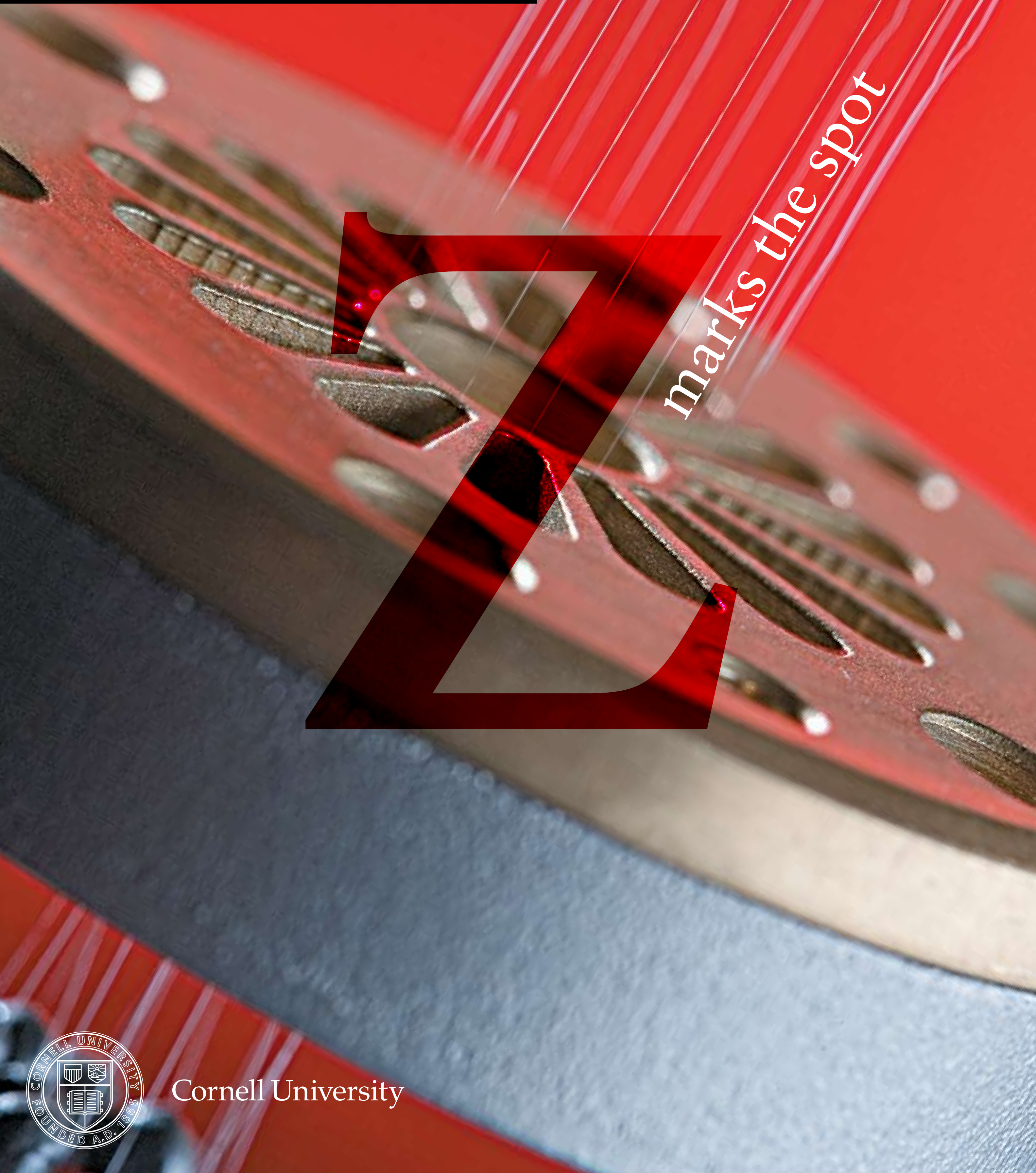
CORNELL ENGINEERING

FALL 2006

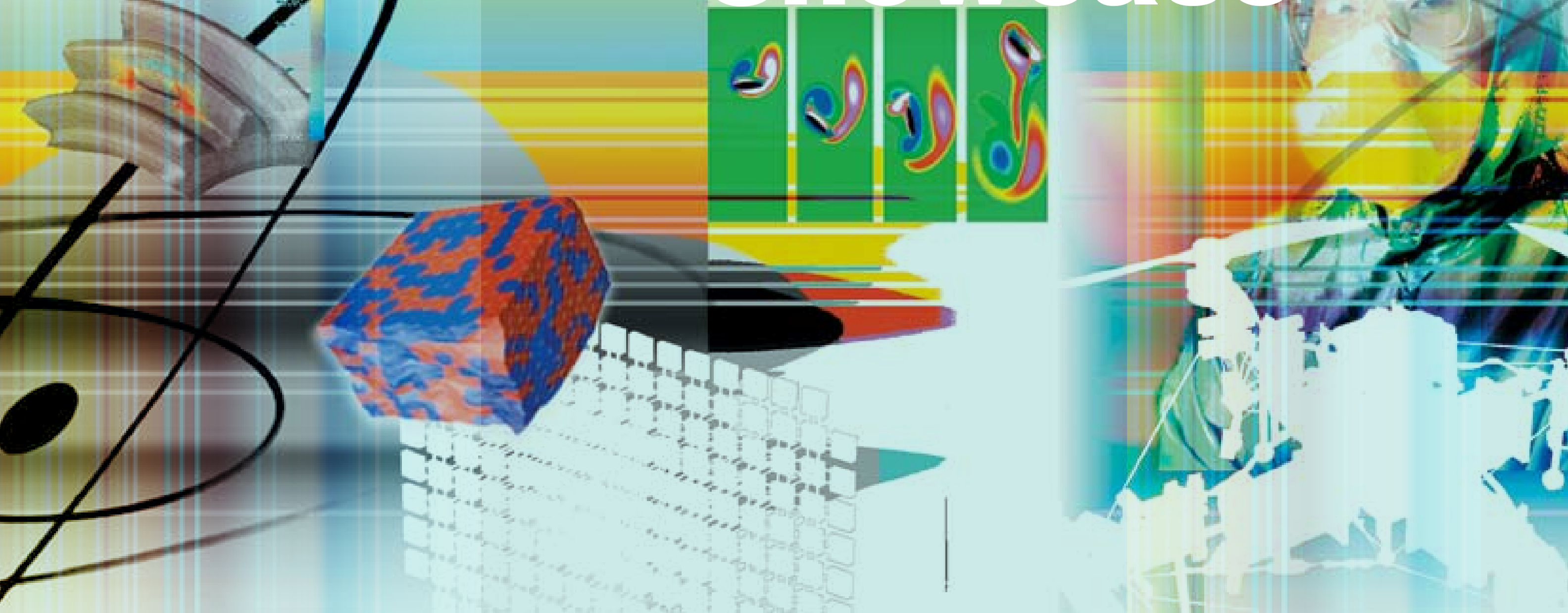


Cornell University

September 11, 2007
3:00 p.m. – 7:00 p.m.
Duffield Hall Atrium

ANNOUNCING THE

2007 Engineering Research Showcase



Plan now to attend the 7th annual Engineering Research Showcase, featuring graduate student poster presentations, master of engineering program displays, and undergraduate research projects.

The program will include a welcome by Engineering Dean Kent Fuchs and other speakers, followed by an awards presentation.

Cornell alumni and corporate visitors are invited to attend; drinks and hors d'oeuvres will be served.

Don't miss this opportunity to meet our students and to preview the breakthrough discoveries and emerging research underway on the engineering quad.

For information on student submissions and corporate sponsorship, please contact:
Research and Graduate Studies
College of Engineering
222 Carpenter Hall
Ithaca, NY 14853-2201
607 255-7413
engr_grad@cornell.edu

www.engineering.cornell.edu/research-showcase

C-ENG.

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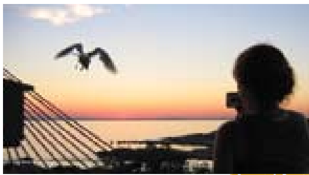
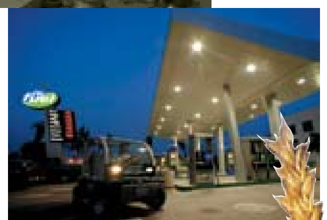




DEPARTMENTS

C-ENG.NEWS

FALL 2006

CRITICAL MASS

NSF grant to increase numbers of women in science and engineering.

Jason Koski/University Photo

Leaders of the ACCEL program within the Provost's Office are, from left, Provost Biddy Martin; Shelley Correll, associate professor of sociology; Marjolein van der Meulen, associate professor of mechanical and aerospace engineering; Robert Harris, vice provost for diversity and faculty development; and Sheila Hemami, professor of electrical engineering.

To increase the number of women faculty in engineering and the sciences, Cornell will use a $3.3 million grant from the National Science Foundation to work on recruiting, retaining, and promoting more women in leadership positions. The grant also will create a new center called ACCEL (Advancing Cornell's Commitment to Excellence and Leadership), which on Nov. 1 became a permanent part of the Provost's Office.

"We have an important opportunity to increase the number of women science and engineering faculty," said Cornell Provost Carolyn A. "Biddy" Martin. "We want a critical mass of women in each department, the environment that most determines faculty daily life."

To correct the current imbalance, Cornell has set ambitious goals: to reach a level of 20 percent women faculty in each science and engineering department in the next five years and to have more than 30 percent by 2015, Cornell's sesquicentennial. At present, about half, or 27 of 51 science and engineering departments, fall below 20 percent, and some departments have no women faculty.

ACCEL will lead four initiatives:

- The Climate Initiative will focus on departmental cultures, seeking to build awareness of gender issues among the faculty by training department chairs, providing orientation for new faculty, and bringing speakers to campus to discuss gender issues.
- The Recruiting Initiative will focus on all stages of hiring, seeking to increase the number of applications from women, the number of women interviewed, and the number of offers.
- The Women's Power Tools Initiative will focus on women who are already on the faculty, supplying them with information, resources, and opportunities to help them move into leadership positions.
- Monitoring and Evaluation will track the effectiveness of the new policies. It will include a longitudinal study by Shelley Correll, associate professor of sociology, that will follow both pre- and post-tenure professors through their careers, trying to identify barriers and see if they are different for men and women.

Although the focus of the NSF grant is on women in engineering and the physical, life, and social sciences, organizers of the new center hope for a "ripple effect" that will enhance the lives and careers of both men and women faculty throughout the university.

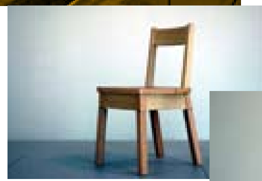
As the only Ivy League university that was coeducational almost from its beginnings, Cornell has a rich history of including women in all areas and can point to many firsts for women in higher education, but it still needs to increase the representation of women in its faculty, Martin said.

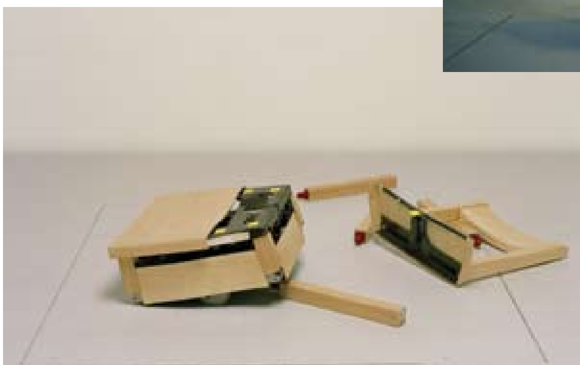
Martin is principal investigator on the grant, with co-principal investigators Robert Harris Jr., vice provost for diversity and faculty development; Marjolein van der Meulen, associate professor of mechanical and aerospace engineering; Sheila Hemami, professor of electrical and computer engineering; and Correll. Hemami will initially serve as programming director of ACCEL, while van der Meulen serves as engineering college liason; they will swap roles in the second half of the grant. Correll will serve as co-director.

"With a National Science Foundation Advance grant, Cornell can renew its leadership by demonstrating that reaching a critical mass of women scientists at an elite, research-intensive university is not only possible, but critical to the quality of the institution," said Martin.

—Bill Steele, Cornell Chronicle Publications

THINGS FALL APART





Photos provided by Raffaello D'Andrea

"The Robotic Chair" falls apart and reassembles itself autonomously. http://www.mae.cornell.edu/raff/InteractiveDynamicArt/InteractiveDynamicArt.htm

A seemingly simple, sturdy, wood-veneer chair has become an online video hit. With its "brain" in its seat, the chair collapses into a disheveled, disconnected heap; its legs then slowly find each corner of the base, connect back together, and eventually, the chair stands upright.

The next breakthrough in artificial intelligence?

Not quite, says the chair's system architect, Raffaello D'Andrea, Cornell associate professor of mechanical and aerospace engineering.

"It has no utilitarian value," D'Andrea said. "It is an art piece."

The artistic brainchild of Canadian artist Max Dean, the chair is currently on tour at art exhibits around the world, most recently at the Ars Electronica show in Austria.

Better known around Cornell as the faculty adviser to the world champion student RoboCup team, D'Andrea partnered with Dean two years ago as chief engineer for the Robotic Chair project, which also included Matt Donovan—another Canadian artist—and D'Andrea's former student Steve Lowe.

The creation of the chair would have been artistic achievement enough, but the robot's rapid rise to fame over the Internet has created an unexpected buzz. A recent spot that aired on the Discovery Channel also helped surge the chair into the international spotlight.

The hype began, D'Andrea said, right after he spoke about the chair at a Cornell-sponsored event in Silicon Valley in May. He and the rest of the chair team had just finished building a working prototype.

"Word just got out, and somebody decided to put the video on YouTube," said D'Andrea, who is currently on a year's leave from Cornell, working on a startup company he helped found that employs robotic technology.

The Internet home video hub YouTube has received more than 180,000 download requests for the video of the Robotic Chair, and varying user comments.

"It's cool, however it doesn't really have a point :P," one viewer wrote. "Are you Kidding Me? Yes it does have a point! They can use this technology to make robots that can be regenerative if destroyed," another viewer replied.

"The Robotic Chair" isn't the first engineering/art collaboration D'Andrea has worked on with Dean. In 2001, a nondescript robotic table that followed people around was the focus of the pair's artistic sensibilities. The table was exhibited at the Venice Biennale and later purchased by the National Gallery of Canada.

As system architect for the chair, D'Andrea figured out how the robot, which involves 14 motors, two gearboxes, and many other parts, would accomplish the task of autonomous self-assembly. Donovan and Lowe built the robot, while D'Andrea outlined the engineering specifications and wrote the algorithms that bring the chair to life. The robot uses a sophisticated algorithm to know how to find its component pieces and build itself back up. It communicates with a computer, which sends commands to the chair's "brain" in the seat so it knows which pieces it needs next.

"Some people thought it was a hoax, or fabricated, or computer animation," D'Andrea said. "Others thought it was remote-controlled. The reality of it is, it's not. It's a self-contained system that does what it does."

—Anne Ju, Cornell Chronicle Publications

SHAPING THE FUTURE

Provided by Stephen Sass

Cornell faculty on the waterfront in Shanghai are, from left, Ulrich Wiesner, Lara Estroff, Barbara Baird, Dan Luo, Shefford Baker, Edwin Kan, and Stephen Sass.

Exploring new possibilities in research collaborations and faculty exchanges, a seven-member contingent of Cornell faculty recently finished a series of nanoscience workshops at two Chinese universities.

Participant Stephen Sass, professor of materials science and engineering and a Stephen H. Weiss Presidential Fellow, said that while many consider the 20th century to have been dominated by the United States, the 21st century may well be the century of China.

"It's important to form relationships with the strongest Chinese universities so that Cornell can participate in the growth of science and technology in China, and in a small way, help to shape the future," Sass said.

A group of computer science faculty from the College of Engineering had earlier visited Beijing's Tsinghua University in November 2005 for a two-day meeting, the Tsinghua-Cornell Workshop on Information Science and Technology. The present group of faculty from the College of Engineering and the College of Arts and Sciences gave presentations in the 2006 Tsinghua-Cornell Workshop on Nanoscience and Nanotechnology, held Oct. 9 and 10.

Following that event, the group attended another workshop on Oct. 12 and 13 at Jiao Tong University in Shanghai called the 2006 SJTU-Cornell Nanoscience and Technology Symposium.

Cornell participants in the intensive workshops dealing with nanomaterials, nanodevices, and nanocomposites included Barbara Baird from chemistry and chemical biology, Edwin Kan from electrical and computer engineering, Dan Luo from biological and environmental engineering, and Shefford Baker, Lara Estroff, Ulrich Wiesner, and Sass, from materials science and engineering.

—Anne Ju, Cornell Chronicle Publications

DRINK UP

Provided by AguaClara

Contractor Juan Gomez and local resident Roni Ramos work on the foundation of a water plant in Ojojona, a village in Honduras.

A project to share skills and knowledge with Hondurans for building drinking water treatment systems in rural areas has brought national recognition for Cornell engineering students and instructors.

Engineers for a Sustainable World, a 30-chapter national organization founded five years ago at Cornell, has awarded the Cornell-based AguaClara its Best Project Award. The project, which was competing against several sustainability programs across the nation, received the award at the ESW Conference in Iowa City, Iowa, Sept. 27–30.

AguaClara—Spanish for clear water—involves engineering students who research and design the technologies and then train Hondurans to build and operate the water treatment plants. Coordinated by Cornell civil and environmental engineering senior lecturer Monroe Weber-Shirk, the multiyear effort has focused on rural Honduran communities where clean drinking water is not available.

In the program, student teams research and develop technologies that meet the challenges of developing communities throughout the world. The constraints they face include the need to produce clean water without using electrical power and to build the facilities at a cost of less than $10 per person using locally available materials.

"One of the big goals for this project is to transfer knowledge," Weber-Shirk said. "And not just a particular design, but to transfer knowledge so Hondurans can go on building these plants." For this reason, AguaClara is partnered with the Honduras organization Agua Para el Pueblo—"water for people."

ESW Director of External Relations Leti McNeill said that the Best Project reviewing team looked for quality of partner organizations, academic integrity, integration into coursework, technical difficulty, and overall impact.

"I think they stood out as hitting all those categories really well," McNeill said.

—Anne Ju, Cornell Chronicle Publications

MAGNIFICENT GENEROSITY

Cornell alumni Irwin Jacobs '54, B.E.E. '56, and Joan Jacobs '54 have established a $30 million scholarship and fellowship endowment for Cornell's College of Engineering.

The couple's gift will provide $750,000 annually over five years to Irwin and Joan Jacobs graduate fellows in the School of Electrical and Computer Engineering, and $750,000 annually to undergraduate Jacobs scholars. More than 30 Jacobs scholars and about 15 Jacobs fellows will be named every year.

"The future of our economy in the United States is very much tied to innovation, to students studying both science and engineering, and to their ability to apply their studies," said Irwin Jacobs, who founded the global wireless and voice data company QUALCOMM Inc. in 1985. "The number of students entering engineering hasn't been growing. We hope additional aid can increase the pool of students entering the field and, therefore, improve the economy."

"We are indebted to the Jacobs for their magnificent generosity," said Kent Fuchs, dean of the College of Engineering. "Their fellowships and scholarships will have a profound impact on the quality and visibility of our research and graduate program, as well as on the accessibility of Cornell and our ability to attract the very best undergraduates."

—Anne Ju, Cornell Chronicle Publications

WALK THIS WAY

Lindsay France/University Photography

Graduate student Viktor Zykov, former student Josh Bongard, and Hod Lipson, Cornell assistant professor of mechanical and aerospace engineering, watch as a starfish-like robot pulls itself forward.

Nothing can possibly go wrong ... go wrong ... go wrong ...

The truth behind the old joke is that most robots are programmed with a fairly rigid "model" of what they and the world around them are like. If a robot is damaged or its environment changes unexpectedly, it can't adapt.

So Cornell researchers have built a robot that works out its own model of itself and can revise the model to adapt to injury. First, it teaches itself to walk. Then, when damaged, it teaches itself to limp.

Although the test robot is a simple four-legged device, the researchers say the underlying algorithm could be used to build more complex robots that can deal with uncertain situations, like space exploration, and may help in understanding human and animal behavior.

The research, reported in the Nov. 17 issue of the journal *Science*, was carried out in the Cornell Computational Synthesis Lab under Hod Lipson, assistant professor of mechanical and aerospace engineering, with Josh Bongard, a former Cornell postdoctoral researcher now on the faculty at the University of Vermont, and Cornell graduate student Viktor Zykov.

Instead of giving the robot a rigid set of instructions, the researchers let it discover its own nature and work out how to control itself.

"Most robots have a fixed model laboriously designed by human engineers," Lipson explained. "We showed, for the first time, how the model can emerge within the robot. It makes robots adaptive at a new level, because they can be given a task without requiring a model. It opens the door to a new level of machine cognition and sheds light on the age-old question of machine consciousness, which is all about internal models."

—Bill Steele, Cornell Chronicle Publications

BEST OF SHOW

Lindsay France/University Photography

Biomedical engineering students demonstrate a prototype of an auto-syringe. Pictured from left to right: M.Eng. student Matthew Weaver, Timothy Miller of West Pharmaceutical, and M.Eng. students Alex Deyle, Alicia Billington, and Jennifer Kim.

Human tissue engineering to repair damage to cartilage, or menisci, in the knee is a technology that Cornell master of engineering (M.Eng.) student Andrea Ippolito hopes to contribute someday to the biomedical engineering field.

Ippolito, the winner of the 2006 Engineering Research Showcase poster competition in the graduate student category, displayed the results of her ongoing meniscus engineering experiments alongside the research of more than 120 other master's, Ph.D., and undergraduate students at the 2006 College of Engineering Research Showcase. A panel of judges from companies including Intel and Xerox selected the best posters for awards, based on such criteria as quality of research, aesthetic display, and clarity of description.

Other award winners included Dmitriy Levchenkov, a Ph.D. operations research student, for "Scheduling Cornell Final Exams" (second place, graduate student category); Marleen Kamperman, materials science and engineering Ph.D. candidate, for her poster, "High Temperature Ceramics with Hierarchically Ordered Pore Structure" (third place, graduate student category); and biological and environmental engineering student John Polimeni, whose "Neural Mouse Project" reaped top honors in the undergraduate research category.

An important judging criterion, according to judge Heidi M. Grenek from Xerox, was the ability for students to communicate their projects to a lay audience—a skill the students will need when looking for jobs. The other judges were John P. Spoonhower, Eastman Kodak; Kimberly W. Sills, Intel; and Nader Mehravari, Lockheed Martin.

The research showcase coincided with the start of Career Fair Days, a universitywide event that brings job recruiters from all fields to campus. "The purpose is to attract employers and recruiters interested in talking to our students," said Jeffrey K. Newman, director of research and graduate studies for the College of Engineering.

—Anne Ju, Cornell Chronicle Publications

$12 MILLION FOR X-RAYS

Visiting the Cornell campus last summer, New York Gov. George Pataki announced $12 million in state appropriations for preliminary work on the proposed Energy Recovery Linac. Construction, in a 1.3-kilometer-long tunnel under university parking lots, is scheduled to begin at the end of this decade, at an estimated cost of about $400 million.

Cornell scientists are currently developing critical components of the ERL, and in 2008 expect to complete construction and testing of a prototype, for which the National Science Foundation has provided $18 million and Cornell $10 million. "But there's still a gap," Pataki said. "So the state is providing a $12 million capital appropriation."

In the linac, or linear accelerator, electrons will be pushed to almost the speed of light, then fed into the Cornell Electron Storage Ring. At various points around the ring, facilities of the Cornell High Energy Synchrotron Source will convert them into high-energy X-rays. CHESS will become what Robert Richardson, Cornell vice provost for research, who shared the podium with Pataki, called "the brightest X-ray source in the history of the world."

—Bill Steele, Cornell News Service

TAKING IT TO THE STREETS

Photo by Peter Moran

The 2005 DARPA Challenge called for autonomous vehicles to negotiate punishing desert terrain in the Southwest.

In 2005, the goal was to build a vehicle that could drive itself, without human intervention, across 132 miles of desert with unpaved roads, ditches, berms, sandy ground, standing water, rocks and boulders, narrow underpasses, construction equipment, concrete safety rails, power line towers, barbed wire fences, and cattle guards.

Compared with this year, that was a piece of cake.

The new DARPA (Defense Advanced Research Projects Agency) Urban Challenge, leading up to a competition in November 2007, is to build a car that can drive itself on city streets, obeying traffic laws, stopping at stop signs, navigating traffic circles, and dealing with other vehicles.

DARPA will give a team of Cornell students and faculty up to $1 million to try. Based on an initial proposal from the team, DARPA has selected Cornell as one of 11 "Track A" participants (out of more than 60 applicants) that will receive advance funding to develop their vehicles.

"Technologically it's a leap above the other [challenge]," said Ephrahim Garcia, associate professor of mechanical and aerospace engineering and one of several faculty members advising the team. "If you look at the literature on robotic vehicles, it mostly stops at static obstacle avoidance. Think of every detail you do when you drive, and imagine how you would program that."

Mark Campbell, associate professor of mechanical and aerospace engineering, and Dan Huttenolocher, the John P. and Rilla Neafsey Professor of Computing, Information Science and Business, are also faculty advisers, and the team receives additional support from Bart Selman, professor of computer science, and from mechanical and aerospace engineering faculty members Mark Psiaki, professor, and Hod Lipson, assistant professor.

DARPA's long-range goal in sponsoring the challenges is to develop robotic vehicles that can carry out dangerous missions without endangering humans.

—Bill Steele, Cornell Chronicle Publications

NEW PHASE FOR ARECIBO

University Photo

Arecibo is one of only two telescopes in the world with radar capability.

On Nov. 3, the Senior Review, an advisory panel to the National Science Foundation's Division of Astronomical Sciences, recommended a 24 percent cut in funding over the next three years for Arecibo Observatory, which Cornell manages as the National Astronomy and Ionosphere Center. The panel also advised the center to find outside partners to cover another recommended 40 percent funding cut by 2011 or risk closure.

Despite this news, Cornell astronomers remained upbeat about the long-term future of the telescope. Joseph Burns, Cornell vice provost for physical sciences and engineering, issued a statement in response to the report:

"….Cornell supports the NSF's overall plan to find funds to carry out new initiatives, but we are disappointed with some of the Senior Review's specific recommendations into the next decade. We remain dedicated to the core scientific programs of the Arecibo Observatory and, accordingly, we are pleased that the review recognizes the facility's significant contributions today and its potential for important discoveries well into the next decade. Our staff will be working with our astronomy community to identify cost savings … (and) we are confident that Arecibo's remarkable research and educational programs will be kept strong into 2011 and beyond."

The Arecibo Observatory's 305-meter diameter antenna, the world's largest and most sensitive radio-radar telescope, attracts more than 250 scientists to northwestern Puerto Rico from around the world every year and has been the source of pivotal discoveries about pulsars, planets, distant galaxies, near earth objects, and the interstellar medium, as well as key findings about gravitational physics, atmospheric sciences, and more.

—Lauren Gold, Cornell Chronicle Publications

Jason Koski/University Photo

Chris McEvoy, chief technical officer of Vicarious Visions, delivered the keynote address at the American Society for Engineering Education Conference, held at Cornell in November.

NEXT BEST GAME

Twenty years ago, the most popular video games were made by teenage computer gurus in their spare time. With a knack for computer programming and some enthusiasm, anybody could be making the next best game.

Not anymore. The video-game industry has evolved: Today's games have multimillion-dollar budgets and large, dedicated teams. These changes demand a new mindset for educating the next generation of game programmers, said Chris McEvoy, chief technical officer of Vicarious Visions, a game-development studio in Albany, N.Y., and keynote speaker at the American Society for Engineering Education St. Lawrence Section Conference, held at Cornell, Nov. 17–18.

The two-day event brought together faculty members, industry leaders, and students from New York state and Canada to discuss engineering education. To Cornell participants, McEvoy's keynote resonated with those who worked to establish the new minor degree in game design, offered in the Department of Computer Science for the first time this year.

"We have to look at game development through the lens of software development, like Microsoft Word," said McEvoy, who believes that making today's complex games requires project management skills because developers no longer work alone. "For game programmers, their clients are the artists, animators, and producers. They have to produce tools for these guys to recreate their visions of how the game should be."

McEvoy said that higher education can help game programmers excel in their evolving role. "The requirements of what makes a game fun are not well-defined, so not everything in school is applicable. But people should come out of school with the right mindset, one of continuous improvement," said McEvoy, who suggested one way of learning the right material is for the game-development community to publish their work and to exchange ideas with academia.

— Alex Kwan, Cornell Chronicle Publications

Provided by ICE Cube

Research Associate Jin-Woo Lee tests CubeSat electronics. The satellite project involved more than 100 Cornell and Ithaca-area high school students over three years.

CRASH COURSE

A Russian rocket carrying two Cornell-built satellites and satellites from nine other universities and one private company crashed shortly after launch near the Kazakhstan-Uzbekistan border on July 26. The project, called CubeSat and developed by California Polytechnic State University and Stanford University's Space Systems Development Laboratory, was part of an ongoing effort to make space more accessible to students nationwide.

The rocket launch proceeded according to plan until after the first-stage separation. The rocket then lost contact with the ground for many minutes before observers received official word that it had failed. The cause of the crash is under investigation.

The two Cornell ICE Cube satellites (ICE stands for Ionospheric sCintillation Experiment) were 4-inch cubes weighing 2 pounds each. Built to study the effects of scintillations in the Earth's ionosphere on communication signals, the satellites involved more than 100 Cornell and Ithaca-area high school students over three years.

Mark Campbell, the project leader and an associate professor of mechanical and aerospace engineering, said he hopes the rocket failure doesn't cast a shadow over the CubeSat program.

"One of the benefits we have is that the satellite and the research we get out of it are not our product; the product is our students," he said, noting that many of the project's alumni have gone on to careers in aerospace engineering. "I've gotten so many e-mails from students who worked on the project saying, 'Just to let you know, I wouldn't be where I am today without it.' It made me feel good about what we had accomplished from that end of it."

—Lauren Gold, Cornell Chronicle Publications

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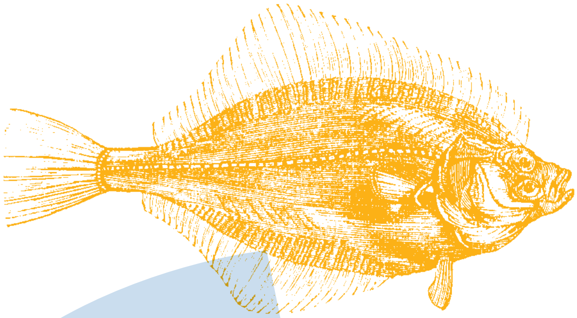


Engineering interns work to balance the triple bottom line — social, economic, and environmental needs — for an island research community.

At home, flush the toilet and it's easy to forget the waste ever existed. At Cornell's Shoals Marine Lab, the situation is a bit more complicated—and transparent. On this rustic island research station six miles out to sea in the Gulf of Maine, there is no municipal system to take care of details. Instead, a diesel-powered generator runs the pump that pulls water from the ocean and into the tank of each toilet. Another pump powered by that same diesel generator draws fresh water from the island's only well—or through a reverse osmosis desalinator that converts seawater into something potable—and into the bathroom faucets. On the other side of the equation, every drain on this 95-acre island empties into a three-tank wastewater treatment facility—also powered by that diesel generator. At season's end, island staff carry the treated solid waste out to sea and dispose of it in compliance with an overboard discharge permit issued by the State of Maine. Here, every flush—and every kilowatt that makes one possible—counts.

The concept of scarce resources strategically deployed isn't news to anyone who's set foot on an island surrounded by miles of ocean. But for four engineering undergrads who spent a month this summer as interns at Shoals, the implications of a closed loop system became abundantly clear. Leslie Campbell '08 CE, Nicole Ceci '08 GS, and Yuan "Clara" Yuan '07 OR, together with University of New Hampshire senior Lisa DiMiano, put

Appledore Island's engineering systems under the microscope as the first participants in Integrated Island Engineering Sytems for Sustainability, an internship supported through a grant from the Saquish Foundation, founded by Charles Werly '27. "We're a perfect test-tube for engineering," says station manager Ross Hansen, who supervised the interns. "Because it's an island, you can get your hands around things—what comes in and what goes out—get a real-world experience. It's a perfect place for students to get immersed."

Shoals Marine Lab was founded as a place for immersion—in marine ecology. Operated in partnership by Cornell and the University of New Hampshire since 1973, Shoals offers undergraduates at the two campuses the opportunity to hear about the object of their study in a lecture, and moments later reach into a tidal pool or lean over the side of a boat to pull that creature from the water for closer examination. Over the last three decades, the seasonal lab has expanded to offer experiential learning for high school and graduate students, families, and professional scientists. Every summer, close to 3,000 visitors take the forty-five minute boat ride from Portsmouth, N.H., to take classes, conduct field studies, band birds, and explore marine life.

When sustainability leapt to the top of Cornell's academic priorities, Shoals administrators saw an opportunity to extend such immersion experiences to undergraduates and faculty for whom marine ecology holds limited appeal. "Shoals offers a nice meeting point for many of these issues in sustainability," says lab director Willy Bemis, a Cornell professor of ecology and evolutionary biology. "The chance to bring together students from different backgrounds—from life sciences, engineering, sociology, history, natural resources, conservation—in one convenient place lends itself to the kind of intense thinking necessary to define what the future of sustainability might be, both in a curricular sense and more society-wide."

Throughout the summer, the four engineering interns grappled with the very real challenge of defining sustainability—a loose concept sometimes known as the "triple bottom line" that balances concern for the environment with contemporary and future human needs and cost consciousness—in the context of Shoals Marine Lab's engineering systems. Frequently, that balancing act meant discarding an environmentally attractive solution because of cost or implementation difficulties, or recognizing that a legacy system might be operating inefficiently, but that its replacement would break the bank. "When you're doing day-to-day operation or day-to-day maintenance, it's so easy to lose sight of sustainability," says Yuan, an operations research major. "The incentive structures aren't there to really be sustainable—it's all money, money, money, and net present value. It was very educational for me to see that happen, to participate in the process myself. I can stand on my soapbox and tell other people to be sustainable all I want, but until I'm actually in the position of being an engineer and having all these practical considerations.... It was very educational."

Over the course of four weeks, the all-female quartet delved into the intricacies of the island's fresh and saltwater systems, analyzed the wastewater treatment plant and possible alternatives, detailed the lab's electrical supply and demand, mapped and labeled the tangle of wires and pipes that crisscross the island, and investigated strategies for increasing efficiencies and decreasing ecological impacts. "We really didn't know much about the operational side of a lot of the systems that we were working with," says Campbell, who pursued the internship to test her interest in environmental engineering. "We spent entire days just following wires, figuring out where the power comes from, where it goes, how it's all being used."

> "The wastewater dye test—sampling the tanks and measuring them later—it felt like we were doing real work."

Beyond mapping a system cobbled together over thirty years—in some cases reaching the heights of elegant simplicity and in others rivaling Rube Goldberg for sheer complexity—the students gained hands-on expertise to complement the theoretical foundation they'd already acquired through problem sets and homework assignments in Ithaca. "We had to teach ourselves a lot being out there," says Campbell. "We spent so many hours in the library, just looking up resources, trying to figure out how systems work, what different parts do. Every system has its specific equipment and methods. It was really hard to get our heads around each system and then take the next step to say 'What do they need to do with that system? How can it be improved? How can it really work out there?'"

Hansen coordinated visits from the local utility company, a purveyor of composting toilets, a renewable energy systems consultancy, and faculty from UNH and Cornell. "Half of every internship is work and the other half is learning," says Ceci. "When people would come in from industry or professors would come talk to us, they'd try to start teaching us the physics background and we'd say 'No, we've had that. We just don't know what the system does.'"

By summer's end, the team could speak authoritatively not only about how leach fields might be incorporated into the island's wastewater treatment system, but about wet-stacking (the piston-clogging result of running a diesel generator at sub-optimal levels) and a wealth of technical details related to the island's three generators. "I'd only been exposed to the theoretical, small-scale circuitry stuff, which just isn't that interesting to me," says Ceci of her previous experiences in electrical engineering. "Actually being out there and working on the entire system was really, really interesting. That's just not an experience everyone else gets. There's no class on this campus that says, 'Go follow the entire grid.'"

They also inventoried the island's plug-in appliances and their electrical loads, measured per capita consumption of power and water over the course of each day and throughout the summer, and analyzed more than 300 samples taken as part of a rhodamine dye test for evidence of leaks in one of the wastewater treatment plant's holding tanks and a nearby body of water affectionately known as "Lake Titikaka." They even managed to get faculty, staff, and students participating in the island's other programs to tally the number of flushes at each toilet. "I felt like a real engineer," says Yuan. "The wastewater dye test—sampling the tanks and measuring them later—it felt like we were doing real work."

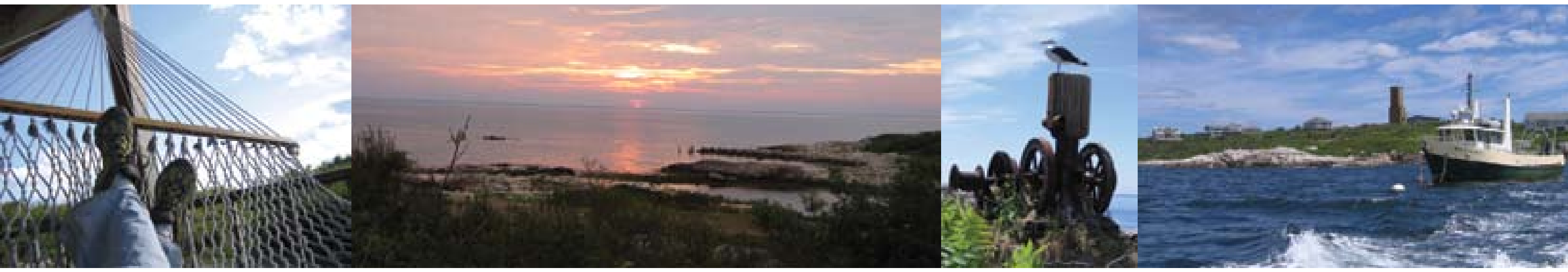
For lab administrators, committed to making Appledore a sustainable campus while minding a tight budget, the interns provided crucial insights into the current state of affairs and what it will take to decrease the island's reliance on fossil fuels and other inputs. "People knew there were issues in terms of capacity, age of the systems, and sustainability, measured in terms of cost, fossil fuels," says John Foote '74, who recently chaired an ad hoc planning group for Shoals charged with optimizing the island's programs and operations. "No one really knew with certainty what was going on. People had intuitive opinions, and a sense of the situation, but no one could say 'we're maxing out at 27 kilowatts,' or something like that. To get to the next step, we had to take a baby step, measuring the situation."

As they measured the situation, the students also began forming opinions—about which appliances demand too much electricity for too little value (the ice maker in the dining room, says Ceci) and how best to deal with human waste (composting toilets, say all four). Ultimately, any recommendation they offered had to fit with all of the island's systems, as part of an integrated whole. "There's clearly a connection between water usage and electrical usage because we have to pump water around," says Bemis. "But finding those ties and realizing those interconnections is a really important part of the learning experience and one that takes place at every level—at the student level, at our own staff level, and so forth."

Early in their time at Shoals, wastewater became a high priority for the interns. The lab's overboard discharge permit expires in 2009, and lab administrators anticipate revisions to its terms—if the permit is renewed at all. Their second day on the island, the interns themselves were horrified to learn that Shoals, an academic unit dedicated to the study of marine life, would dispose of any human waste—even treated and in accordance with state permits—in the ocean. And then the rhodamine dye test revealed a slow, steady leak from one of the holding tanks into Lake Titikaka. The quartet devoted some 32 pages of their 76-page final report to the topic, and became expert on a wealth of innovative wastewater treatment strategies, including sand filtration systems, alternative leach fields, and solar aquatic treatment systems that use plants, snails, and fish in progressive tanks to clean wastewater. "We spent this whole internship questioning and knowing there are other ways to get things done," says Campbell, "learning that just because an approach is unconventional doesn't mean it's not going to work."

Simultaneously, the group developed increasingly stringent standards for which solutions might be successfully implemented at the lab. Incinerating toilets—which do exactly what you might imagine—were dropped from consideration because of their high energy requirements. The hope of simply replacing the flush toilets in each building with their composting counterparts also fell by the wayside, due to space constraints imposed by the bedrock foundation on which most of the buildings sit. Instead, the students recommended the construction of centralized outbuildings outfitted with composting toilets and possibly powered by a handful of solar panels being offered to Shoals by the university. "I'd like to see Appledore become a laboratory or example that could be looked to by not just other island communities up and down the coast of Maine, but also coastal communities," says Foote, who attended the team's final presentation as part of an alumni panel including UNH grad and retired utility executive Mike Dalton; Tom Johnson '76; alternative energy consultant Abigail Krich '04 BE, M.Eng. '06 EE; and Cornell sustainability coordinator Dean Koyanagi '90. "The ideas that were being presented were 'out of the box,' but completely intriguing and caused me to think differently about what solutions are possible."

Ultimately, says Foote, Shoals' engineering interns have laid a solid foundation for the lab's long-term efforts to become energy and resource efficient. "In addition to being very bright and knowledgeable," says Foote, "the students had perceptive insights into how things work and how they don't work and really inventive ideas about how to make Appledore an example of sustainability. The future is very exciting."



Photography by Nicole Ceci

Lower part of a 16-wire cylindrical 8-mm array showing the contacts of the wires with the negative electrode (cathode).

Robert Barker/University Photo

Cornell researchers and their partners lead the quest to achieve a viable fusion energy source.

Z marks the spot

By Jason Gorss

Buried in the high desert of New Mexico southeast of Albuquerque, surrounded by concentric pools of de-ionized water and oil, sits a machine that everyone simply calls "Z." When an operator hits the switch, electric current pulses toward a single spot in the center. The current generates unimaginably high forces on parallel wires that form a cylindrical cage about the size of a spool of thread. The wires are vaporized and ionized, creating a searing plasma that can be, for an instant, many times hotter than the interior of the sun.

Housed at Sandia National Laboratory, Z is a gymnasium-sized affair that produces the world's most energetic X-ray pulses. Supporters hope it will someday crush a tiny pellet of fuel, ignite a controlled thermonuclear fusion reaction, and provide nothing less than a limitless supply of clean energy to the world.

Cornell researchers are recreating the mayhem of Z in the basement of Grumman Hall, albeit on a smaller scale. Funded by the U.S. Department of Energy's National Nuclear Security Administration—the same group that funds the Z machine—these researchers and their partners are studying the fundamental nature of high energy density plasmas, a sizzling topic the National Research Council recently dubbed the "X Games" of contemporary science.

In 2002, the National Nuclear Security Administration began providing $2 million per year to establish the Center for the Study of Pulsed-Power-Driven High Energy Density Plasmas, which is led by Cornell and includes partners at Imperial College, London; the University of Nevada, Reno; the University of Rochester; the Weizmann Institute of Science in Israel; and the P.N. Lebedev Physical Institute in Moscow. The bulk of the center's research is focused on understanding the physics behind imploding arrays of wires—the objects at the heart of Sandia's Z machine. A number of potential applications and insights could stem from the work, but the overarching goal is to support Sandia and other national laboratories in the quest to understand high energy density plasmas and, ultimately, to achieve a viable fusion energy source.

Pinch me, I'm dreaming

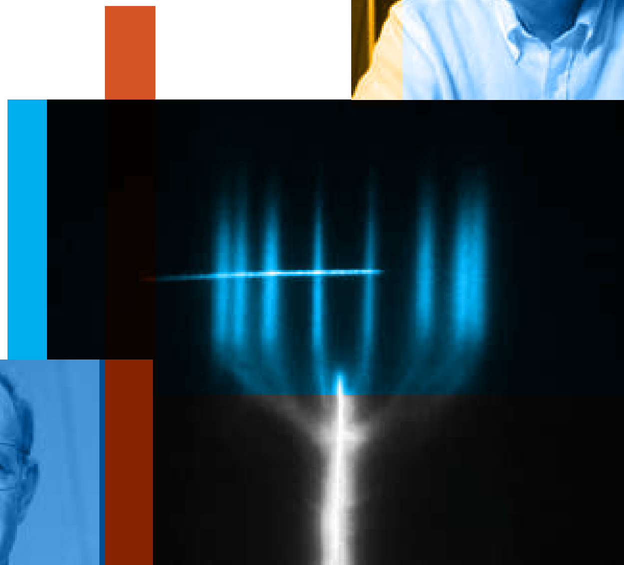
In a fusion reaction, two atoms are smashed together to form a single heavier atom. The total mass of the new atom is less than the combination of the original two; the extra mass is converted into energy in accordance with Albert Einstein's legendary equation, $E=mc^2$. Since the speed of light (c) is a very big number, even a tiny mass (m) can release an enormous amount of energy (E). This is the hope of fusion: One gram of fusion fuel could potentially produce more energy than burning 10 tons of coal.

All nuclear power plants operating today are based on the concept of fission, or splitting atoms apart. The original versions of the atomic bomb were also based on fission. While fission reactions release two million times as much energy per kilogram as burning traditional fuels like gasoline or coal, they release only 25 percent of the energy per kilogram of fusion reactions. In addition, the fuel for fusion reactors is more abundant in nature and the byproducts cleaner than is the case for fission. But in order to get nuclei of the atoms close enough to combine, they must have enough energy to overcome the repulsive forces that want to keep them apart.

To get an idea of how much energy, consider the hydrogen bomb—a fusion-boosted fission explosive device that makes an ordinary fission bomb look like a firecracker. In a hydrogen bomb, fusion reactions are ignited by exploding a fission bomb *first*.

Needless to say, scientists are pursuing other avenues to produce fusion in the laboratory. In stars like our sun, fusion is achieved by heating gravitationally confined hydrogen gas to temperatures above 10 million degrees, at which the hydrogen atoms are stripped of their electrons, forming a plasma. Achieving such high temperature plasmas on earth is no mean feat, of course, but researchers have found two viable approaches. The most well known of these is magnetic confinement fusion, which is soon to be implemented as

Robert Barker/University Photo



Above is a digital version of the streak camera image. The time sweep is vertical and 200 nanoseconds from the top to the bottom. The wires start out at on a 1.6 cm diameter. The horizontal line is a 150 picosecond laser pulse used for timing. The image is self-emission of visible light from the wires as they merge to the cylindrical axis.

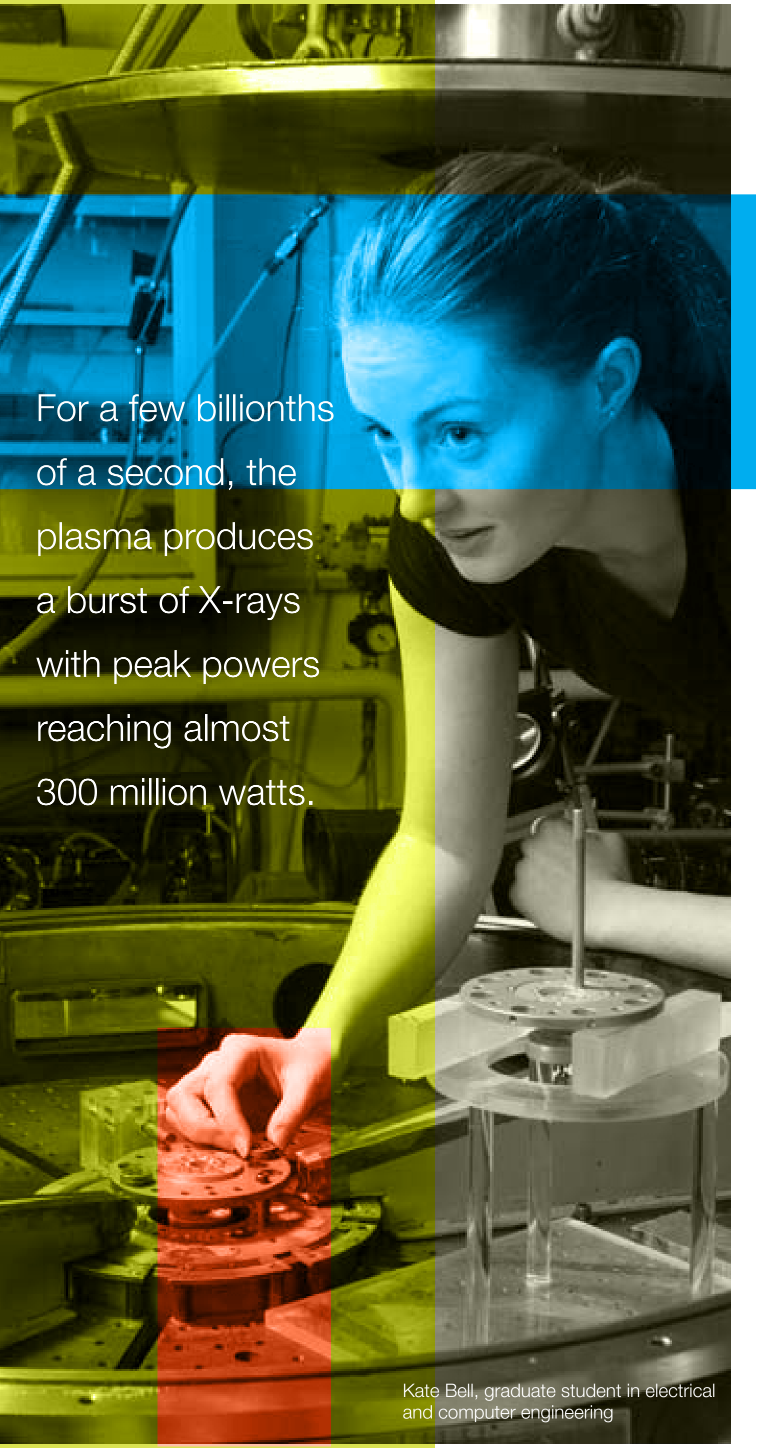
University Photo

the gargantuan fusion experiment known as ITER. (ITER was originally an acronym standing for International Thermonuclear Experimental Reactor.) This approach uses huge magnets in a toroidal configuration called a tokamak to confine the hot plasma long enough to generate energy. After 10 years of construction, ITER is expected to run its first tests to produce significant energy by 2020.

The other main approach is called inertial confinement fusion. In these experiments, a tiny spherical capsule of fusion fuel is bombarded with intense radiation. The pellet implodes and ignites the fuel, spurring fusion reactions. The radiation can be furnished using extremely high-powered lasers, such as the one being built at the National Ignition Facility at Lawrence Livermore National Laboratory. It can also be achieved by generating X-rays with a wire array "Z-pinch," which is the approach taken by Sandia's Z machine.

With a current pulse of about 20 million amperes, soon to be increased by 35 percent, Z heats a cylindrical arrangement of fine metal wires until it becomes a plasma. At the same time, the flow of electrical current creates a strong magnetic field, essentially pinching the plasma toward the axis of the cylinder—the "Z axis." For a few billionths of a second, the plasma produces a burst of X-rays with peak powers reaching almost 300 million watts.

While this amounts to the most powerful laboratory



Kate Bell, graduate student in electrical and computer engineering

Robert Barker/University Photo

source of X-rays in the world, it still falls short of the level needed to achieve a significant number of fusion reactions.

The adventures of COBRA and MAGPIE

Enter the Cornell-led research team. "We are working on experiments and theoretical support of experiments similar to the larger ones at the national laboratories," says Bruce Kusse, professor of applied and engineering physics at Cornell and director of the center. "Our experiments are at a smaller scale and consequently we can collect data at a higher rate than they can."

By operating at less severe conditions, the university researchers can more easily make measurements of basic physical phenomena. Goals, in addition to achieving a better understanding of Z-pinch physics, include improving the efficiency of wire array implosions and developing new diagnostic techniques for the larger national laboratory programs. "Centers like the one at Cornell play an important role in developing the science behind the applied research at Sandia," says Daniel Sinars, a researcher with Sandia's Z machine program.

The heart of the Cornell program is COBRA. This pulsed-power machine, which was commissioned in July 2004, is capable of generating extremely short bursts of current in excess of one million amperes. This offers scientists from around the world—as well as Cornell undergraduate and graduate students—a critical tool to study the high energy density plasmas similar to those produced by Sandia's Z machine, but on a much more manageable scale.

The center also boasts several other user facilities at locations across the globe, including Imperial College's MAGPIE. "It would be a waste of money to make two identical facilities, so COBRA was designed to complement MAGPIE," says Simon Bland, a research fellow in the plasma physics group at Imperial College. The main difference between the machines is the current pulse: COBRA has a flexible current pulse shape that reaches one million amperes in as little as 100 nanoseconds; MAGPIE takes 240 nanoseconds to reach its peak current, but this can be up to 1.4 million amperes at present—and it will soon be upgraded to about two million amperes.

"These differences allow different physics to be explored," Bland says. With its higher current and longer pulse, MAGPIE can drive heavier arrays made of more wires, allowing the researchers to examine how symmetry affects the implosion of an array. COBRA, on the other hand, can explore how faster rates of rising current affect array dynamics, according to Bland.

Bland spent more than a week in Ithaca last summer, giving seminars and exchanging data with Cornell researchers. "I came over to Cornell mainly to share information," Bland says. "This is one of the actual purposes of the center, and it has proven to be incredibly useful. Based on this, we are now working on two or three joint publications."

Why focus on wire array Z-pinches? Bland believes ITER will eventually succeed in demonstrating a controlled fusion reaction, but in the end, he fears that a tokamak-based approach will be "so costly as to never see the light of day." Likewise, he expects the National Ignition Facility at LLNL to demonstrate the feasibility of using lasers to ignite fusion, and this knowledge will help move the whole field of inertial confinement fusion forward. But even the best lasers are not very efficient—5 to 10 percent at best.

"Wire arrays to drive inertial confinement fusion have a number of potential advantages," Bland says. "They produce incredible powers and energies of X-rays, and this is done at amazing efficiencies. Approximately 15 percent of the energy available to power an array is converted to X-rays." And the generators required to implode arrays are relatively inexpensive, he adds.

One of the center's primary goals is to increase the efficiency of wire arrays even further, according to David Hammer, the J.C. Ward Professor of Nuclear Energy Engineering at Cornell and the center's associate director. "If we understand the processes of wire array Z-pinch explosions better, to the point that we can reduce some instability or get a little extra radiation out because it implodes more uniformly, then Sandia can pick up what we learn and apply it to their machine and hopefully get the same improvement," he says.

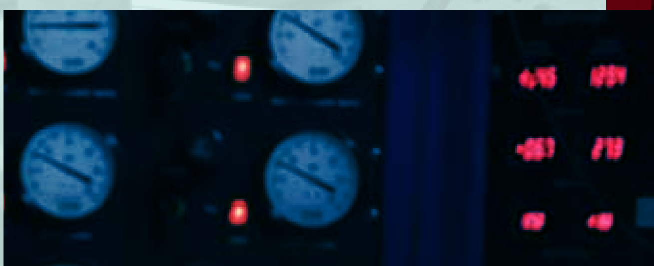
This has happened in the past, Hammer notes. Some fundamental Cornell experiments in the late 1990s had a significant effect on the way researchers expected wires to explode, causing people to rethink the initial conditions used in computer codes they were using to help to understand the experimental results. And studies performed on both MAGPIE and COBRA have provided valuable measurements of the dynamics of wire arrays. "The resulting understanding . . . has given us important tools for 'tailoring' the radiation produced by wire arrays to match the requirements for inertial confinement fusion, and thus has helped us make a credible case for our ability to achieve fusion driven by Z-pinch-produced radiation," Sinars says.

True believers

Of course, fusion research has its detractors. The running joke among cynics is that a viable fusion energy source is about 20 years away, and it will always be about 20 years away. But Hammer is, by his own admission, an incurable optimist. And he has been for more than 40 years.

"I started in plasma physics because of fusion, and I have been in it for 42 years now," he says. "In 1964, after my senior year at Caltech, I was offered a summer job at Oak Ridge National Laboratory in a group that was carrying out experiments in magnetohydrodynamics and plasma physics, neither one of which I had heard of." After only two months of working at the lab, the research team's enthusiasm

Clayton Myers, senior in applied and engineering physics



Robert Barker/University Photo

for controlled fusion had permanently rubbed off on the young intern. Hammer came to Cornell a year later to begin graduate work in the burgeoning plasma physics program.

"I had convinced myself that I wanted to be an 'applied physicist,' meaning that I wanted to work on 'useful applications' of physics, rather than things like elementary particle physics and cosmology," Hammer remembers. "As a graduate student, I helped start the intense electron beam experimental program starting in 1967 and did a thesis on intense electron beam propagation. Although my thesis was not directly relevant to fusion research, that application was enough in the back of my mind to be part of the conclusion chapter in my thesis."

Kusse was also drawn to the field more than 40 years ago, and he is similarly optimistic. "I believe that nuclear power, whether fusion, fission, or a hybrid fusion/fission process, is the most likely energy source once fossil fuels are no longer widely available," he says.

Both men's careers are success stories that researchers involved with the center hope to repeat. In fact, one of the most important aspects of the center is that it attracts talented students into the high energy density physics community and prepares them for careers in the field, providing a valuable supply of Ph.D.s to national laboratories and universities. Sinars is a case in point: He received a Ph.D. in applied physics from Cornell in 2001, studying under Hammer and Kusse. Now he spends his days working directly with the Z machine. He and his colleagues are hoping to take the next step with a refurbished facility called ZR that could potentially double the X-ray power output of Z. They expect ZR to come online in Spring 2007.

Some of the "bad press" about fusion stems from unrealistic assessments of the technical difficulties that needed to be overcome, according to Kusse. "The fusion process is much more difficult than fission and may be a more expensive energy source," he suggests. "Two things have to happen before fusion power plants are a reality: more work needs to be done on the practical aspects of fusion plants, and the costs of energy production from fossil fuels will probably have to increase significantly above what they are now."

As for that running joke: "People have been saying we're going to have fusion in 20 years, but a device to do it has never been built," Hammer says. "We finally are doing that with ITER. In effect the clock is starting as soon as they dig the first spade of dirt."

When opportunity knocks

Fusion is not the only game in town. The groups at Imperial College and the University of Rochester have been pioneers in another application of the Z-pinch technology: laboratory astrophysics. The idea is to simulate in the laboratory the processes thought to occur near black holes, rotating neutron stars, and newly forming stars. The results are then compared to computer simulations and observations of actual astrophysical events.

On its face, "laboratory astrophysics" is something of an oxymoron. How is it possible to replicate absurdly energetic events near black holes in the confines of a laboratory? The topic is not uncontroversial, but Richard Lovelace defends it. "I think these experiments are very revealing of mechanisms," says Lovelace, professor of applied and engineering physics and astronomy at Cornell and a co-investigator at the center. "It's necessary to consider how the properties scale. In the lab you are dealing with an experiment that is 10 centimeters across, whereas in astrophysics it is 10 to the 14th power centimeters across. The lab experiments can shed light on these mechanisms when scaled properly."

Outer space has many different systems with astrophysical jets: active galaxies, binary black holes, early versions of solar systems. Each has different properties, and little is known about the mechanisms behind their formation. Astrophysical jets are very high energy phenomena, which makes them perfect for studying in the high energy environment produced by a Z-pinch. The majority of Lovelace's work to date has been theoretical, but he is planning to begin some experimental work on COBRA within the next year.

Another area of research that has produced surprising results involves an alternative configuration called the X-pinch. Instead of the Z-pinch's wire array, the X-pinch is formed by passing about 100,000 amperes of current through two or more thin wires that cross at a single point. Just as in a Z-pinch, the wires vaporize and form a plasma that emits X-rays. But the radiation is concentrated at one tiny spot, making the machine an excellent point source of X-rays.

Hammer's original interest in the X-pinch was as an X-ray source for lithography in microelectronics manufacturing. "We demonstrated that you could get adequate power out of it to be able to run a production line, but industry did not decide to go that direction," he says. The X-pinch showed a great deal of promise, but chip manufacturers stuck with optical methods that were already familiar to them.

The X-pinch also has shown promise as a "camera" for producing extremely high-resolution radiographs of very small objects. At a 2001 meeting of the American Physical Society, the Cornell team received a good deal of attention for showing off images of house flies and beetles with micrometer-scale detail. And because the X-pinch produces relatively low total energy in the radiation bursts, it could be useful for imaging of biological tissue: the radiation is benign enough to image even live objects, such as ants. The X-ray pulse happens so quickly—in less than a nanosecond—that it produces stop-action radiographs of extremely fast-changing events, like exploding wires.

Hammer is happy to highlight some of these X-pinch experiments because they excite people and help attract more students. "Not very many people are interested in the fundamental instabilities of exploding wires, so when opportunity knocks, we try not to ignore our bug-imaging capability," he says. "But ultimately, no matter what the immediate goal of an experiment is, off in the distance there is the idea that we could contribute to producing energy from the fusion process."

By Stephanie Bergeron

It took 14 applications to get into the astronaut program, and that was only one of his careers.

Persistence Pays

Dan Barry loves a challenge.

By Stephanie Bergeron

You can call him an M.D., a scientist, or a shoemaker. He's an engineer, an entrepreneur, a father, and a husband. He received five degrees between 1975 and 1982. He has worked as a physician in rehabilitative medicine and has patented five products including a prosthetic arm, a running shoe, and his most recent invention: robots that assist people with disabilities. He's even been a contestant on the CBS television show, *Survivor*.

But for Dan Barry '75 EE, who has circled the earth 481 times, his most hard-won title is astronaut. "It was what I wanted to do my whole life — fly in space," he says.

Barry, 52, spent most of his childhood in Alexandria, La. After taking an engineering aptitude test in high school, he received a postcard from Cornell.

The offer of a McMullen scholarship and the reputation of the Ivy-League school were enough to lure Barry north. "I didn't know very much about Cornell," he says. "I'd never seen it until the first day I showed up as a freshman. For a kid from a small town in the Deep South, it's a big transition, but I really liked it," he says. "I don't know that there was anything I didn't like about Cornell."

His undergraduate work in electrical engineering included a bioengineering project on learning in invertebrates and a Mars rover project in autonomous obstacle detection. Barry was also a member of Theta Chi, a fraternity on Stewart Avenue (currently inactive at Cornell).

As a senior, Barry wrote to Edward Gibson, a Theta Chi brother and Skylab astronaut, for advice on how to get into the space program. Gibson wrote back with what Barry called the best advice he has ever heard. He told Barry to follow his heart.

"Gibson said to do what you really like to do and then you'll be good at it," Barry says. As for preparation for the space program, Barry recalls that Gibson said, "Whatever you want to do, as long as it has a science bent to it, is going to be relevant to space flight."

So with Gibson's advice in mind, Barry enrolled in graduate school in electrical engineering at Princeton University. In 1977, he began work with assistant professor Sol Gruner, who is now a professor of physics at Cornell.

At the time, Gruner was working on the structure of the photo protein inside the rod cells of eyes. But in order to study eyes, Gruner needed samples. He and Barry headed to a slaughterhouse where they worked in the "disassembly line" clipping eyeballs from cow carcasses.

"It turns out that after a while he got quite good at it," says Gruner. Barry's research with Gruner formed the basis of his Ph.D. thesis.

"Dan was a wonderful student to work with for many reasons," says Gruner. "He really is very bright and he was willing to try all kinds of things"

While a student at Princeton, Barry first applied to and was rejected from NASA's astronaut program. Determined to fulfill his dream, he applied again and again over the years—while he continued his work as a grad student at Princeton, as a medical student at the University of Miami, as an intern and resident at the University of Michigan, and even as an assistant professor at Michigan. Fourteen times in all.

"If you have ever received the 'thin' envelope, I can relate to how you felt. I was the king of 'thin' envelopes," he said in a commencement address to Beloit College, where he received an honorary degree in 2003.

But persistence paid off and he was accepted into NASA's fourteenth class of astronaut candidates for the space shuttle program in 1992, the same year he was granted tenure at Michigan. Since then, Barry has flown on three space shuttle missions as a mission specialist. For his first flight on *Endeavour* in 1996, he retrieved the Space Flyer Unit launched from Japan 10 months earlier and deployed and retrieved a Spartan satellite. On a 1999 shuttle *Discovery* flight, Barry transferred supplies to the International Space Station. In 2001, on another *Discovery* flight, Barry's mission delivered the Expedition-3 crew to the station. In all, he's logged over 734 hours in space and performed four spacewalks. Barry is listed as one of the top ten people in the world for career spacewalk length after completing 24 hours and 49 minutes of spacewalking. In April 2005, Barry retired from NASA to start his own company, Denbar Robotics.

> "I thought that it might be fun to go try something without any support where in fact the people around you are your adversaries."

Following his first flight, Barry's adopted hometown of South Hadley, Mass., held "Dan Barry Day,"as a celebration of his work in space. The event included a community parade, slide presentations, and autograph sessions. Hundreds of residents and local college students attended the event.

These days Barry has another claim to fame: he was chosen as a contestant on *Survivor: Panama*. While living on a deserted beach with little more than a machete, he went several days without food and competed in physically and mentally demanding challenges. But for Barry, *Survivor* was just another crazy adventure.

"You go fly in space and you have all this support, thousands of people making sure you have what you need to be successful," he says. "I thought that it might be fun to go try something without any support where in fact the people around you are your adversaries."

Barry, the second oldest of the season's castaways, appealed to audiences as a father figure. "I was sort of the kindly old man character," he says. "That's not exactly who I was out there, but I'm certainly happy with the portrayal of someone who has integrity and is willing to stick to his word."

Barry says that even before the show, he understood that certain parts of his personality would be emphasized.

"These shows are sort of 'reality' in little letters and 'TV' in big letters," he says. "In order to get an audience that wants to watch the show week to week they have to build characters."

He was voted out of the game on day sixteen after losing a challenge involving a puzzle that he and his teammate could not complete before the other team.

Barry returned home from Panama to continue work on his current project. His company, Denbar Robotics, is designing robots to help people with disabilities.

Barry, who was a physician in rehabilitative medicine, became interested in assistive technologies in med school at the University of Miami. In one class, a woman with severe rheumatoid arthritis spoke about a button-hook device that could help her get dressed and get in and out of her car.

"Ten dollars worth of stuff made the difference between this woman's ability to live independently versus having to live in an assisted living situation," he says. "I thought that it was really neat that you could take small pieces of technology and have a really big influence on people's independence."

During his residency in Michigan, Barry researched the sounds that muscles make when they move. His curiosity led to the patent of a prosthetic arm that uses small microphones to trigger movement. He developed the first model using inexpensive microphones from a local electronics store. He later tested it on his patients at the University of Michigan.

"He had no hesitation to get in there and try experiments," says Gruner of Barry's many unique ideas. "He's bright, he's fearless; he loves to try new things."

Gruner was able to try out one of these new things when he found a gift from Barry — a pair of running shoes — in his mailbox. Barry found that one way to enable people to run faster is to use an anisotropic material in the sole of the shoe, so that energy can be stored in the heel and transferred to the arch of the foot when a runner pushes off of the ground.

His first design was a graphite-like material that was too stiff for comfortable walking, but excellent for runners. Shoe companies didn't accept the idea, saying that when people try on shoes in a store, they test them by walking, not running. No one would buy a shoe that was uncomfortable to walk in. Barry didn't give up. He developed a new model using a fluid-based design for cushioning and a less stiff graphite component. The cushioning result was the Brooks Hydroflow.

"They were great shoes. I used them for years," says Gruner.

But despite inventing shoes and arms, floating weightlessly in a spaceship above the Earth, and eating snails in the jungles of Panama, Barry's greatest moments are simple ones: "It's when my kids were born, no question about it," he says.

Barry's children, Jennifer, 20, and Andrew, 18, spent a lot of time away from their father while he was training at the Johnson Space Center in Texas and they were living in Massachusetts with his wife, Sue, a professor of biology at Mount Holyoke College. Still, Barry flew home most weekends for 12 years and, weeknights, he read books to his children over the phone.

"I think we stayed connected as a family really well despite the fact that we worked 1,500 miles apart," he says.

The family also made it a habit not to work on weekends. Instead, they had family Warcraft games and challenged neighboring families to ultimate Frisbee games in the snow. At children's birthday celebrations, Jennifer says that her father was always the life of the party.

"He would play all the games with us and you could tell he wasn't just humoring us — he actually still enjoyed hide-and-go-seek and he wasn't ashamed to admit it," she says.

Jennifer says that she appreciated the time her dad took for nightly reading and weekend fun.

"That has always been very special to me, that he would take that time out of his day, his job, his life, to sit at the phone with a book and read to his children," she says.

She also credits her father for her love of math and physics. Jennifer first became interested in math on a long car ride one summer. A rowdy game with her brother had escalated into shouts. When her father addressed the problem, however, he didn't ask for quiet. Instead, he posed a problem: "x plus y equals 7 and x minus y equals 1. Do you know what x and y are?"

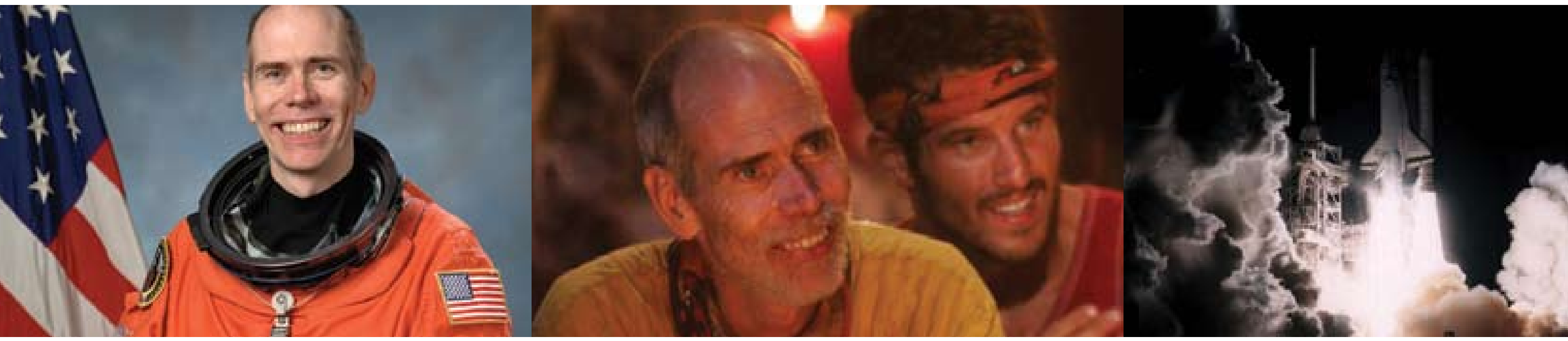
Jennifer, who was nine at the time, thought quietly before responding. "When my father pronounced me correct, I instantly demanded another problem." she says. "This went on during every long car ride—and some short ones—for years until the problems I wanted became too difficult for my father to think up and solve while driving."

Jennifer's interest in problem solving led her father to teach her algebra and calculus at a very young age. She is now a physics major and a math minor at Swarthmore College.

"Whenever anybody asks me why I decided on math or physics, my mind flashes back to a car ride long ago," she says. "My father loves to learn and he has worked hard to pass this love on to my brother and me. I don't know of any lesson more important."

And for Barry, a life of learning has certainly paid off.

"I'm very lucky," he says. "I have no regrets."



Images provided by Dan Barry

A focus on renewable fuels could bring energy independence, spur economic development, and improve environmental quality.

gr

owing
a bio-based future

By Jay Wrolstad

In an unassuming lab tucked behind Riley-Robb Hall sits a round bale of cut grass. It looks just like hay harvested from the fields surrounding Ithaca, but this grass wasn't grown to feed livestock; it was grown to feed the global economy's insatiable appetite for energy.

This is switchgrass. With roughly the same energy content as wood, it has great potential as a source of sustainable fuel. Professor Larry P. Walker is conducting experiments on this and other common perennial grasses to perfect a process in which certain enzymes convert carbohydrates like cellulose into sugars that can be transformed into ethanol fuel.

Switchgrass can also be converted to industrial chemicals such as surfactants, organic acids, and biopolymers. It's a favorite of President George W. Bush, who touted the tall plant in a State of the Union address as an alternative fuel source. And it is just one of the "biomass" materials being tested by Walker and others at Cornell.

Biomass is any organic material containing carbon, nitrogen, and oxygen. That includes most plant life, organic waste, and solid waste. "Looking ahead, we need these resources in place to support sustainable human development," says Walker.

Walker is among those leading a broad-based charge to change the way we think about and produce the power needed to light and heat our homes, and run our cars. "Biomass is the only direct replacement liquid fuel that is imminent," says Walker, a professor of biological and environmental engineering. "It will play a large role in shaping our future, with agriculture becoming a major supplier of energy and industrial chemicals."

Walker initially delved into the fundamental processes of creating energy from biomass during the oil embargo-induced shortages of the 1970s, but when the long lines at the pumps dwindled, so did funding for renewable energy research. Today, however, increasingly fierce global competition for energy, alarm over global warming, and concern for agricultural communities have combined to rekindle interest in biomass.

Making biomass commercially feasible, Walker contends, requires new tools and methods to process organic material more efficiently, and on a massive scale. The corn-to-ethanol conversion process has been the most successful effort to date, he notes, but corn may not be the best option. It requires major inputs of water for irrigation, and of fertilizers and pesticides, which, ironically, are derived from oil. The focus on corn diverts attention from other potential energy crops that are more sustainable in different ecosystems across the country. Also, farmers worry that using corn for ethanol production may cause feed shortages and higher costs.

In 2002, the Biomass Research and Development Technical Advisory Committee, a panel established by Congress to guide the future direction of federally funded biomass R&D, proposed replacing 30 percent of the petroleum currently used by the United States with biofuels by 2030. That vision includes a 20 percent replacement of transportation fuels, which translates to 60 to 65 billion gallons of ethanol each year. Reaching that 30 percent target will require more than one billion dry tons of biomass annually.

To help meet those ambitious goals, Walker hopes to use a process similar to making moonshine.

"One approach is to use molecular biology to engineer microorganisms that can achieve both cellulose hydrolysis and fermentation of the six- and five-carbon sugars that are derived from plant carbohydrates. Another approach is to do what nature tends to do and use a mixture of 'bugs' to process the sugars—and this is an alternative paradigm that biofuels researchers need to develop," Walker says.

"This research is long overdue; we have been dependent on petroleum for too long."

In the Riley-Robb labs, researchers are developing enzymatic and microbial processes to speed the sugar-to-ethanol conversion. They are isolating bacteria from compost reactors and using DNA analysis and high throughput screening to identify those that show the most promise as biocatalysts.

Before the fermentable sugars in perennial grasses can be converted to ethanol, they must first be extracted. A key component of this step is chemical and physical pretreatment, which involves size reduction of the biomass and subsequent treatment using acids or alkalis at various concentrations, temperatures, and pressures. Professor James Gossett, director of the School of Civil and Environmental Engineering, and his graduate student Deborah Sills are investigating this piece of the cellulosic ethanol system.

Another biomass material being studied at Cornell is organic waste. Again using enzymes, scientists can produce hydrogen, biogas, and organic acids from such material. Norman Scott, professor of biological and environmental engineering, explains: "Our work complements that being done by Professor Walker by studying the anaerobic digestion of waste, such as food scraps and animal manure, to create biogas."

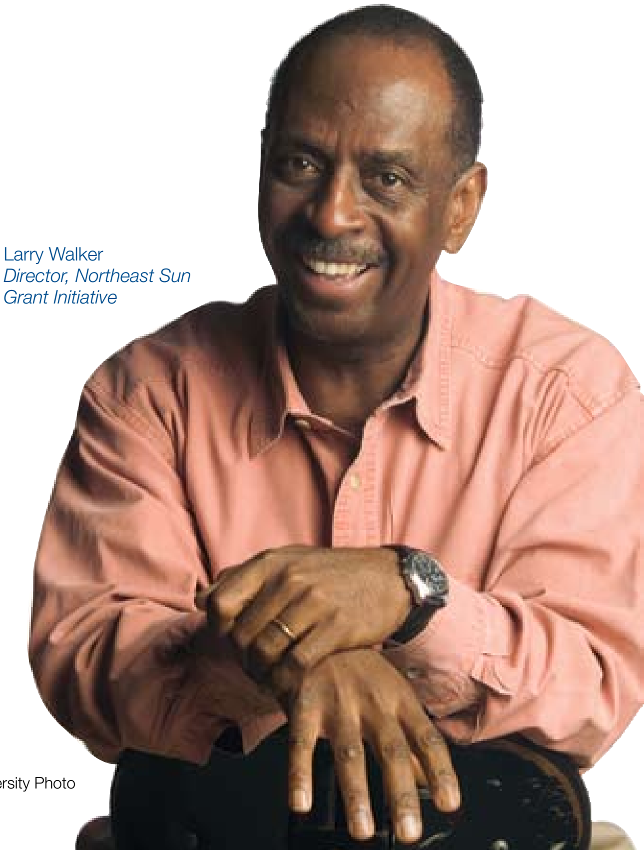
Scott envisions community-based biogas plants relying on a steady supply of manure from farms and other organic wastes from the community. "With the participation of five to 10 farms, and their 20,000 cows, we could convert enough gas to significantly supplement the public natural gas supply," Scott says.

Before such biorefineries are built to process organic waste on a large scale, there are issues to clarify, such as how the waste will be transported to the refinery, whether the farmer or the fuel producer owns the raw product, and how carbon and emission credits might be awarded. The decisions made on these points will help to identify incentives for farmers to participate in a sustainable energy strategy.

Ruth Richardson, an assistant professor of civil and environmental engineering who is collaborating with Scott in harnessing energy from dairy waste, is confident that microbial fuel cells can be developed using bacteria to process the material and turn it into electricity. "Using a diversity of processes will help optimize the amount of energy obtained from biomass material, and that will involve working with soil experts, farmers, and the agriculture industry," she says.

Other microbes feed on organic matter and produce hydrogen. "To make biological hydrogen production economically feasible, we have to increase the yield of hydrogen from feedstocks, such as agricultural and food production wastes," says Sarah Munro, a graduate student in Walker's lab whose objective is to alter bacterial metabolic activity to increase hydrogen yields.

"We are approaching a point where industrial plants or public facilities could be powered by fuel cells utilizing hydrogen generated from these systems," Munro says.



Larry Walker
Director, Northeast Sun Grant Initiative

University Photo

"And these fermentations can also produce other useful co-products such as polymers for bioplastics."

Colleen McGrath, meanwhile, is manipulating bacteria that can hydrolyze plant cell walls and create the sugars to be fermented into liquid fuel. She's looking for specific enzymes that can quickly process biomass and can produce the most sugars.

"This research is long overdue; we have been dependent on petroleum for too long," says McGrath, a graduate student in the Department of Molecular Biology and Genetics. "We can do a better job of producing energy by using biomass resources and cleaner production techniques for making fuel. But it requires government investment in research."

The good news is that our elected officials have responded by funding the establishment of regional hubs for research collaboration under the federal Sun Grant Initiative. Cornell is one of five centers of excellence set up across the United States through the initiative, with the charge to leverage agriculture resources as a supply of both energy and industrial chemicals.

As the lead university for the Northeast Sun Grant Institute of Excellence, Cornell received a four-year, $6-million grant from the U.S. Department of Transportation, with the money spread among research projects from Maine to Michigan.

"We need a regional response to the opportunities biomass presents," says Walker, director of the Northeast Sun Grant Institute of Excellence. "Land grant institutions like Cornell have always played a role in addressing rural development challenges, and we are set up with strong life sciences, agricultural, and engineering capacities. For biofuels to take off, you need a strong linkage between those sectors."

Each center controls 25 percent of its funding, Walker explains, while the rest pays for competitive grants that support renewable energy projects. At Cornell, the grants program launched this fall was designed by a steering committee comprising agriculture experiment stations directors, extension directors, and stakeholders like farmers and non-profit groups.

"We are bringing other land grants in our region to the table to think strategically about developing biofuel," Walker says. He plans to devote most of his attention to agriculture and industrial biotechnology, two areas of strength at Cornell, with engineers who understand the industrial ecology concept.

Engineers are designing bioreactors to process organic material and developing new ways to pre-treat it. Nanobiotechnology can help scientists understand basic biological processes, manipulate them more efficiently, and create new microorganisms. The biological sciences play a significant role as well, with protein engineering research. The challenge is to orchestrate these capabilities into an integrated approach to developing sustainable bio-based industries.

"This is a systems integration project," says Walker. "At Cornell we have all of these components in place."

Harold Craighead agrees. "Engineers can create new biological process monitoring devices and new chemical analytical capabilities, such as labs-on-chips, that will make biological material processing, including the production of fuels, more efficient and practical," says Craighead, professor of applied and engineering physics and director of the Nanobiotechnology Center. "Professor Walker is one of the global leaders in adapting advanced technology, including nanobiotechnology, for increasing the efficiency of deriving fuels from biomass sources."

The interdisciplinary collaboration that has marked Walker's career is essential to the Sun Grant effort. For example, bringing plant breeders to the table is critical, Walker says, in creating sustainable crops. "How much perennial grass can we produce with the best yields and sustainable practices on farms in this part of the country?" he asks. "We need to change our mindset about agriculture. For most farmers it's, 'Tell me what to produce and I'll produce it,' but there are crop storage and handling issues associated with processing biomass. Also, any ethanol producer will want assurances of long-term availability and cost-competitive pricing for biomass feedstocks. Thus, a strategic partnership must evolve between feedstock and ethanol producers."

Any comprehensive energy strategy must also include discussion of erecting massive biorefineries that pull in material from a large region in a centralized production system, or building multiple, smaller plants that serve local communities.

"We can't leave it up to private industry," says Walker, describing an effort along the lines of the Manhattan Project, in which the public and private sectors collaborated on nuclear research. "We can exploit the multidisciplinary research being done at Cornell and establish partnerships with state and local governments and businesses."

He cites New York State's $25-million biorefinery pilot-plant initiative. A consortium of private businesses and researchers, including Walker, was recently selected to build one of two plants and it will be a proving ground for technology developed at Cornell. Further state involvement can be seen in a facility for students evaluating industrial biotechnology systems, and the investment of $750,000 that the New York State Office of Science, Technology and Academic Research made in Walker's biofuels/industrial biotechnology research program. Industry is taking notice, too, with oil giant British Petroleum earmarking $500 million for biomass energy centers. "Companies like BP and Chevron realize that we must diversify our energy system," Walker says.

"The pleasure for me is that we can do exciting research through the Sun Grant Initiative and apply what we learn," he adds. "We can play a leadership role in national and international research. We are training a new generation of scientists that will take sustainable energy to the next level."

ENGINEERING PERFECTION

Crew Chief Chad Walter couldn't get racing out of his system.

Walter and his Hendrick Motorsports crew of 35 are responsible for the No. 5 Lowe's Chevrolet. At their best, custom-designed stock cars are engineering "masterpieces," he says.

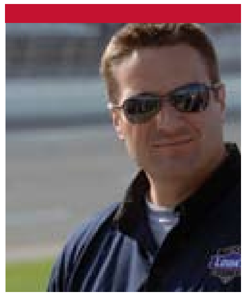
Hendrick Motorsports photos

Chad Walter has made it to victory lane twice in the Daytona 500—the "Super Bowl" of NASCAR—not behind the wheel of a winning stock car but on the team that engineered it.

"I've always been on the safe side of the pit lane," he says. Now a crew chief at Hendrick Motorsports, Walter has been in the business of building fast stock cars since he graduated from Cornell in mechanical engineering in 1993. The cars can reach top speeds of 200 miles an hour.

In August Walter spoke about his life and career during a break at Watkins Glen International, a raceway 25 miles west of Ithaca, where he was readying his team's car for a NASCAR Busch series 82-lap, 200-mile race the following day.

The race's location feels like home territory to Walter because it is only two hours southeast of Albion, N.Y., the town of 5,000 where he grew up. The Glen is one of two remaining road courses in the NASCAR circuit, and Walter saw his first race there as a high schooler in the late 1980s when an uncle who raced cars took him.



Chad Walter '93, crew chief for NASCAR Busch series Chevrolets with Hendrick Motorsports, cemented his love of fast cars when he helped design Formula SAE winning race cars as an engineering student.

"I was awestruck by the cars and how they went up different parts of the track," says Walter. The speed and noise thrilled him then, and still do.

When Walter joined the Society of Automotive Engineers race car design team at Cornell, the team won the national competition twice, helping cement his love of racing. About the rest of his Cornell experience, Walter says, "I loved every minute." A math and science whiz, he switched from landscape architecture to engineering and played defensive end on the Big Red football team, helping to win an Ivy League championship in 1990.

After graduation, he headed to stock car country—North Carolina. The plan: "To get it out of my system, then go to graduate school." Instead he stayed, learned how to build the cars by doing, and rose through the ranks to his current position.

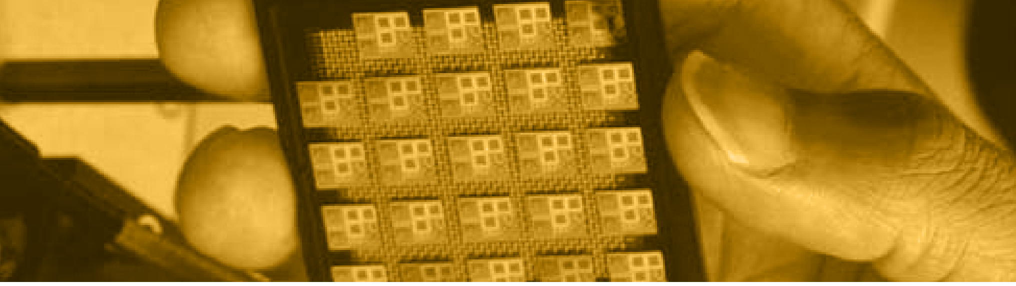
"There's nothing stock about a stock car today," comments Walter. "Most people don't realize how much there is in getting these cars to do what they do."

Indeed, his team's car—a bright blue and yellow Chevrolet with the number "5" and "Lowe's" emblazoned on it—bears little resemblance to a standard Chevy. The enormous tires are virtually without tread to increase speed. "They're like gumballs—they lay a lot of rubber on the track," says Walter. And the 800-horse-power engine is modified from race to race to improve the car's performance on different tracks. Walter calls the final product "a masterpiece, like a Mona Lisa or a fighter jet. If everything works out right, it's engineering perfection."

On the day of the Watkins Glen race, the sun shone in a cloudless sky. Walter remained in constant radio contact with his driver, Kyle Busch, alert to any change. The bad news came on lap 28, when the car inexplicably tried to roll over at every turn. After several pit stops and a replaced part, the problem was fixed, but Busch only regained one of the four laps lost, despite besting the speed of the winning driver, and the car finished 37th.

Walter took the results in stride, however, pointing out that his crew worked with speed and efficiency and the driver accomplished what is most important in terms of season ending point standings: "Finishing the race."

—Linda Myers; first published by the Cornell Chronicle



BEYOND THE MOLE PLOW

Nanotech devices for biology research, a new way to pasteurize milk, improvements in cellular phone systems, and new strawberry varieties were among the 41 patents issued to 32 Cornell inventors during fiscal year 2005–06. They were honored Oct. 24 in a recognition ceremony presented by the Cornell Center for Technology, Enterprise and Commercialization in Statler Ballroom B.

"Cornell has a long history of its faculty and staff inventing and receiving patents," said Richard Cahoon, acting executive director of the center. "Since Ezra Cornell received U.S. Patent No. 3456 on his 'mole plow' for laying telegraph cable, Cornell inventors have received hundreds of patents in many different technical fields. CCTEC is currently working with inventors at Cornell on the transfer of patented inventions to the commercial sector through licensing, so inventors and Cornell will realize the transformation of their research advancements to market innovations for the public good."

In the five years ending with 2004, CCTEC and its predecessor, the Cornell Research Foundation, received 990 invention submissions from Cornell researchers, secured 912 U.S. patents, completed 373 license agreements, and launched 36 startups. Between 1990 and 2004, net income from patent licensing was $26.2 million.

Among the inventors recognized, members of the engineering community include:

• Gregory T. Baxter, biomedical engineering; and Sandip Tiwari, electrical and computer engineering: Electronic Gain Cell Based Charge Sensor.

• Geoffrey W. Coates, chemistry and chemical biology; and Lewis Fetters, chemical and biomolecular engineering: Functionalized Poly(ethylene-co-syndiotactic propylene).

• Harold G. Craighead, applied and engineering physics; Jonas Korlach, biochemistry, molecular and cell biology; Mathieu F. Foquet, applied and engineering physics; Michael Levene, applied and engineering physics; Stephen W. Turner, applied and engineering physics; and Watt W. Webb, applied and engineering physics: Method for Sequencing Nucleic Acid Molecules.

Jason Koski/University Photography

• Harold G. Craighead, applied and engineering physics; Jonas Korlach, biochemistry, molecular and cell biology; Michael Levene, applied and engineering physics; Watt W. Webb, applied and engineering physic; and Stephen W. Turner, applied and engineering physics: Zero-Mode Clad Waveguides for Performing Spectroscopy with Confined Effective Observation Volumes.

• Zygmunt J. Haas, electrical and computer engineering: Methods and Systems for Concurrent Paging of Mobile Users in Cellular Networks and Independent-Tree AdHoc Multicast Routing.

• Edwin C. Kan, electrical and computer engineering: Chemoreceptive Semiconductor Structure.

• Brent M. Ledvina, mechanical and aerospace engineering; Mark L. Psiaki, mechanical and aerospace engineering; Paul M. Kintner, electrical and computer engineering; and Steven P. Powell, electrical and computer engineering: Real-Time Software Receiver.

• Dan Luo, biological and environmental engineering: Controlled Nucleic Acid Delivery System.

• Michael L. Shuler, biomedical engineering: Self-Priming Micropump.

• Sandip Tiwari, electrical and computer engineering: Scalable Nano-transistor and Memory Using Back-side Trapping.

—Bill Steele, Cornell Chronicle Publications

Jon Reis Photo

FUCHS REAPPOINTED

Cornell Provost Biddy Martin has announced the reappointment of W. Kent Fuchs as the Joseph Silbert Dean of the College of Engineering for a second five-year term. Approved by the Cornell Board of Trustees, the appointment is effective July 1, 2007.

"I am delighted that Kent has agreed to continue as dean of the College of Engineering," said Martin. "He is a spectacular administrator and has made significant contributions to the quality and vitality of the college."

During Fuchs's term as dean, the College of Engineering initiated a collaborative strategic planning process to place the college in a position of national leadership. Several components of the college's strategic plan have already been implemented, including the formation of a new Department of Biomedical Engineering. Other components are currently in progress and will be completed this year. Fuchs's priorities for his second term include a focus on the strategic research areas defined in the college's plan and enhancing the college's faculty and student diversity.

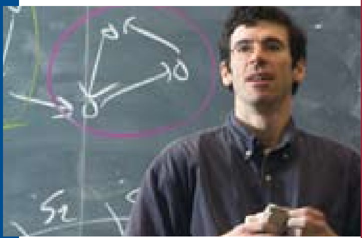
—By Susan Lang, Cornell Chronicle Publications

C·ENG.PEOPLE

FALL 2006

THE KING AND I

University Photography



Jon Kleinberg

Jon Kleinberg, Cornell professor of computer science, received the 2006 Rolf Nevanlinna Prize at the International Congress of Mathematicians in Madrid, Spain, for his "deep, creative, and insightful contributions to the mathematical theory of the global information environment."

The prize has been awarded every four years since 1982 by the International Mathematics Union, in recognition of the most notable advances made in mathematics in the "information society"—that is, the modern world as influenced by information technology. It is considered to be a computer-science oriented parallel to the prestigious Fields Medal, regarded as the equivalent of a Nobel Prize in mathematics.

The prize, a gold medal, was presented by King Juan Carlos of Spain at the opening session of the conference. On Aug. 25 Kleinberg presented a lecture associated with the award.

In 1996, Kleinberg introduced the idea of "authorities" and "hubs" on the Internet and devised algorithms to analyze their links to one another, which have greatly influenced how today's search engines operate. He has made major contributions to the theory of small-world networks (the origin of the term "six degrees of separation") that have applications in fields ranging from sociology to the design of peer-to-peer file-sharing networks. He developed a mathematical model to recognize "bursts" in data streams, showing what topics are receiving attention at a given time in a large collection of data, from national news to personal e-mail.

Kleinberg received his bachelor's degree from Cornell in 1993 and an S.M. degree (1994) and Ph.D. (1996) from the Massachusetts Institute of Technology. Among his distinctions are a Sloan Foundation fellowship, a Packard Foundation fellowship, and the Initiatives in Research Award of the U.S. National Academy of Sciences. In 2005, Kleinberg received a MacArthur "genius" fellowship from the John D. and Catherine T. MacArthur Foundation.

—Bill Steele, Cornell Chronicle Publications

FROM THE BEGINNING

Photo by Steve Gallow

Bryan Isacks (left) talks with his former grad student Tom Cahill at the October symposium.

The story, says Cornell geologist Bryan Isacks, is usually pretty much the same. People study geology because they have a certain set of characteristics: They love physics and the outdoors; they're adventurous and curious.

It was his story, too. But colleagues are quick to point out that his career has been exceptional from the beginning.

Isacks, Cornell's William and Katherine Snee Professor of Geological Sciences, was honored at an Oct. 8–10 symposium, "Subduction, Orogeny and the Surface of the Earth." The event, organized by Cornell's Department of Earth and Atmospheric Sciences and the Institute for the Study of the Continents, celebrated Isacks' recent 70th birthday and marked the beginning of his phased retirement (he will retire fully in 2008).

The symposium included presentations by a host of Cornell alumni, including Isacks' former and present graduate students and other leading earth scientists. A banquet Oct. 9 featured appreciations from colleagues, among them Frank H.T. Rhodes, president emeritus of Cornell and professor of geology.

Isacks began his career as a seismologist in the 1960s, when he contributed fundamental research on plate tectonics in the islands of the southwest Pacific. A pivotal 1968 paper co-authored by Isacks, Cornell Professor Emeritus Jack Oliver, and Lynn Sykes of the Lamont-Doherty Earth Observatory was a major advance in better understanding of the process of subduction.

When he joined the Cornell faculty in 1971, Isacks began studying geomorphology in the central Andes, initiating a Cornell presence in Argentina that has grown into the largest U.S. academic group working in South America. He is currently a leader in using remote sensing techniques to study how atmospheric conditions alter the Earth's surface in mountain chains.

Isacks chaired Cornell's geology department from 1994 to 2003 and was a major force in Cornell's merging of its earth and atmospheric sciences departments and in developing the undergraduate Earth systems major.

—Lauren Gold, Cornell Chronicle Publications

MAJOR IMPACT

University Photography

Éva Tardos

Éva Tardos, professor and chair of the Department of Computer Science, has received the George B. Dantzig Prize, awarded jointly by the Mathematical Programming Society and the Society for Industrial and Applied Mathematics.

Established in 1979, the Dantzig Prize is awarded for "original research, which by its originality, breadth, and scope is having a major impact on the field of mathematical programming." The prize, consisting of a certificate and a cash award that varies from year to year, was presented in July at the Society for Industrial and Applied Mathematics Annual Meeting in Boston.

Tardos's research focuses on "optimization," in which a computer is asked to find the most efficient way to organize a large number of elements. Examples range from airline scheduling to the management of communication networks. The computer must try every possible combination to find which is best, and sometimes this can add up to days, months, or years of processing. Tardos has developed approaches that approximate ideal solutions and prevent the computer from becoming lost in unsolvable problems.

Tardos joined the Cornell faculty in 1989. She is currently a member of the American Academy of Arts and Sciences and a fellow of the Association for Computing Machinery. She has been a Guggenheim fellow, a Packard fellow, a Sloan fellow, and a National Science Foundation Presidential Young Investigator. She received the Fulkerson Prize in 1988. She is the editor of several journals, including *SIAM Journal on Computing*, *Journal of the ACM*, and *Combinatorica*.

—*Bill Steele, Cornell Chronicle Publications*

LEADING BY EXAMPLE

Lauren Gold/Chronicle Publications

Joe Burns, right, shares a light moment with French astronomer Andre Brahic.

Dozens of astronomers, physicists, and engineers came together for a symposium July 28–29 at Cornell to celebrate the 65th birthday of Joe Burns, the Irving Porter Church Professor of Engineering, a professor of astronomy, and vice provost for research.

The symposium, called "From Dust to Planets," was a look back at 40 years' work in planetary science and celestial mechanics. Burns' colleagues and former graduate students spoke on topics ranging from planetary ring systems and the neuromechanics of swimming in lampreys to the experience of earning a Ph.D. under Burns' demanding but always good-humored guidance.

"It's too infrequent that we get a chance to say thank you publicly for people who have impacted our lives," said former graduate student Bob Kolvoord, now a professor at James Madison University. "And I think for all of his students he has done that. He showed us the importance of trust and high expectations and the virtue of diligence and hard work. He modeled hard work by example."

French astronomer Andre Brahic reflected on his long friendship with Burns in an after-dinner speech in the Statler ballroom. And the colleagues who couldn't attend in person participated with written tributes.

"You have always done everything you do to the highest standards, even when insanely busy," wrote Richard Durisen, an Indiana University astronomer. "Joe, you are one of the shining examples of how to be a superb, creative, and influential scientist and a warm human being at the same time."

But the symposium was a brief pause, not an endpoint, in Burns' career. Currently at work on NASA's Cassini mission studying Saturn's ring system, Burns and colleague Jeffrey Cuzzi wrote a recent article in *Science* summing up the mission's progress so far and its potential for the coming years. The mission is slated to end in 2008, but Burns and others are recommending the mission be extended for up to four more years.

—*Lauren Gold, Cornell Chronicle Publications*

FAMILIAR FACE

University Photography

Harold Craighead (right) in his lab with research specialist Bojan Ilic and graduate student Yanou Yang.

Harold Craighead, the Charles W. Lake Jr. Professor of Engineering and professor of applied and engineering physics, has returned to the post of director of the Cornell Nanobiotechnology Center.

Craighead was the first director when the center was created in January 2000. In June 2001, he was named interim dean of the College of Engineering, and Barbara Baird, professor of chemistry and chemical biology, became director of the center. After W. Kent Fuchs was named dean of the College of Engineering in March 2002, Craighead became co-director of the center.

The Nanobiotechnology Center is a National Science and Technology Center of the National Science Foundation, the only one of its kind in the nation. It uses the tools and processes of nano- and micro-fabrication to build devices that operate on the same scale as biological systems to advance research in molecular and cell biology. As the home of the center, Cornell leads a research consortium that includes Princeton University, Clark Atlanta University, the Wadsworth Center of the New York State Department of Health, Howard University, and Oregon Health Sciences University.

"With the potential for in vivo measurement of nanostructures, nanoscience and technology could provide the methods leading to a revolution in understanding biological systems and new forms of biotechnology," Craighead said in a recent review of the field. "New understanding of life processes at the fundamental subcellular and molecular level will have a profound impact on medicine and on understanding of ecological interactions. There is hope for improved medical diagnosis and treatment and new types of chemical and biological sensors for environmental monitoring and defense."

Craighead joined the Cornell faculty in 1989. His research focuses on improving the techniques of nanofabrication and using nanostructures as tools in biological research. His research group has created devices that can detect and identify single bacteria and viruses, nanoscale gas sensors, and nanofluidic devices that can separate, count and analyze individual DNA molecules.

—Bill Steele, Cornell Chronicle Publications

GOLDEN ANNIVERSARY

University Photography

Arthur Ruoff

The Department of Materials Science and Engineering and students of Arthur Ruoff, the Class of 1912 Professor of Engineering, organized a symposium on Sept. 18 in the Statler Hotel Carrier Grand Ballroom to honor the 50th anniversary of Ruoff's joining the Cornell faculty.

Speakers at the symposium, which was devoted to several aspects of high-pressure physics, included many of Ruoff's former students, now professors and industrial scientists, Cornell Professors Roald Hoffmann and Neil Ashcroft, and Ruoff's son Rodney Ruoff, the John Evans Professor of Nanoengineering at Northwestern University.

Arthur Ruoff has dedicated his career to the study of the effect of very high pressure on materials. In 1990, by squeezing small samples between two diamond anvils, he reached a static pressure of 416 GigaPascals (GPa), becoming the first scientist to create a static pressure greater than at the center of the Earth, 361 GPa. Scientists had theorized that at such a pressure, hydrogen would become a metal and a superconductor, but in 1998 Ruoff disproved the theory, cracking several diamond anvils in the process. He later obtained a pressure of 560 GPa, the highest static pressure obtained to date.

Among other awards, Ruoff received the Bridgman Medal for outstanding high pressure research from the Association Internationale pour l'Avancement de la Recherche et de la Technologie aux Hautes Pressions and the Westinghouse Award for Outstanding Teaching. He received a National Science Foundation Science Teacher Fellowship in 1962. He is the author of two books on materials science and developed an audio-tutorial course on introductory materials science, which has been used at 60 universities.

On July 1, 2006, Ruoff became professor emeritus, but he intends to continue his research. Although he will miss some aspects of teaching, he says it will be nice to have more free time. "It will be great to have the time to travel to more meetings and get new ideas," he says.

—Bill Steele, Cornell Chronicle Publications

NEW NANO TEAM

Charles Harrington Photography

George Malliaras, Cornell associate professor of materials science and engineering, was named the L.B. Knight Director of the Cornell NanoScale Science and Technology Facility, effective Aug. 15. Don Tennant, a 1973 Cornell graduate in engineering physics, now at Lucent Technologies, began as the center's director of operations on the same date.

University Photography

George Malliaras

Don Tennant

The appointments are the result of a more than one-year search in collaboration with researchers who use the national facility, which is largely supported by the National Science Foundation.

"George and Don will bring new energies and new ideas to CNF, a facility that is already thriving," said Joseph Burns, the I.P. Church Professor of Engineering, professor of astronomy, and vice provost for physical sciences and engineering at Cornell, in announcing the appointments.

Malliaras succeeds Sandip Tiwari, professor of electrical and computer engineering, who served as director from 1999 until 2005, when he left to become director of the National Nanotechnology Infrastructure Network, a consortium of 13 nanoscale manufacturing facilities, including the Cornell NanoScale Science and Technology Facility. John Silcox, the David E. Burr Professor of Engineering, has served as interim director since then, with senior research associate Jurriaan Gerretsen as associate director.

"I'm honored and delighted," Malliaras said. "CNF has established a dominance in nanoscience and nanotechnology, and the challenge is going to be to perpetuate that excellence. And I look forward in particular to working with Don Tennant. We have a lot to learn from each other."

Malliaras said he plans to expand the facility's efforts to work with biologists and hopes to bring in the medical community. "There are calls from the medical community, especially from surgeons, for better tools, and I think we can help with that." As part of the celebration of the facility's 30th anniversary in 2007, Malliaras plans a series of major symposiums, one of which will deal with nanotechnology in medicine.

Malliaras' research focuses on organic electronics, the use of organic materials in place of such traditional semiconductors as silicon to create electronic devices, including organic light emitting diodes, organic thin film transistors and organic photovoltaics. He received a B.S. in physics from Aristotle University, Greece, in 1991, and a Ph.D. in mathematics and physical sciences from the University of Groningen, the Netherlands, in 1995.

Before joining the Cornell faculty in 1998, he spent two years at the IBM Almaden Research Center. He is the recipient of the National Science Foundation Young Investigator Award, the DuPont Young Professor Grant, and a Cornell College of Engineering Teaching Award. He is an editor for the Japanese *Journal of Applied Physics* and serves on the editorial board of *Sensors*.

Tennant has been a scientist at Lucent Technologies and affiliated with the Brookhaven National Laboratory. He is one of the nation's most highly respected experts in nanofabrication and electron-beam lithography and has held national policy roles.

The Cornell NanoScale Science and Technology Facility, which is also supported by Cornell, industry, and the New York State Office of Science, Technology and Academic Research, provides facilities for the manufacture and testing of submicroscopic devices for such diverse fields as astronomy, plant pathology, materials science, physics, chemistry, and the life sciences.

—Bill Steele, Cornell Chronicle Publications

GENERIC DNA

Dan Luo, assistant professor of biological and environmental engineering, has garnered a 2006 Faculty Early Career Development Program award from the National Science Foundation.

The five-year, $400,000 grant rewards young teacher-scholars; Luo plans to use most of his grant to fund one graduate and one undergraduate student to work with him on nucleic acid engineering research. The balance will fund materials and supplies as well as travel costs for the students to attend professional conferences.

Luo's research focuses on integrating DNA into biomaterials by using DNA to construct new materials and nanodevices. His work, he explains, deviates from the traditional concept of DNA as a genetic material, and instead uses DNA as a generic building block for the construction of biomaterials with biomedical and biotechnical applications.

In addition, a company that Luo co-founded, DNANO Systems, has won a prize for its life sciences-related business plan. The company, which commercializes Luo's research, was the second-place finisher in the Purdue University Life Sciences Business Plan Competition. The prize carries a $20,000 cash award for the company, plus $8,000 for in-kind legal and business services.

—Anne Ju, Cornell Chronicle Publications

HOMETOWN HERO

Sophomore Nathan Ford keeps his eyes on the prize as he juggles classes and coursework along with practices and games for two varsity sports.

GOAL TO GO

The quarterback takes the snap from center and drops back to survey the field, dodging an onrushing lineman and, while running to his right, rifling a pass downfield to an open receiver. It's another first down for the Big Red football team and signal-caller Nathan Ford of Palo Alto, Calif., a skilled and versatile athlete who somehow finds time to meet the demands of pursuing an engineering degree while playing two varsity sports.

Last spring the 6-foot-1, 200-pound Ford was handed the starting quarterback's job by Cornell coaches and he's stepped into that role with confidence and poise. "He's a great leader, and an intelligent young man who works hard," head football coach Jim Knowles says. "It's unusual to put a sophomore at such a critical position, but he's handled the pressure very well."

As a dual-threat quarterback who can beat teams with his legs as well as his arm, Ford is a gifted athlete who presents a problem for the opposition that must guard against either option, Knowles says.

Indeed, five games into the 2006 football season Ford was among the Ivy League's total offense leaders with more than 900 yards passing, 200 rushing, and seven touchdowns. After engineering a 38-14 homecoming romp over regional rival Colgate in early October, Ford earned league offensive player of the week accolades.

At season's end, he won't have much time off to catch up on his studies before putting on a baseball uniform and taking the field as a catcher/infielder for the Big Red. He recorded a respectable .290 batting average as a freshman despite getting a late start due to a lingering leg injury suffered during the football campaign.

Ford acknowledges that juggling classes, coursework, team practices, training, and games is a challenge. "Time management is key. I use any free time to stay ahead with my school work, and I've learned not to procrastinate," he says. It's all part of staying on track to graduate with a degree that leads to a career in industrial engineering.

With a mother, father and sister who all graduated from Notre Dame, it's a wonder Ford isn't suiting up for the Fighting Irish. "I looked at Notre Dame, but they saw me as a walk-on candidate and would not guarantee a spot on their teams," he says. "And unlike Cornell, they would not let me play both football and baseball."

When asked to pick which sport he favors, Ford equivocates, saying both football and baseball provide opportunities to use his athletic abilities and establish strong relationships on close-knit teams.

By all accounts, Ford has handled this double duty with aplomb. Baseball coach Tom Ford (no relation) notes that two-sport athletes are more common at Ivy League schools than institutions that grant athletic scholarships with players focusing on a single team.

Still, coach Ford says, "It's very demanding to play two sports, especially football and baseball. Nathan has worked hard to improve his game; he has a quick bat, with some power, and a strong arm. He's a good teammate and is the type of person we want to represent our program."

Knowles echoes that sentiment, describing his quarterback as a player who makes smart decisions under pressure and is a model Cornell athlete. "He takes his academics seriously, and pursues sports with a passion," the coach says.

Ford, in turn, credits his mentors and teammates for his success on the field. "Starting at quarterback as a sophomore is an honor," he says. "The football coaches have done a great job in preparing me to lead the offense, and I have a lot of good athletes around me."

— *Jay Wrolstad*

Photography by Cornell Athletic Communications

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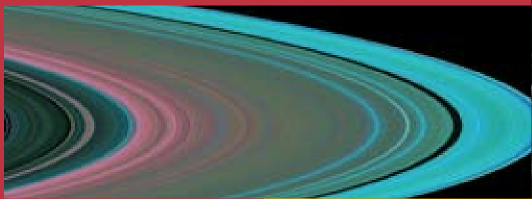


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