations. Nekut sees another value in all those trees: They could supply clean, renewable fuel for small communities and, in the process, bolster local economies by retaining billions of dollars currently shipped overseas to purchase fossil fuels. An optimal system would leverage the synergy of locally harvested, low-value plant material such as waste from logging or specially cultivated crops grown on abandoned agricultural land and high-efficiency, low-emission boiler systems generating combined heat and power. To prove that his vision has merit, Nekut partnered with Cayuga Nature Center, a nascent local landholder's cooperative, NYSERDA, and Advanced Climate Technologies, a boiler manufacturing concern in Schenectady, N.Y. "We're running out of cheap and easy fossil fuels at the same time the climate is screaming out for help," he says. "In some sense, I think of my work with alternative energy as atonement [for a career in the oil industry]."

A former Amoco engineer, Nekut tuned in to the intersection of climate change and peak oil in the nineties. When his employer merged with another petrochemical firm and went through a massive downsizing in 2000, Nekut and his family sold their home in Oklahoma and resettled in Ithaca, where he works at Vector Magnetics, founded by his dissertation advisor Art Kuckes, a professor emeritus of physics. "It's all very cozy," says the engineer, who writes data analysis software and manages product development for the firm, which provides directional drilling technology used to put out oil well fires and tap natural gas. "It was nice to come back to Ithaca, and my expertise is well matched to what Vector Magnetics does."

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With advanced combustion technology, wood chips like these can provide clean, affordable, and renewable energy in forested regions like upstate New York.

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Biomass combustion results in zero net additional carbon in the atmosphere.

The owner of a 130-acre woodlot in nearby Cortland County, the climate activist was already pondering prospects for renewable, locally sourced fuel, and soon after his northern migration he honed in on biomass combustion. In the summer of 2007, he attended a conference at Cornell on the topic where he met lecturer and renewable energy systems expert Francis Vanek '91 ME, Ph.D. '98. Soon, the pair was developing a project for students in Vanek's CEE 492: Engineers for a Sustainable World. "I wanted to have a local project and be able to represent the whole bio-energy realm," says Vanek, who invited Nekut to work on the Cayuga Nature Center boiler project with his students in the fall of 2007.

Some conventional wood-burning stoves and residential wood boilers operate at less than 50 percent efficiency and generate much of New York state's air pollution load. The system slated for installation at the Cayuga Nature Center passes stringent European air quality standards and boasts efficiency rates of up to 90 percent, comparable to oil-fueled alternatives. New York state needs clean-burning, renewable energy systems, says NYSERDA's Ellen Burkhard, a senior project manager in clean energy research and market development who's worked closely with Nekut and the entrepreneur who plans to begin manufacturing the systems in Schenectady, N.Y. Nekut's work to provide proof of concept and forge relationships has been critical, she says.

"We need to evaluate this technology, how it performs. If an organization is choosing between a new oil-fired or wood-fired system, we want to maximize efficiency," she says. "We don't want to see a net increase in emissions."

In 2008, Vanek invited Nekut to again engage participants from the class. This time, three subgroups of students investigated topics that emerged from the previous year's work: analysis of air quality standards related to biomass boilers; investigation of the business prospects for biochar, a soil amendment made from combustion byproducts; and cooperative arrangements for biomass pellet production. This fall, Nekut plans to include Vanek's students in final logistical arrangements for the Cayuga Nature Center boiler. "Tony is a skilled research engineer and he's in the marketplace developing these ideas with an eye toward local, practical solutions," says Vanek. Nekut benefited, too: The students provided valuable research assistance on everything from the fastest-growing, cleanest-burning plants likely to thrive in the region to the thermodynamics of the high-pressure, low-oxygen combustion required to create biochar. Says Nekut: "I want students who show interest to get hands-on, in-depth exposure."

That first year, six undergrads—civil, mechanical, and engineering physics majors—signed on to work with Nekut. "It definitely turned into something I was really interested in," says Dave Templeton '08 ME, who designed and maintained the group's Web site and served as the team's chief financial officer, calculating how many tons of wood chips would be required to heat the CNC lodge and how long it would take for a local cooperative with collectively owned harvesting equipment to generate a profit. Nekut, who describes his mentorship style as

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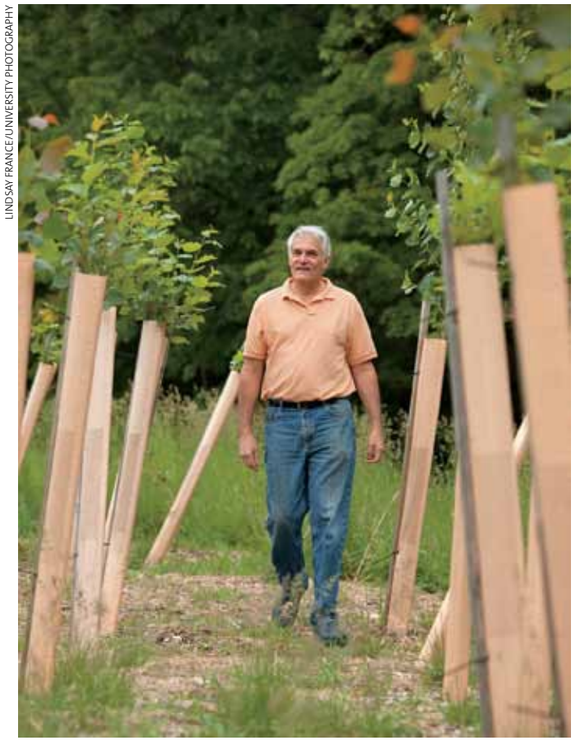
Emissions from the European-designed boiler to be installed at Cayuga Nature Center are being tested at the manufacturer, Advanced Climate Technologies in Schenectady, N.Y.

"I wanted to have a local project and be able to represent the whole bio-energy realm."

—FRANCIS VANEK, PROJECT ADVISER

"laissez-faire," gave the group significant freedom to set its own course. "We were all seniors, learning to think for ourselves and Tony let us do that," says Templeton. "It was a good transition from school into my job." The experience also made Templeton, avowedly not an active environmentalist, more aware of energy consumption and conservation. This spring, as his employer, Sikorsky Aircraft, solicited cost-cutting suggestions from staff members, Templeton drew on his biomass project experience, responding to the employee survey with energy-saving ideas including overnight computer shutdown and enhanced insulation.

As they came up to speed, the students discovered that the scope of the boiler project would require more time than the 15 weeks allocated for the course. "There was a let-down, realizing we wouldn't finish in one semester," says Templeton, who extended his work on the project as an independent study in his final spring semester on campus. "Once we realized that our



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"It was cool to know that what you were doing could have an impact. It wasn't just 'I finished the semester,' it was 'I contributed something that others could use in the future.'"

—JENN WILLIAMSON '09 CE

role was to set goals, launch the project, and do a small part, it was satisfying." The students also got an education in the complexity of balancing alternative energy with environmental conservation, stumbling across a valuable lesson in the process: There is no silver bullet. "We discovered the megafolia tree, a genetically created hybrid," says Templeton. The species seemed too good to be true: fast growing, low in CO_2 emissions and particulates, cleaner than oil. "And then we learned that it's invasive; if you planted it everywhere, it would take over the world."

Pennsylvania native Jenn Williamson '09 CE enrolled in Vanek's class in the fall of 2008. Like the 2007 team, the students with whom she worked represented a mix of Cornell engineering majors, as well as two Ithaca College undergrads. "You had people with different knowledge and more varied interest [than my other engineering classes]," she says, "and the project was more open so we got to figure out what exactly what we wanted to do." Because several members of the air quality group had a particular interest in public policy, Williamson got an introduction to a field she previously hadn't considered. "It increased my interest," she says, "and made me appreciate the variety more."

Williamson worked on the pyrolysis sub-group with Nekut. "I was excited to do a project that had implications for the real world," says Williamson, who started work this summer in the Washington, D.C.-based building technology practice of Simpson Gumpertz & Heger. "It was cool to know that what you were doing could have an impact. It wasn't just 'I finished the semester,' it was 'I contributed something that others could use in the future.'" ●

Green Powerhouse

Jefferson Tester leading sustainable energy initiative

By Robert Emro

Jefferson Tester '66, M.S. '67 ChemE, thinks America—and Cornell—have reached a watershed moment. Amid rising fuel prices, national security concerns, and increasingly dire climate change warnings, the federal government is pouring massive investment into sustainable energy research in a bid to stimulate the economy. At the same time, driven in part by a desire to make a difference, more young people are choosing engineering after decades of declining enrollments.

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During the first energy crisis in the seventies, Tester led a group researching and developing geothermal energy at Los Alamos National Laboratory, until oil started flowing again, and alternative energy research funding dried up. "But this time is different. We are realizing that our entire energy system needs an overhaul. Climate change, energy security, and sustainability concerns in general have fueled a grassroots national movement, including students and faculty, all focused on how we're going to solve some of these problems for the long term," says Tester, who recently left MIT to accept Cornell's offer to be the first Croll Professor of Sustainable Energy Systems. "Our mission will require creative, enlightened engineers and scientists and a lot of good policy experts and people who can understand how to make decisions loaded with many uncertainties."

It will also take an academic culture that fosters collaboration across disciplines and an administration, faculty, and student body committed to change. "Cornell as a whole can contribute differently than other places," Tester says. "The intellectual elements of the research that goes on here are extremely broad and deep in critical areas and that's a necessary component for working in sustainability. The co-location of world class research in engineering, agriculture, and physical, social and life sciences on a single campus gives Cornell unquestionable advantages for working collaboratively on new energy technologies. Cornell is well on its way to putting everything together in a way that works better than anywhere else."

Tester is helping to create an energy institute at Cornell to capitalize on these advantages. Like the Cornell Center for a Sustainable Future (CCSF), for which Tester is the associate director for energy, the institute will bring researchers across the university together on energy issues. But it will also solicit grants, hire research staff, and train graduate students, like the KAUST-CU Center for Energy and Sustainability.

The institute will have its physical home in Snee Hall, alongside the college's Department of Earth and Atmospheric Sciences, but it will reach out to other faculty within the college and across the university, especially in the colleges of Agriculture and Life Sciences, Arts and Sciences, Architecture, and Human Ecology. "We want to add value over what would normally be done by Cornell researchers individually," says Tester, "to help bring new knowledge and new technologies that address complex, critical energy challenges."

One way the institute will accomplish this goal is by developing interest in multi-investigator, multidisciplinary proposals, like the ones Tester helped develop here in response to President's Barack Obama's stimulus package. "These efforts highlight Cornell's ability to tackle some of the toughest sustainability problems," he says.

Tester also sees the institute issuing small seed grants to stimulate research, similar to CCSF's academic venture fund. "I would envision there would be a set of opportunities continuously evolving on energy technology applications that would be centered on engineering and science topics, which would be appropriate for the institute to fund."

The new energy institute will also help in attracting and retaining faculty in key areas. "There are certain parts of engineering that have been ignored by national objectives over the last 20 or 30 years," he says. "Frankly university research on renewables and energy storage, even energy conversion on a fundamental as well as applied level, has been rather sparsely funded. That's all changing now given the high expectations for adopting more sustainable approaches nationwide for supplying and using energy. Clearly there's opportunity to bring Cornell's engineering faculty into this area and attract new faculty to come to Cornell because it's an exciting place to work."

Cornell President David Skorton's signing of the American College and University Presidents Climate Action Commitment to

The university's unique graduate field system fosters conversations and collaborations between faculty from different departments and colleges. And that's just what's required to solve any sustainable energy challenge—from biofuels, green buildings, and plug-in hybrid electric vehicles to geothermal, carbon sequestration, and photovoltaics.

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climate neutrality helps make Cornell attractive to alternative energy researchers and research funding, says Tester. "It shows that the university, from the top through deans and department heads, as well as faculty and students, is going to work together for a common set of goals," he says. "The Climate Action Plan not only provides a framework for achieving sustainable energy deployment at Cornell—it also provides a model for others to follow.

"Cornell's actions provide a means for America to enter a new era of innovation and sustainable energy development—now that is truly exciting to me," says Tester. "Unlike many schools, Cornell can actually build and demonstrate new energy technologies on campus because we have the space as well as the institutional commitment and knowhow to improve our energy footprint."

Tester, who studies advanced rock drilling methods using thermal spallation and hydrothermal upgrading of biomass, is leading an effort to evaluate whether engineered geothermal systems could be developed in the Ithaca area. Beyond its research value, such local demonstration projects would provide invaluable educational opportunities. "Cornell must continue to be a premier educational institution as well as a research university; we have to do both well," he says. "Our mission isn't just about classrooms and teaching, but it's not just about research either."

The link between climate change and burning fossil fuels adds a ticking clock to the already enormous problem of finding safe, suitable energy alternatives. Today's students are rising to that challenge, and many have drawn parallels to the space race, when an earlier generation was inspired to study engineering. Tester was a boy growing up in a Connecticut River valley farming community when the Russians launched Sputnik. When he wasn't milking cows, getting in the hay, or delivering newspapers, he liked to dismantle and reassemble farm and household equipment. He attributes this fascination with how things work to a "free thinking, curious, creative" aunt and to his mother. "They would repair things all the time themselves," he says.

When it came time to choose a career, Tester chose engineering. "There was a

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big emphasis on space and technology in general at that time," he says. "Those represented engineering problems as opposed to basic science and it seemed that maybe engineering was more for me. Working on a farm convinces you that you've got to do things. You have to meet certain deadlines. People are counting on you to get things done."

Tester applied to several colleges. He was attracted to Cornell for a couple of reasons. "I really loved Cornell in that it fit with my sense of place because it was easy to make an adjustment to a campus like this as opposed to a city school," he says. "It was far enough away from where I was brought up, so I'd have my own life and be on my own, away from the family for a while to focus on engineering."

His choice was also influenced by Cornell's financial aid package. "My mother was a hard-working single mother, and Cornell's scholarship was bigger than some of the others. I really liked the place, so it was an incredibly easy decision," he says.

After Cornell, Tester married his high school sweetheart, Sue Kelsey '67, an English major. Before the two moved to Boston to start their graduate education, Tester took a summer internship at Los Alamos National Laboratory, where he first learned about the lab's work on geothermal energy. He returned to Los Alamos for a postdoc position before taking over as a station director of MIT's School of Chemical Engineering Practice at Oak Ridge National Laboratory.

Two years later, when Los Alamos asked him to join a large-scale effort in geothermal energy, he jumped at the chance. "It got me immersed in earth sciences and convinced me that the multidisciplinary structure is the right structure to tackle these kinds of problems," he says. "There were engineers, physicists, and trained geologists, including seismologists, geochemists, and volcanologists. We all came in with different professional backgrounds and technical languages and we all had to figure out how to talk to one another."

That multidisciplinary atmosphere reminded Tester of Cornell. The university's unique graduate field system fosters conversations and collaborations among faculty from different departments and colleges. And Tester firmly believes that's just what's required to solve any sustainable energy challenge—from biofuels, green buildings, and plug-in hybrid electric vehicles to geothermal, carbon sequestration, and photovoltaics.

Wind power is a good example. Cornell has experts from civil and mechanical engineering who can design large wind towers that can last for decades and rotors efficient at energy capture. The university also has the Laboratory for Ornithology, one of the world's leading institutions in understanding the behavior of birds, and the Johnson Graduate School of Management. "It's critical to understand how birds and bats interact with large-scale wind turbines. And these devices are very capital intensive, so you also need to think about business development," says Tester. "Just try doing that combination at other places around the country.

"Cornell's here with the right program and the right people," says Tester. "We're not the only school to make that claim, but I truly believe we are well positioned to take the lead in the field of challengers."

Researcher's 3-D model highlights role of protein in tumor growth

By observing the behavior of cancer cells grown in both two and three dimensions, Cornell assistant professor of biomedical engineering Claudia Fischbach-Teschl has demonstrated that a previously underestimated protein secreted by cancer cells could be a key factor in allowing cancer to grow and spread in the body.

The experiments, detailed in the Jan. 13 issue of the *Proceedings of the National Academy of Sciences* (PNAS, 106:2), looked at how cancer cells binding to the material that surrounds them, called the extracellular matrix, regulate the secretion of proteins called angiogenic factors. These proteins allow tumors to develop blood-vessel networks and eventually metastasize, or spread to other parts of the body.

Fischbach-Teschl found that when cultured in different ways, the cancer cells behaved differently, and the differences led to new questions about which angiogenic factors are more important in the progression of cancer. Notably, the protein interleukin-8 (IL-8) was secreted 35 times more heavily in three-dimensional cell cultures than when grown on flat, two-dimensional cultures prepared from the same material.

"Our research focus is to understand how cells are interacting with their environment," said Fischbach-Teschl, who began the work as a postdoctoral associate at Harvard University under co-author David J. Mooney and finished the experiments at Cornell. "And when we talk about environment, it's not only that cells are interacting with neighboring cells, but also with their surrounding matrix."

In her Weill Hall lab, Fischbach-Teschl creates realistic, 3-D experimental models that mimic how tumors grow in the body, and she compares them with tumor studies using traditional petri dishes, or in two dimensions. She has found that tumor cells grown in more realistic culture environments are generally more aggressive than the ones grown in conventional plastic dishes. They also secrete different levels of angiogenic factors.

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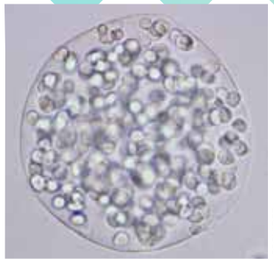
Claudia Fischbach-Teschl cultures tumor cells with lab manager Daniel Brooks.



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Tumor cells encapsulated in RGD-modified alginate beads.

In the experiments described in the *PNAS* paper, her lab cultured cancer cells three dimensionally using beads of a hydrogel called alginate. To further re-create conditions in the body, the researchers added peptides called RGDs to the alginate beads, which are normally found in the extracellular matrix and bind to receptors on cell surfaces. This caused the cancer cells to interact with the alginate beads, mimicking what happens in the body when cancer cells stick to surrounding material.

The researchers found that the cancer cells produced the exceptionally high amounts of IL-8 only when they were able to attach to the RGDs. In control cultures without the peptides, the IL-8 secretion was much lower.

Previous research had shown that another angiogenic factor called vascular endothelial growth factor (VEGF) was secreted heavily in two-dimensional tumor cell cultures. In fact, a cancer drug approved by the Food and Drug Administration works by specifically blocking VEGF secretions. But that same secretion did not occur at the same rate in the more realistic three-dimensional culture systems.

The experiments show that IL-8, not VEGF, could be the more important chemical to signal blood vessels to grow around the cancer, allowing it to flourish in the body. The researchers further note that IL-8 may contribute to the spread of cancer.

The paper was also highlighted in the Jan. 20 edition of *Science Signaling* (2:54) as an "Editor's Choice."

—*Anne Ju*

Big Give winner Stephen Paletta '87 starts student service trip to Rwanda

An impromptu trip to Rwanda in 2004 changed Stephen Paletta's life. Five years later, he is hoping a group of Cornell students will have a life-altering journey of their own to the same country.

Paletta '87 CE, winner of the reality TV show "Oprah's Big Give" in April 2008, helped organize a summer service-learning trip to Rwanda for seven Cornell students. The students, whose main requirement is "a heart for the developing world," spent three weeks in the central African country working with Paletta's nonprofit organization, the International Education Exchange.

Paletta founded IEE after his 2004 last-minute service trip with friends to Rwanda. IEE supports primary schools in Rwanda with teacher training, construction projects, and pen-pal programs between Rwandan and U.S. schools.

As the "Big Give" victor, Paletta won $1 million, half of which he was required to donate to philanthropic endeavors. He used the money to establish a second nonprofit organization, called Stephen's Journey, which highlights the work of social entrepreneurs and philanthropists all over the world.

After his Oprah win, Paletta contacted the Cornell Public Service Center with the idea of sponsoring a student trip to Rwanda through IEE. Now working with five Rwandan primary schools, the organization's goal is to partner with 1,000 schools by 2020, with support of Rwanda's government, Paletta explained.

"Because of the show and because of some of the money I'd won and had been able to give back to IEE, we decided to grow it tremendously," Paletta said.

The students have raised more than $20,000 to cover the cost of the trip. This past semester, they attended serving-learning seminars with John Weiss, associate professor of history, and Robin Remick, the ILR School's director of international programs.

PROVIDED/STEPHEN PALETTA

Stephen Paletta '87 waves to a crowd of schoolchildren during a recent trip to Rwanda.

In addition to spending much of their time in schools training teachers in English language and computer skills, the students worked with Dar Caldwell '04 to install solar panels at the primary school in Rwinkwavu.

—*Anne Ju*

Engineering alumnus gives back with GE Edison Award

General Electric engineer Mark Adamiak '75 EE, M.Eng. '76, recipient of the 2008 GE Edison Award, has given $12,500 to Cornell to support power-system engineering education.

The award, which Adamiak received last May, recognized his work in developing GE products that ensure stable electric power grids. It came with $25,000 that Adamiak could give to a university of his choice; he gave half to Cornell and the other half to Virginia Tech.

Adamiak cites mentorship from professors, course work, and a co-op at American Electric Power as foundations for his career.

"What I got from Cornell was the ability to learn," said Adamiak, who works outside of Valley Forge, Pa. "I've taken what I started with and built on top of it."

With Adamiak's gift, the School of Electrical and Computer Engineering created, in honor of one of Adamiak's mentors, the Sam Linke Lecture on Power Energy series. Adamiak gave the first lecture last spring.

—*Anne Ju*

Ober honored for true excellence

Interim Dean Christopher Ober was among three Cornell professors named to the inaugural class of American Chemical Society fellows. The society cited him, as well as Chemistry and Chemical Biology professors Roald Hoffmann and Harold Scheraga, with "true excellence in their contributions to the chemical enterprise."

Comprising more than 154,000 members, the ACS is the world's largest scientific society and represents professionals in all chemistry-related areas of study. Its first class of 162 fellows, who come from fields ranging from high school teaching to entrepreneurship, academia and government service, were recognized at an Aug. 17 ceremony in Washington, D.C.

Ober, the Francis Bard Professor of Materials Science and Engineering, studies polymers, lithographic materials for microelectronics and biotechnology, and new environmentally and biologically friendly materials. He was honored by the ACS in 2006 with an award in applied polymer science.

—*Anne Ju*

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Susan and Mark Adamiak '75 EE, M.Eng '76

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Interim Dean Christopher K. Ober

Alumnus targets tragic medical condition affecting 2 million women

Of the countless health afflictions women in developing countries face, a condition called obstetric fistula may be among the most tragic.

Caused during prolonged labor, the condition causes a gap, or fistula, in the tissue separating a woman's bladder from her vagina, leading to incontinence and often lifelong humiliation and ostracism. Obstetric fistula virtually disappeared from the United States in 1895 and is surgically treatable in 90 percent of cases, but more than 2 million cases now are estimated in the developing world.

It's this disparity that moved Seth Cochran '00 OR, M.Eng. '01, to devote himself full time to ending obstetric fistula worldwide. His nonprofit organization, Operation OF, is now being piloted in Uganda.

Cochran was a successful financial manager at the company ADC Telecom in Berlin. He was in charge of a $160 million budget with seven factories across Europe, "making good coin," he said. But financial success couldn't make up for the feeling that he wasn't doing something that really mattered.

He'd always been involved in charitable work. While working in Berlin, Cochran built up ADC's corporate foundation activities in Germany, creating a structure he scaled to several other countries. These organizations have issued nearly $1 million in grants to local charities since their inception.

And in June 2007, Cochran created a fundraiser called Summit for Smiles in which he raised $40,000 for The Smile Train, a cleft palate and lip repair foundation, by climbing Mt. Kilimanjaro.

In March 2008, Cochran quit his job to become what he calls a full-time social entrepreneur. A friend directed him to the issue of obstetric fistula, and Operation OF was born.

Cochran has spent the months since researching the condition and connecting with hospitals and other groups across Africa, particularly in Uganda, Kenya, Ghana, Rwanda, and the Democratic Republic of Congo. He has built Operation OF as an organization that supports local groups not only in the logistics of treating patients but also in helping the patients reintegrate into society using microcredit.

He hopes the model will spread worldwide. "By empowering local people to do the work, we can find a woman with fistula in the most remote village, get her to treatment, train her as an entrepreneur, and get her started in the business—all for around $400," Cochran said. "This is a

people

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Seth Cochran '00 OR, M.Eng. '01, speaks with an obstetric fistula patient at Kitovu Mission Hospital in Masaka, Uganda.

profound value given her state of mind when we find the woman and her subsequent potential to positively transform the same community that rejected her."

Cochran considers the OR education he received at Cornell critical to everything he does, including Operation OF.

"The training I got from Cornell really set my mind to always try to do things the best way you can," he said. "That is, using an analytical approach to maximize an objective within a given set of constraints—classic OR thinking," he said.

For more information, visit operationof.org.

—*Anne Ju*

Butcher wins $10,000 for clearly explaining research

The competing researchers covered such projects as listening to cancer cells, observing proteins in their natural habitat, and detoxifying manure by pasteurizing it. But Jonathan Butcher, assistant professor of biomedical engineering, did the best job explaining his work, on 3D X-rays, at Cornell's Third Annual Public Engagement and Science Communication Symposium, May 12.

For his efforts, which were judged by such community members as local high school and community college students, grocery chain executives, bankers, and pharmaceutical executives, Butcher won a $10,000 grant-extension award. In the judges' view, Butcher did the best job communicating in clear language to a lay audience his research, "Virtual Reality of Living Science Made Possible Through Micro-Computer Tomography," conducted with research technician Mark Riccio and GE Healthcare.

The work shows how two-dimensional X-rays could be transformed into 3D images to peer into plants, animals, and machines to find hidden tumors or broken mechanisms. "We have worked to develop and implement the next-generation micro-CT system, which can now image so much more than just bone," said Butcher. "It is 10 times faster than the currently available systems, which means less X-ray dose for the same quality image and many, many more images that can be taken."

Cynthia Reinhart-King, assistant professor of biomedical engineering, won second place and $1,000 for her work, "Light: Strong Enough to Stop a Speeding Cell," conducted with David Erickson, assistant professor of mechanical and aerospace engineering, and graduate students Casey Kraning and Joseph Califano.

"We are developing a novel device to use light to trap cells and measure the forces they exert during migration," explained Reinhart-King. "If our hypothesis that metastasis cells are stronger is correct, then the device would predict metastasis depending on tumor cell strength." It is estimated that 90 percent of the 8 million cancer-related deaths in this country are due to metastasis, yet no medical procedure can now determine or predict if a tumor will metastasize.

The competition highlighted faculty research funded by the Center for Life Science Enterprise, a NYSTAR-designated Center for Advanced Technology. The symposium included a faculty research poster showcase and displays, a panel discussion on science commercialization and communication, and a keynote address by Rohit Shukla, CEO of the Larta Institute, on the commercialization of breakthrough technology and the success of innovative companies.

—*Susan Lang*

ROBERT BARKER/UNIVERSITY PHOTOGRAPHY

Jonathan Butcher, right, receives his first-place award in the Faculty Research Poster Showcase from Susi Varvayanis, director of applied resources at the Cornell Institute for Biotechnology and Life Science Technologies.

Pass named Microsoft Fellow

Rafael Pass, assistant professor of computer science, has been selected as one of five 2009 Microsoft Research New Faculty Fellows. His fellowship will support research into new ways to conduct transactions safely and reliably in such situations as auctions and anonymous online voting.

The five faculty fellowship winners each receive an unrestricted cash gift of $200,000, as well as additional Microsoft resources, including software, invitations to academic and professional conferences, and the opportunity to engage firsthand with leading researchers from Microsoft Research.

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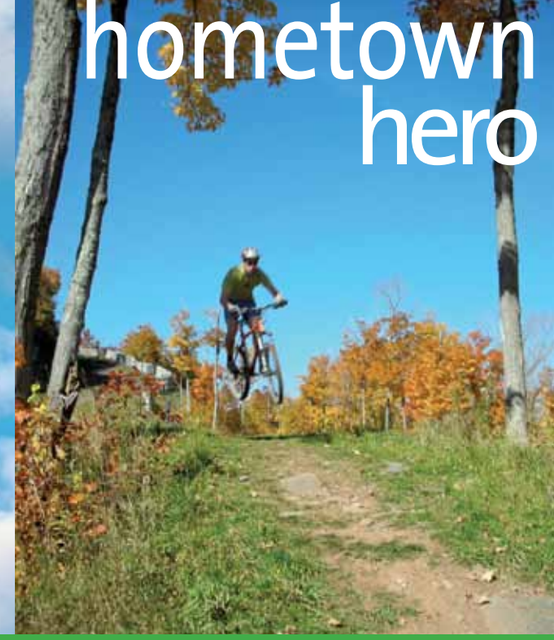
Rafael Pass

Microsoft's New Faculty Fellowships are awarded annually to five promising researchers who are "advancing computing research in novel directions with the potential for high impact on the state of the art, and who demonstrate the likelihood of becoming thought leaders in the field." Created in 2005 to honor early career university professors, the program now includes 25 academic researchers.

This is the third year in a row a Cornell faculty member has received a Microsoft New Faculty Fellowship. Assistant Professors Adam Siepel and Robert Kleinberg are previous recipients. Cornell is now tied with Stanford and the Massachusetts Institute of Technology for the most winners in the program.

—*Bill Steele*

hometown hero



FLYING HIGH: CHAD KOSSAR

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Chad Kossar '10 ME, like many prospective Cornell students, flew to Ithaca for an interview. During his meeting, he peered at the gathering clouds in the sky, mentioning his slight concern about the weather for his flight home to Newtown, Pa. His interviewers dismissed his worries with a wave, assuring him the plane could handle it—until Kossar informed them he had flown it himself.

Kossar survived the return flight, which helped him score his pilot's license. Now the lanky young man with a wide smile and curly hair is a junior in mechanical engineering at Cornell. Somewhere between studying for classes, training for ski racing, managing the upkeep of his fraternity house, and tutoring middle schoolers, Kossar has found the time to chat about his Cornell experience. His laid-back, cheerful demeanor belies his busy schedule of juggling full course loads with a slew of extreme sports and community involvement. "He's really just full of life," says Mechanical and Aerospace Engineering associate professor Mark Campbell, Kossar's academic adviser. "He doesn't let things get in his way."

A driving force in Kossar's life is a love of the outdoors—and flying above it. In fact, Kossar hopes to make a career out of aerospace or aircraft design. "He's always had an interest in flying," says Kossar's father, Bruce. "First he wanted to fly a real plane, so I got him interested in remote control airplanes. ...That only worked for a little while (until he was 12). By age 14 he was back to wanting to fly a real plane." Kossar's parents gave in, and he was soon flying solo. By the time he was in high school, his passion for flying helped him choose an engineering career path. "I think that was an extension of his love of flying," says Bruce. His other dominant obsession has been skiing, which Kossar started "when he started walking," says Bruce. With two to three trips to Jackson Hole, Wyo., every year, he quickly learned to negotiate the most daunting slopes. "The snow can't be too deep and the hills can't be too steep," Bruce adds. Around age 13, Kossar decided to take up ski racing, which he's continued into his college career. The Cornell ski team trains and races five days out of the week at the local ski resort located 30 minutes from campus. "Chad's out there more than I am," says Bruce Kenneth Hamlin, ski team captain. "This week we have a home race and we've been running around like chickens without our heads." The hard work has paid off, however, as Kossar made it to the Nationals competition this spring.

On top of ski-team responsibilities and a full course load, Kossar works as a mountain biking instructor for the Cornell Outdoor Education program, is the house manager for his fraternity, and last fall, enrolled in a teaching class that put Cornell engineering students into classrooms in secondary schools around Ithaca. The class, "The Art of Teaching," appealed to Kossar, who had spent the past five summers working with kids as a camp counselor at Mount Hood, Ore., and he signed up to teach for a few hours a week in the Dewitt Middle School. "I like to work with kids because they don't take themselves too seriously," says Kossar. "They're a lot of fun."

Kossar is the latest addition to the 10-year-old Cornell teaching program, which was originally started by Michel Louge, professor of mechanical and aerospace engineering. Louge's daughter had attended Dewitt Middle School and had complained of not getting enough help during her technology class due to the teacher-student ratio. "Some students at this age aren't able to follow instructions well," says Louge. "The teachers spend a long time answering questions." So Louge decided to enlist Cornell students who were looking to get real-world teaching experience to help in middle school classes. The technology teachers at Dewitt, Bob Walters and David Buchner, were more than happy for the extra help, and "for college students, you're involved in the community experience," says Buchner. "If you're interested at all in working with secondary-ed students this is a rare opportunity to do this."

Kossar admits that the first time he entered the eighth-grade classroom as an authority figure, it felt a little odd. "But the kids were all pretty enthusiastic about it," he says, and soon he was comfortable teaching them how to solve mathematic equations and build simple machines. "Chad was very comfortable, he's a laid-back kind of guy, and that made it easy for middle school kids to be comfortable," says Buchner. "He had a really good rapport with the kids—Chad was very aware of who he was working with and what he could get away with."

Kossar's broad range of activities is unusual, even in the Cornell community. "Certainly, Cornell engineering has a reputation of having students who really like to do projects," says Campbell, Kossar's adviser. "But the diversity of what Chad does is not common at all." Campbell recalls meeting Kossar as a first-year student who was eager to dive into multiple projects. "As his adviser, I said, 'Look, I can't really recommend this,' but he went for it. And he's been able to handle it," says Campbell. "That's pretty unique. I'm interested to see where he goes with all this ... it seems like the sky's the limit."

—*Lauren Cahoon*

Atomic Sandwiches

Materials Science and Engineering professor Darrell Schlom makes sandwiches just a few atoms thick to feed science and technology's appetite for new materials.

Like most materials scientists, he used to take an experimental approach to cooking up new recipes. He'd combine a little of this with a little of that and then taste. But now Schlom makes sandwiches to order for Craig Fennie, another new Cornell Engineering faculty member. Fennie uses first-principles quantum mechanics to predict the properties of new materials before they've even been created. "I used to go on fishing expeditions," says Schlom, laughing. "Now I have a map."

The ingredients in Schlom's sandwiches are complex oxides, the properties of which vary tremendously depending on the charge, spin, and orbital ordering of electrons, as well as crystal structure. While knowing the ingredients and how they should be layered cuts out the guesswork, figuring out how to actually put the sandwich together still takes time. "It's a big challenge. After about two years we either give up totally, or we succeed," says Schlom. "For all of his predictions that we've tested, he's got a 100 percent batting average, which has really given me a lot of faith in the relatively new materials-by-design approach that brave theorists like Craig have been boasting about."

Materials Science and Engineering professor Darrell Schlom

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Far Above... and going farther

Claudia Rodriguez '08 immigrated to the United States from Nicaragua and is the first in her family to attend college. The Jack M. and Joan E. Scanlon Scholarship and the William F. Gratz Cornell Tradition Fellowship helped make Cornell a "dream come true" for her. The new chemical engineer now works for Johnson & Johnson.

Far Above... The Campaign for Cornell

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