

FALL  
11

CORNELL ENGINEERING

MAGAZINE

TRIPPING  
the LIGHT  
FANTASTIC

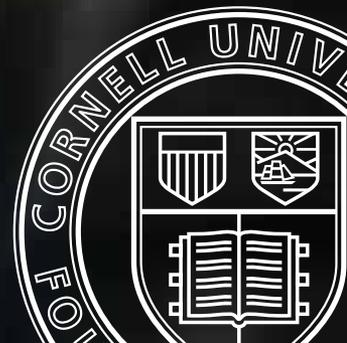
**Michal Lipson**

**pioneers**

**photonics**

**research**

PAGE  
19



# The Cornell Engineering Alumni Association congratulates the 2011 CEEA Award recipients

Tau Beta Pi Professor of the Year

**José Martínez**

Associate Professor

School of Electrical and Computer Engineering

Academic Achievement Award

**Bruce Land**

Senior Lecturer

School of Electrical and Computer Engineering

Undergraduate Research Award

**Kevin Fuhr '12**

For work in fluid dynamics.

Nominated by Professor Charles Williamson

Sibley School of Mechanical and Aerospace Engineering

**Iriny Ekladious '12**

For work on brain cancer

Nominated by Professor Claudia Fischbach-Teschl

Department of Biomedical Engineering

Albert R. George Student Team Award

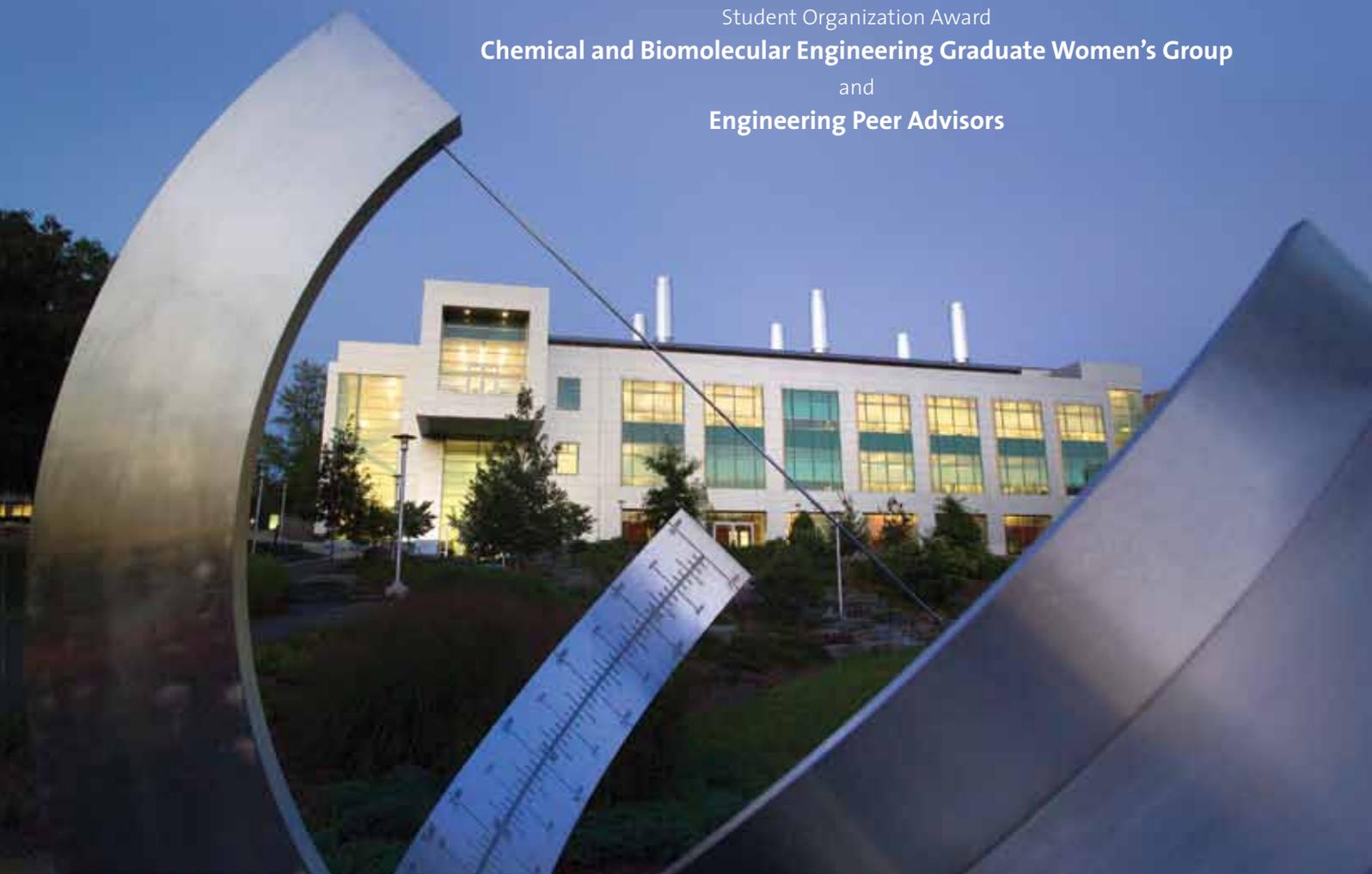
**Violet Satellite Project**

Student Organization Award

**Chemical and Biomolecular Engineering Graduate Women's Group**

and

**Engineering Peer Advisors**



# contents

DEPARTMENTS

CORNELL ENGINEERING MAGAZINE/FALL 2011

2  
NEWS



27  
PEOPLE



31  
HOMETOWN  
HERO  
Casey Garland



## Features



### 19 Tripping the Light Fantastic:

Michal Lipson pioneers photonics research.  
*By Lauren Cahoon*



10

Head in the Cloud:  
Siddharth Anand helps build  
Netflix's video infrastructure  
in the cloud.  
*By Michael Gillis*



14

Better Together:  
Graphic interface meshes  
engineering with architecture  
for greener buildings.  
*By Sharon Tregaskis*



23

¡Hola! from Santander:  
Cornell Engineering and  
Universidad de Cantabria create  
model exchange program.  
*By Sherrie Negrea*

## GROWING THE 'TECHNOLOGY ECOSYSTEM' OF THE FUTURE IN NEW YORK CITY

NEW YORK — On July 19, Cornell announced it would respond to a request for proposals from New York City Mayor Michael Bloomberg for an applied sciences and technology campus in the city. Proposals are due to the city Oct. 28, and the city will award the contract in late December. Kent Fuchs, provost of Cornell; Lance Collins, dean of the College of Engineering; and Daniel Huttenlocher, dean of the Faculty of Computing and Information Science, recently answered questions about why Cornell is the right choice for the project.

**Q:** How committed is Cornell to the New York City tech campus initiative?

**Kent Fuchs:** 100 percent. We already have expertise in key areas for the New York City tech sector, and the city itself is part of our destiny. We have programs and initiatives in the city already, and technology and applied sciences are exactly the areas in which we are committed to growing. The urban environment gives us the ability to create technology transfer, contribute to the state of New York and specifically New York City's economy.

**Q:** Will the proposed New York City tech campus compete with the Ithaca campus in terms of resources, faculty and students?

**Fuchs:** Our goal for this new campus is to have no negative impact at all on the Ithaca campus in terms of funding or competition for programs, and in fact, to enhance the opportunities for those on the Ithaca campus to participate in new programs in the New York City urban environment. We will hire new full-time faculty, and in addition, faculty and students from Ithaca will spend time at the New York City campus either over summers or away on sabbatical.

Our expectation is that the operating budget will be funded through a number of sources including research grants; contracts with the government, companies, and foundations; tuition funds; as well as philanthropy. Additionally, there will be some income from the development on the physical site, as we are proposing that some companies and others lease space relevant to programs there.

**Q:** What types of students will populate the new campus?

**Fuchs:** Given the goal of leading-edge research resulting in new businesses and innovation, the campus will be focused on graduate education. We anticipate attracting 1,000 or more Ph.D. and master's students to earn their degrees on this campus.

We are not proposing to grow Cornell's undergraduate program through this initiative. However, we would expect a significant number of Ithaca undergraduates having summer or semester-long internships there, or being involved in research projects as interns.

**Q:** How will research programs on the new campus be organized?

**Fuchs:** The focus of this initiative from the city's perspective is to create new high-technology jobs by supporting intellectual property and knowledge, resulting in economic development for the city. As a result, we decided not to organize the campus in a traditional way with colleges, schools, and departments, but rather to have this new campus focus on very broad application domains, which we are calling research "hubs," that are relevant to new and existing companies and are applicable to the industries that matter to NYC. We wanted to focus on applications more than fundamental

academic disciplines.

We expect that faculty and students from all kinds of areas can be involved in these hubs, which we also see changing over time. This gives us an agility that a traditional academic environment does not have, while still maintaining academic excellence because the disciplines are tied back to academic homes in Ithaca.

**Q:** What is a 'technology ecosystem,' and how is Cornell going to support one in New York City?

**Dan Huttenlocher:** By this we mean a collection of companies at different stages of development – [from] very early startups tying back to things going on in research labs and universities [to] larger corporations that might be customers or potential acquirers for what those smaller companies are doing. The pace of developing new companies is getting faster and faster, and the key factor is getting the right people into an environment where they can focus on and solve the most relevant technology problems. Cornell alumni already play a leading role in the New York City tech startup ecosystem, and this campus will increase that many fold. We envision an environment that encourages our students to start companies in New York City over any other area of the country.

**Q:** How is Cornell poised academically to lead the New York City tech campus initiative?

**Lance Collins:** We have a top-rated College of Engineering, a top-rated Computing and Information Science program, an outstanding electrical and computer engineering department, expertise in



Provost Kent Fuchs (right) discusses the NYC Tech Campus with David Keating '10, of Cornell Public Affairs, in New York City.

advanced materials, and in nanotechnology, we are one of the premier universities in the country. It's important to have strengths in all these areas, particularly those aligned with New York City's tech industries, to create new technologies that will be commercially viable. Also, we have a culture for interdisciplinary research that we will replicate in New York City. This culture has developed over decades and involves a combination of an administrative setup and a campus personality that allows us to interact in ways that cannot be found at most universities.

**Q:** What kind of experience does Cornell have in developing and running a remote campus?

**Fuchs:** Cornell has a history of developing programs in New York City, where we have our Weill Cornell Medical College – now engaged in a \$1 billion capital project that includes a new medical research facility – and each of our colleges has academic and research programs in the city. We also have experience overseas – our medical school in Qatar, which we launched 10 years ago and is the only accredited medical school in that country.

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## STUDENTS DEVELOP ROBOT HELPERS

Someday you may have a personal robot to help around the house. It will move smoothly from room to room, avoiding obstacles, people, and pets. It will pack your suitcases, clear the table, and do the dishes. It might even be programmed to assign chores to the kids or wait for the cable guy. We might see such appliances first as assistants for the disabled and elderly.

Students at Cornell are figuring out how to make robots do all these tasks and more. Their work was on display May 17 in the Duffield Atrium as a final exercise in the course Robot Learning, taught by Ashutosh Saxena, assistant professor of computer science.

The students presented an array of small projects, each demonstrating the ability to perform one special task. But eventually all the programming could be combined into one robot, Saxena said. He pointed to a device about the size of a dorm refrigerator with a robot arm mounted on top, rolling across the Duffield floor on a base taken from a Segway. “It could all go on that platform, which we call Polar [for Personal Assistant Robot]” he said. Since Cornell’s mascot is a bear, three of the recent robots have been named Polar, Panda, and Blue.

Industrial robots can be programmed to do just one thing and do it perfectly over and over, Saxena explained, but a personal robot needs to be able to learn about its environment and adapt to changes. The underlying technology is what computer scientists call “machine learning,” in which a computer program takes note of events and in effect reprograms itself in response.

With that in mind, some teams of students connected computers to a standard industrial robot to manipulate objects that are not always the same size and shape or in exactly the same place. Using a camera cannibalized from a Microsoft game console, the computer builds a 3-D image of its working area. Students train it by showing it how to manipulate a few basic shapes, such as a plate, a bowl, a cup, or a wine glass. Then it learns the right way to pick up and handle objects, picking up a plate by its edge, for example, and sliding it on an angle into the plate holder in a dish rack, or picking up a wine glass by its stem and inverting it before setting it in the rack. From there, the robot can generalize to even unfamiliar objects.

Another program lets the robot manipulate an object with bendable parts, in order to place objects in a cardboard box and then close the flaps of the box. One application described as a primitive construction worker finds blocks wherever they are on the table and stacks them in a prearranged order.

Some projects are aimed at search and rescue applications. Several student teams modified Quadrotors—a flying toy you can buy for about \$300—to avoid objects, follow humans, go to predetermined GPS coordinates, or act as sentries, checking the ID of anyone who approaches. One flyer has been taught to escape from a building by flying through hallways looking for exit signs and open doors.

A personal robot integrating all these capabilities could be made inexpensively, selling for perhaps \$2,000 to \$20,000, Saxena said, depending on whether it has a robot arm. “While the hardware is getting there, we need software that can make these robots truly smart,” he said.

—Bill Steele



Quadcopter approaches, but doesn't hit. A small camera with face-detection technology identifies human beings so the flyer can avoid them. Go to [www.engineering.cornell.edu/cem](http://www.engineering.cornell.edu/cem) to check out a video of the robot learning expo.



ISSN 1081-3977  
 Volume 17, Number 2  
 Fall 2011

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

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 Printed on recycled paper.

09/11 ML 40M 100196

## CORNELL ADVANCING UNPOWERED MEMORY

Tomorrow's nonvolatile memory devices—computer memory that can retain stored information even when not powered—will profoundly change electronics, and Cornell researchers have discovered a new way of measuring and optimizing their performance.

Using a very fast oscilloscope, researchers led by Dan Ralph, the Horace White Professor of Physics and member of the Kavli Institute at Cornell for Nanoscale Science, and Robert Buhrman, the J.E. Sweet Professor of Engineering, have figured out how to quantify the strength of current-induced torques used to write information in memory devices called “magnetic tunnel junctions.” The results were published online Feb. 27 in the journal *Nature Physics*.

An example of nonvolatile memory today is flash memory, but that is a silicon-based

technology subject to wearing out after repeated writing cycles, unlike magnetic memory.

To measure these spin torques, the researchers used an oscilloscope in a shared facility operated by Cornell's Center for Nanoscale Systems. They applied torque to the magnetic tunnel junctions using an alternating current and measured the amplitude of resistance oscillations that resulted. Since the resistance depends on the relative orientation of the two magnets in the tunnel junction, the size of the resistance oscillations could be related directly to the amplitude of the magnetic motion, and hence to the size of the torque.

The researchers hope such experiments will help industry make better nonvolatile memory devices by understanding exactly how to structure them, and also, what materials would best

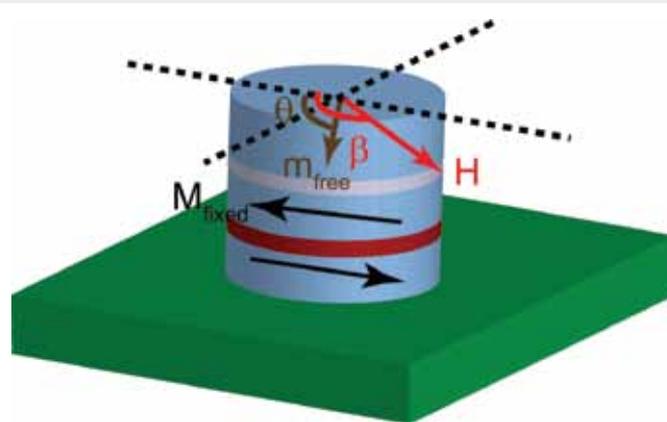
be used as the oxide insulators and the ferromagnets surrounding them.

The work was supported by the National Science Foundation, the Army Research Office, and the Office of Naval Research, and

included collaborators Chen Wang, graduate student and first author; graduate student Yong-Tao Cui; and Jordan A. Katine from Hitachi Global Storage Technologies.

—Anne Ju

PROVIDED



The geometry of a magnetic tunnel junction.

## SONIC WORKSHOP TAKES STUDENTS TO THE CLOUD

Six students majoring in computer science gained new insight into the Internet at a Cornell workshop that showed them how the hardware and software work beneath the surface. In the process they got a glimpse of what an academic career in computer science and engineering might be like.

The SoNIC Workshop (for

Software defined Network InterfaCe), led by Hakim Weatherspoon, assistant professor of computer science, brought five students from Howard University and one from the University of Puerto Rico to Cornell June 12-18 for an in-depth look at Weatherspoon's research, which explores how information is encoded into packets of digital bits for transmission and

how networking hardware sends and receives those packets.

His work is part of a larger Cornell effort to improve the reliability of cloud computing, in which data is stored and processed in remote data centers. Cloud computing is becoming the “platform of choice,” Weatherspoon said, and data centers are proliferating. “It's as easy as ordering one online and having it shipped to any location,” he said.

Weatherspoon's goal is to network such data centers successfully. Fiber-optic networks stretch and squeeze bundles of information, sometimes delivering them too fast for the receiving computer to read correctly, causing errors or introducing delays when packets must be resent.

The visiting students worked with Weatherspoon's SoNIC platform, a combination of hardware and software that makes it possible to encode information in any form the researcher chooses—not always according to standard Internet

protocols—and send the resulting messages across the country and back on the National LambdaRail scientific research network and analyze them when they return.

The workshop also included presentations on other aspects of computer networking and other fields of engineering from various faculty members. A goal of the workshop, Weatherspoon said, was to encourage the students—mostly juniors and seniors—to consider pursuing a Ph.D. degree and a career in research.

“The whole time we were exposing them to the technical subject we were letting them know they can pursue research careers instead of just going into industry,” he explained.

There was no cost to the students. Workshop funding was provided by the National Science Foundation and its TRUST Science and Technology Center, Cornell's Faculty of Computing and Information Science and College of Engineering, and industry partners.

—Bill Steele



Hakim Weatherspoon, right, works with computer science students Jay Jackson, left, from Howard University and Hector Tosado from the University of Puerto Rico in a summer workshop on Internet hardware and protocols.

## TERAHERTZ CHIPS COULD MAKE PORTABLE SCANNERS FOR MEDICINE



Ehsan Afshari, right, and graduate student Omeed Momeni design microchips that generate terahertz radiation for medical, dental and security applications.

Terahertz radiation, used in airport body scanners, promises a wide range of applications in science and medicine, from detecting cancer and tooth decay to inspecting food through its packaging.

Its range of wavelengths—between microwaves and infrared light—penetrates cloth, paper, and leather and a very short distance into the skin—all without the damaging effects of X-rays. Terahertz devices also can detect unique signatures of explosives.

Such applications require a portable, low-power radiation source, but most terahertz sources are still bulky and expensive, usually involving lasers and vacuum tubes. Cornell researchers have now demonstrated new ways to generate signals in the lower end of the terahertz range on a microchip at 10,000 times more power than previously possible, with the inexpensive CMOS chip technology used in many everyday electronic devices.

Solid-state terahertz devices could range from hand-held medical scanners to portable weapons scanners for the military, said Ehsan Afshari, assistant professor of electrical and computer engineering, who reported on new approaches to generating high-frequency signals at the 2011 IEEE International Solid-State Circuits Conference Feb. 22 in San Francisco. A paper on related work appears in the March 2011 issue of the *IEEE Journal of Solid-State Circuits*.

The maximum frequency at which a chip can operate and the power it can put out are limited by the physical characteristics of the material. Oscillator circuits seldom reach the maximum possible frequency or power, said Afshari.

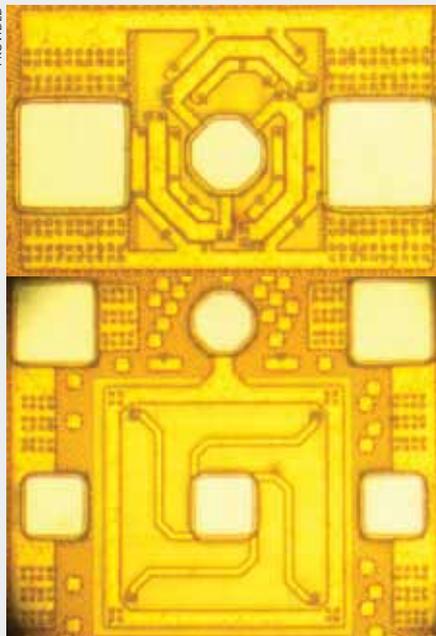
The best previous effort on a CMOS chip generated a signal at 410 GHz with an

output power of 20 nanowatts (billionths of a watt). Using new techniques, Afshari has built CMOS oscillators operating at up to 480 GHz with an output of 0.2 milliwatts (thousandths of a watt)—10,000 times higher power. These are still very low-power signals, roughly comparable to Bluetooth devices, but enough for medical instruments that might be held close to the skin.

“We broke the record, but it’s more important than that,” Afshari said. “Nobody can break our record because we have a method that can look at any given process and come up with a topology that can guarantee the maximum power and frequency.”

At radio frequencies, the length and shape of wires and other components are critical. Afshari and graduate student Omeed Momeni developed a mathematical analysis to calculate the characteristics of these components that would achieve the highest possible frequency and power on a given chip material.

PROVIDED



Microphoto of high-frequency CMOS chips developed in Prof. Ehsan Afshari’s lab: above, an oscillator circuit; below, a frequency doubler. Large white areas in the images are contact points where external wires are attached to the chip. At radio frequencies, the length of wires is critical. A new mathematical analysis enables researchers to design circuit elements to get the best possible performance.

The next step, Afshari said, will be to work with Cornell researchers who are familiar with gallium nitride, a material capable of operating at much higher frequencies and with power levels up to 2,000 times more than can be handled by silicon. Cornell is considered a world leader in gallium nitride research, he noted. Computer simulations, Afshari said, indicate that a gallium nitride device could generate frequencies up to 1 terahertz with enough power to scan a 1-meter-square area 10 meters away, with resolution down to 1 square centimeter—more than adequate for a soldier or police officer to scan an approaching stranger for weapons.

The research was supported by the Semiconductor Research Corporation through the Center for Circuit & System Solutions and by the National Science Foundation. Chips were manufactured through the Taiwan Semiconductor Manufacturing Company University Shuttle Program.

—Bill Steele

## NSF GRANT FUNDS THEORETICAL MODELS OF THERMAL CONDUCTIVITY

A nearly \$200,000 National Science Foundation grant will fund continued Cornell research on theory-based calculations of how certain materials conduct heat, which could lead to better engineered materials and devices.

Derek Stewart, senior research associate with the Cornell NanoScale Science and Technology facility, received the grant in collaboration with David Broido, professor of physics at Boston College.

Accurate theoretical modeling of thermal transport in materials due to lattice vibrations is essential to numerous fields, including microelectronics cooling, thermal barrier coatings, and thermoelectronics.

At Cornell, researchers will focus on first-principles calculations of thermal conductivity in such crystalline materials as lead chalcogenides and certain classes of semiconductors, and also recently developed nanostructured semiconductor alloys that contain embedded nanoparticles.

—Anne Ju

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## SCIENTISTS UNCOVER TRANSFORMATIONS IN COBALT NANOPARTICLES

Understanding the intricacies of how nanoparticles undergo chemical transformations could lead to better ways to tailor their composition, which can lead to advanced material properties.

Using the Cornell High Energy Synchrotron Source, scientists led

by Richard Robinson, assistant professor of materials science and engineering, uncovered exactly what happens when cobalt nanoparticles transform into two phases of cobalt phosphides.

Their work, published in the *Journal of Materials Chemistry*,

was featured by the journal as a “Hot Article” in May.

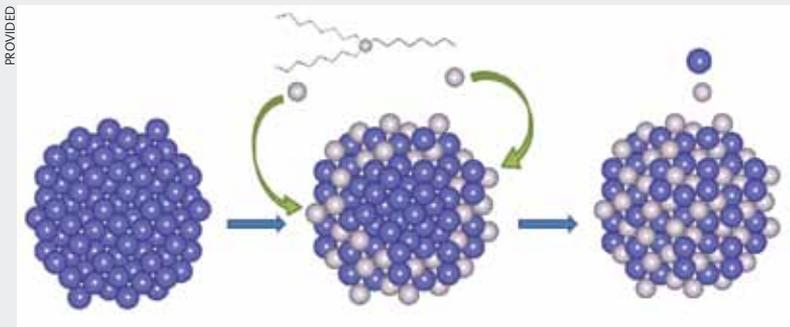
The effect Robinson’s team observed in the cobalt phosphide transitions was a nanoparticle hollowing due to asymmetric diffusivities of cations and anions. In other words, the cations move out from the core faster than anions can diffuse in, leading to a hollow particle.

Other groups have reported on this “Kirkendall” effect, but the Robinson team was the first to show that this hollowing is more complex than previously thought and can be

studied as a two-step process. Their work could be used to control this process and to produce complex particles with properties tailored for use in energy applications. Metal phosphides have a wide range of properties—ferromagnetism, superconductivity, catalytic activity, and magnetoresistance among them.

The work was done in collaboration with scientists led by Richard Hennig, assistant professor of materials science and engineering. It was supported by King Abdullah University of Science and Technology, the Cornell Center for Materials Research, and the Energy Materials Center at Cornell.

—Anne Ju



The evolution schematics of transition from cobalt to cobalt phosphide nanocrystals.

## ARTIFICIAL TISSUE SPEEDS WOUND HEALING

Improved tissue grafts designed by Cornell scientists that promote vascular growth could hasten healing, encourage healthy skin to invade the wounded area, and reduce the need for surgeries for serious burn victims.

These so-called dermal templates were engineered in the lab of Abraham Stroock, associate professor of chemical and biomolecular engineering at Cornell and member of the Kavli Institute at Cornell for Nanoscale Science, in collaboration with Dr. Jason A. Spector, assistant professor of surgery at Weill Cornell Medical College, and an interdisciplinary team of Ithaca and Weill scientists. The research was published online May 6 in the journal *Biomaterials*.

The biomaterials are composed of experimental tissue scaffolds that are about the size of a dime and have the consistency of tofu. They are made of a material called type 1 collagen, which is a well-regulated biomaterial used often in surgeries and other biomedical applications. The templates were fabricated with

tools at the Cornell NanoScale Science and Technology Facility to contain networks of microchannels that promote and direct growth of healthy tissue into wound sites.

“The challenge was how to promote vascular growth and to keep this newly forming tissue alive and healthy as it heals and becomes integrated into the host,” Stroock said.

The grafts promote the ingrowth of a vascular system—the network of vessels that carry blood and circulate fluid through the body—to the wounded area by providing a template for growth of both the tissue (dermis, the deepest layer of skin), and the vessels. Type I collagen is biocompatible and contains no living cells itself, reducing concerns about immune system response and rejection of the template.

A key finding of the study is that the healing process responds strongly to the geometry of the microchannels within the collagen. Healthy tissue and vessels can be guided to grow toward the wound in an

organized and rapid manner.

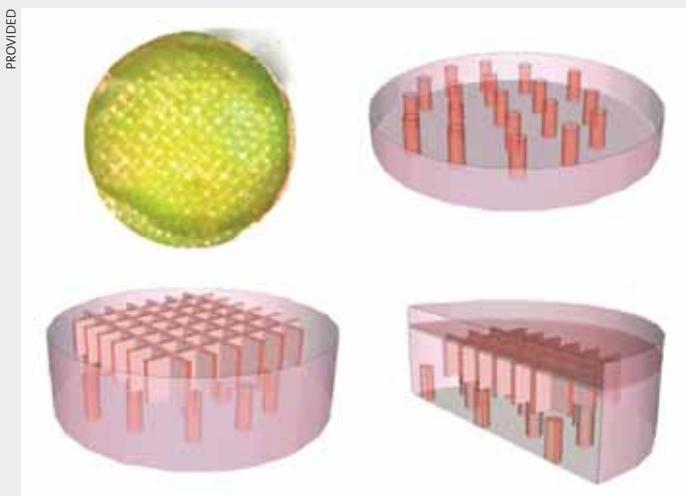
Eventually, the scientists may try to improve their tissue grafts by, for example, reinforcing them with polymer meshes that could also act as a wound covering, Spector said.

Other collaborators include first author Ying Zheng, a former postdoctoral associate in Stroock’s lab; Dr. Peter W. Henderson, chief research fellow

at Weill Cornell’s Laboratory for Bioregenerative Medicine and Surgery; graduate student Nak Won Choi; and Lawrence J. Bonassar, associate professor of biomedical engineering.

The work was supported by the Morgan Fund for Tissue Engineering and the New York State Office of Science, Technology and Academic Research.

—Anne Ju



Top left, a tissue scaffold with pores visible. Clockwise, schematic diagrams showing cross-sections of microstructured tissue templates.

## CORNELL CHIPSATS ON ENDEAVOUR'S FINAL LAUNCH

NASA's space shuttle Endeavour lifted off May 16 carrying three fingernail-sized satellites developed at Cornell.

The prototype chip satellites, named "Sprite," were mounted on the International Space Station after the shuttle delivered them on its final flight. Such satellites may travel to Saturn within the next decade, collecting data about chemistry, radiation, and particle impacts as they flutter down through its atmosphere.

The thin, 1-inch-square chips, in development for three years in the lab of Mason Peck, associate professor of mechanical and aerospace engineering, were mounted to the Materials International Space Station Experiment pallet, which was attached to the space station, exposing them to the harsh conditions of space to see how they hold up and transmit data.

Although grapefruit-size satellites have been launched before, they have functioned much like larger satellites. The flight dynamics of a chip satellite are fundamentally different from these larger "CubeSats."

"Their small size allows them

to travel like space dust," said Peck. "Blown by solar winds, they can 'sail' to distant locations without fuel. ... We're actually trying to create a new capability and build it from the ground up. ... We want to learn what's the bare minimum we can design for communication from space," Peck said.

When the prototypes are removed and returned to Earth in a few years, their survival will be assessed.

The three prototypes were built entirely by three Cornell students when they were undergraduates—Ryan Zhou '10 and doctoral candidates Zac Manchester '09 and Justin Atchison '10.

The prototypes are physically identical, but each transmits differently. "They all emit at the same frequency ... [but] they are different and distinct from each other in ways that we can recognize on the ground," said Peck. "That's very important because it's a pathfinder for something we hope to do in the future. We want to launch a huge number of these things simultaneously but still sort out

NASA STOCK IMAGE



Preparing NASA's space shuttle Endeavour for space flight.

which is which."

The current prototypes are made primarily of commercial parts, but Peck's group has partnered with Draper Lab in Boston to work on making a more space-ready prototype.

"We're seeing such an explosion in personal electronics ... all these components are super high performance, and they have far outstripped what the aerospace industry has at its

disposal," said Peck, noting that these technologies were used on the small satellites.

Cornell, he added, plays a leading role in the field of chip satellites. "We are definitely the first to launch something, and we are the first to be looking at the flight dynamics as a way to enable new ways to explore space," he said.

—Elizabeth Simpson

## UNDERSTANDING BACTERIAL SYNERGY COULD IMPROVE FUEL CELLS

Like mutual back-scratching, two common bacteria involved in what was thought to be only a marginally important

relationship actually help each other thrive when grown together in bioreactors, Cornell scientists have discovered.

PROVIDED



Bioelectrochemical reactors in the Angenent Lab.

Understanding this symbiotic relationship could lead to, for example, more efficient microbiology-based fuel cells or better methods for preventing such natural processes as rust corrosion.

The research was led by Largus Angenent, associate professor of biological and environmental engineering, and was published online June 2 by *Energy and Environmental Science*, a publication of the Royal Society of Chemistry.

To study the bacterial interactions, the scientists fed glucose into a bioelectrochemical reactor, in which bacteria on electrodes convert organic material into electricity.

The glucose fed the bacterium *Enterobacter aerogenes*, which, in turn, produced the product

2,3-butanediol. This became a food source for another bacterium, *Pseudomonas aeruginosa*.

In the meantime, the researchers discovered, *Pseudomonas* activity was upregulated, which in turn increased the presence and activity of *Enterobacter*. The result was a 14-fold increase in the electric current production from *Enterobacter* and *Pseudomonas* combined in the bioelectrochemical reactor, than by either microbe by itself.

The paper's first author was graduate student Arvind Venkataraman, who was involved in hypothesis development and who designed and conducted the experiments. The work was supported by a National Science Foundation CAREER grant.

—Anne Ju

## CU SPINS OFF HORSE HEALING DEVICE

UltrOZ Elite Therapy System is the first wearable, therapeutic ultrasound system for the equine market. Nearly the size of an iPod Nano, these battery-operated systems fit within specially engineered neoprene leg wraps. With the device, horses can exercise or feed in the pasture unencumbered while receiving up to six hours of unsupervised ultrasound therapy.

ZetroZ LLC, a business spinoff from Cornell's Department of Biomedical Engineering, has begun selling the device at FarmVet, a large distributor of equine products, as its initial distributor.

For years, veterinarians have used ultrasound to reduce inflammation and promote healing in horses, but the equipment was bulky. The new device is simple to attach to a

horse and provides comfort and reduces pain.

UltrOZ's unique and versatile system provides a consistent, controlled, easy-to-use method of providing long-term ultrasound therapy, said George Lewis, a Cornell medical ultrasound researcher and founder of the spinoff company.

Lewis' hopes for the device are to help people as well as animals of all types, and to make this medical therapy available to people at a low cost and with minimal invasiveness.

"Once it has FDA approval and people are wearing these systems worldwide, I hope that they will find themselves next to the Icy Hot patch on the shelves of consumer health stores," said Lewis, who developed his first portable ultrasound prototype as a graduate student at Cornell.

PROVIDED



David Eldredge, Cornell polo coach, with a horse wearing a portable ultrasound device.

The UltrOZ Elite Therapy System was tested by equine veterinarians and therapists at the Rood and Riddle and Hagyard equine hospitals. Veterinarians reported increased bone healing, quick reductions

in inflammation due to splints, and increased rates of healing in tendon and ligament injuries.

Funding for this research was provided in part by the National Science Foundation.

—Anne Ju

## Cornell Engineering Magazine GOES PAPERLESS

Alumni and friends of the college can now sign up to receive an electronic version of *Cornell Engineering Magazine* instead of a printed copy.

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## CRYSTAL CERAMICS RESEARCH COULD LEAD TO LOW-POWER MEMORY

Magnetic materials in which the north and south poles can be reversed with an electric field may be ideal candidates for low-power electronic devices, such as those used for ultra-high data storage. But finding a material with the right combination of magnetoelectric properties has proved to be a difficult challenge. Using a theoretical approach, Cornell theorists might have found one.

Craig Fennie, assistant professor of applied and engineering physics, and research associate Nicole Benedek, used theoretical calculations to understand exactly why and how a particular crystalline ceramic, a layered

perovskite, is multiferroic. Multiferroic materials are simultaneously ferroelectric (electrically polarized) and ferromagnetic (exhibiting a permanent magnetic field). Their results were published online March 7 in *Physical Review Letters*, appearing later in print, and are also the subject of a "Viewpoint" in the journal *Physics* and a "News and Views" column in the journal *Nature Materials*.

Only a small subset of materials called multiferroics respond to both electric and magnetic fields. This discovery decades ago caused excitement due to the potential implications for magnetic storage devices

that require only a bare minimum of power.

The Cornell researchers' density functional theory calculations revealed that octahedron rotations—lattice distortions ubiquitous in complex crystalline materials such as perovskite—simultaneously induce and thereby couple ferroelectricity, magnetoelectricity, and ferromagnetism.

This prediction is remarkable because octahedral rotations usually cannot produce a polarization. It also lends new insight into the problem of how to introduce multiferroic order into different materials and the possibility of discovering the

best materials with which to make low-power electronics at room temperature.

Their study demonstrates the possibility of robust, controllable coupling of magnetization and ferroelectric polarization, as well as suggesting electric field switching of the magnetization.

Benedek's work was supported by the Cornell Center for Materials Research and the National Science Foundation's Materials Research Science and Engineering Centers grant, and Fennie was supported by the Department of Energy-Basic Energy Sciences SISGR program.

—Anne Ju

## NEW TECHNOLOGY SHARES ONLINE VIDEO IN HIGH QUALITY

When you upload video to a sharing site like YouTube, something gets lost in the translation: quality. Such services heavily compress files, often blurring out fine details and sprinkling the video with the scattering of small rectangles known as pixelation. Most sites also limit the length of videos.

FlixQ, a new video-sharing service created by Cornell computer scientists, tosses those restrictions aside and removes artificial limits on quality and length without increasing bandwidth or storage costs.

"People don't know what they're missing. Once you've seen high definition it's a different ballgame," said Gün Sirer, associate professor of computer science, who co-founded United Networks LLC, the startup company behind FlixQ, with graduate students Ryan Peterson and Bernard Wong.

The technology enabling FlixQ

has the potential to drastically reduce the costs of distributing many kinds of data, Sirer said, by reducing the amount of central server space needed. At the same time, he said, it can empower small groups outside the mainstream.

"FlixQ was designed from the start to give the users complete control over who can see their videos," Sirer said. Users can share videos publicly or make them available only to a specified group. FlixQ already has special subsites for a dozen universities, including Cornell, where videos are available only to members of the particular university community.

After about a year of operation, FlixQ hosts several thousand videos, ranging from parades to Cornell Glee Club doings to a cat washing its face.

The key to cost-effectively serving high-quality video is "hybrid peer-to-peer" technology that teams a central server with a distributed network. In

peer-to-peer file sharing, a user downloading a file gets it piece by piece from others on the network. After part of the file has been received, the downloader also becomes an uploader, sharing the pieces already received. That works fine for such popular items as last night's episode of *Glee*, but for, say, the Intercollegiate Ultimate Frisbee Championships or a fastidious cat, the "swarm" of possible sources may be small or nonexistent. So FlixQ caches its files; the viewer may get everything from peers, everything from the server, or parts from both.

The FlixQ server also acts as an overseer, allocating peer and cache resources to give all users a roughly equal speed. "It's like God in the sky saying, 'Steer over here,'" Sirer explained. "People have tried peer-to-peer before, but hybrid peer-to-peer combines the efficiency of peer-to-peer with the centralized control and management of traditional systems."

The technology has tremendous potential for both commercial and private use, Sirer said. For the corporate world it can reduce the power requirements of huge data centers, he said, but it also can help small groups share information efficiently and privately. "If you're not into Ultimate Frisbee it's incredibly boring, but if you're on the team it's incredibly important," he explained, adding that the system would work the same way for families sharing videos of their kids.

"We'd love to get more users," Sirer added. "Our service showcases a much more efficient and private style of video distribution than what most people are used to."

The public site is at <http://flixq.com>. The Cornell subsite limited to campus computers or to users with a Cornell NetID is at <http://cornell.flixq.com/>.

—Bill Steele

# Given $a$ , $b$ , $c$ , $d$ , and $f$ , find $e$



Professor Andy Ruina,  
Mechanical and  
Aerospace Engineering

## The puzzle

A function  $f$  is defined in terms of  $a$ ,  $b$ ,  $c$ ,  $d$ , and  $e$  as

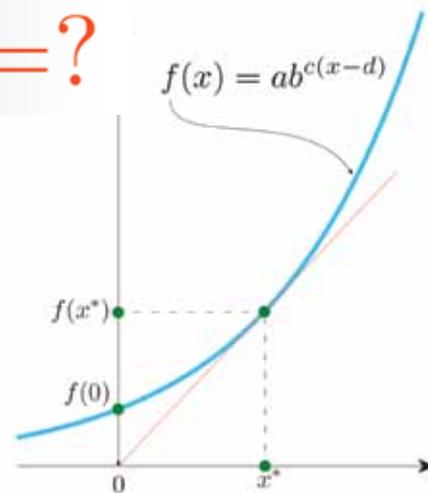
$$f(x) = ab^{c(x-d)}$$

Assume  $a > 0$ ,  $c > 0$ , and  $b > 1$ . At point  $x^*$  the tangent to  $f$  goes through the origin.

Find the ratio

$$e \equiv \frac{f(x^*)}{f(0)} \text{ in terms of } a, b, c, \text{ and } d.$$

$$e \equiv \frac{f(x^*)}{f(0)} = ?$$



## SOLVE THIS TO WIN CORNELL ENGINEERING GEAR

We will draw three winners from correct entries submitted by January 1. They will receive a Garland gift pen, a stainless steel water bottle, or a Cornell Engineering car decal. Congratulations to Paul Kirchner B.E.E. '50 EE, Steven Cushing '76 CE, M.Eng. '79, and John Lefferts '79 EE for correctly solving the spring brainteaser! You can see the solution, and submit your answer at [www.engineering.cornell.edu/brainteaser](http://www.engineering.cornell.edu/brainteaser).

# HEAD in the CLOUD

BY MICHAEL GILLIS

**Siddharth Anand '97 MSE, M.Eng. '02 CS helps build Netflix's video infrastructure in the cloud.**

IT'S 2008 AND NETFLIX IS SIX YEARS INTO A MOVIE RENTAL MODEL that is transforming the industry, attracting millions of customers and approaching a billion dollars in revenue. For a business generating that kind of revenue, it's a comparatively small company, employing only a few hundred people. ¶ In less than a year, that will change dramatically.

But as 2008 begins, consumers are logging on to Netflix as they have since DVD subscription plans began in 1999, loading up a virtual queue of DVD movies that will be shipped in the order they appear on the Web interface. Once a movie is returned to Netflix by mail, the next movie is shipped. It's a system that has turned the video rental

business on its head and lured consumers in droves, and by 2008, it's fairly predictable.

"Under our old model, people primarily visited our site on Sunday and Monday nights to refresh their queues, either adding new movies or altering the queue order," says Siddharth "Sid" Anand '97 MSE, M.Eng. '02 CS of Netflix. "The movies would usually arrive a day later, in time for the following weekend. The weekends were when families would sit together to watch their new DVDs."

As a result, the site's traffic was seldom a burden.

"We only had to handle Internet traffic peaks on Sundays and Mondays," Anand says.

The movie service was already wildly popular and its revenue rising fast.

But as 2008 draws to a close, Netflix is about change the game again.

delivered by

**NETFLIX**

## BREAKING THE DIGITAL DIVIDE

Near the end of 2008, Netflix announced a deal with the cable TV network Starz that would make available more than 2,500 movies to watch instantly. Consumers could now select a movie to watch instantly, if available, on a PC or laptop, on demand. The “watch instantly” feature caught fire.

But online streaming also forced Netflix to change the way it managed its servers and data.

Anand, who is a member of the Netflix cloud systems team, was tapped to help with that transition.

Several changes would occur between 2008 and 2010 that would not only redefine how Netflix served up its movies but also how consumers accessed them.

In an aggressive blitz to promote and expedite this digital transition, Netflix hired hundreds more engineers and began to

**N**etflix is still growing. The company now boasts 25.6 million subscribers in the United States and Canada, and it is pushing into the global marketplace with plans to expand to 43 countries in Latin America this year.

strike deals with a host of electronics vendors to allow devices of all shapes and sizes to stream Netflix movies.

“We’ve tried to be on every consumer electronic device, whether at home or in your pocket,” Anand says.

Netflix is now available on game consoles, Blu-ray, and DVD players, mobile devices and dedicated media devices. Many handle high-definition streaming and 5.1-channel stereo surround audio.

With recent announcements about additional online content—thousands of titles are now available to watch instantly—Netflix is still growing. The company now boasts 25.6 million subscribers in the United States and Canada, and it is pushing into the global marketplace with plans to expand to 43 countries in Latin America this year.

That growth isn’t without its challenges.

“Now people are constantly watching movies, even late into the night, all over the U.S.,” Anand says. “As we go international, we’re going to have to deal with the fact that we’re on all the time.”

## CLIMBING ONTO THE CLOUD

The popularity of streaming content called for significant changes to the company’s server and data infrastructure.

In 2008, Netflix operated its Web site from a single data center, which Anand says was a “single point of failure.” If the data center suffered a serious power outage or loss of broadband, customers would not be able to update their queues and streaming content would go black.

Anand says Netflix began its ambitious plan for improvement in 2009 by expanding to more devices, growing internationally, as the company has done in Canada, and moving much of its data and server infrastructure to the cloud. Cloud-based storage uses network servers in multiple locations to store and retrieve data, diminishing the possibility of losing important information or data in a crash.

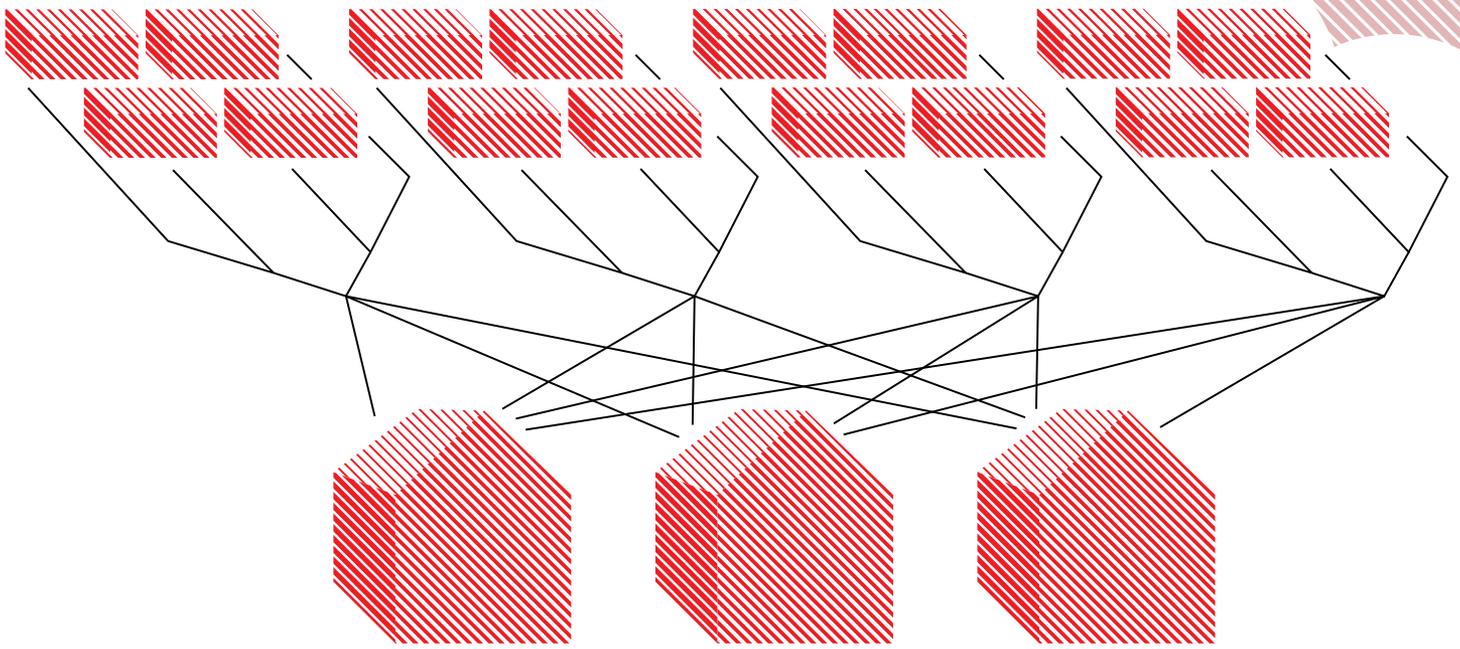
At that time, the major player in the cloud was Amazon, specifically Amazon Web Services (AWS). Anand’s team began what he called the “pathfinding” work to integrate Netflix’s needs with the strengths of AWS.

To get there, Anand says Netflix had to migrate away from its relational database management system—Oracle—to NoSQL, a revolution in database technology that often trades diminished guarantees around consistency for increased guarantees in availability. For a high-traffic, always-on Web site like Netflix’s, the



Siddharth Anand of the Netflix Cloud Systems Team

PROVIDED



Cloud-based storage uses network servers in multiple locations to store and retrieve data, diminishing the possibility of losing important information or data in a crash.

increased availability is a necessity.

“By December 2010, we were serving more than 90 percent of our traffic out of AWS’ cloud,” Anand says.

Anand says that Netflix became something of a “poster child” for AWS, partly because of the complexity, but also because of the scale.

Now, when a customer clicks “play” to begin a movie on Netflix, Netflix servers on AWS authenticate the customer and device, and then send the movie from one of several content distribution networks across the country.

As Netflix continues to see significant growth in this area, the company continues to expand its rapidly growing stable of professionals.

### THE JOURNEY TO THE CLOUD BEGINS

Anand says his gravitation toward the cloud began later in his career.

His focus at Cornell had been semiconductors. Following graduation, he went to work for Motorola in Arizona. There he worked in research, helping to develop devices for spacecraft based on silicon carbide.

But he also found himself dabbling in software engineering, which he enjoyed so much he decided to return to Cornell to pursue a Master of Engineering. His M.Eng. project focused on distributed systems that move data over multiple machines, giving him a strong background for his work at Netflix.

Anand soon joined Siebel Systems as part of their platform optimization team. He analyzed code performance of the Siebel server on various enterprise platforms. He then worked at eBay for multiple teams, including the research labs and the back-end search engine team. It was at eBay that he began working on problems of Web scale, managing millions of auctions per day across the world. Before joining Netflix in 2007, he was Etsy’s first VP of Engineering.

His short stint at Etsy was in large part due to the fact that many of his former eBay colleagues were heading to Netflix, a young company on the verge of scale issues. He decided to find out what all the excitement was about.

### THE STAR OF THE SHOW: CORPORATE CULTURE

Anand says when he started at Netflix, there were about 150 engineers with the company. That number has more than doubled and is still growing.

**“Now people are constantly watching movies, even late into the night, all over the U.S.,” Anand says. “As we go international, we’re going to have to deal with the fact that we’re on all the time.”**

**“In many teams like mine, without marketing direction, we must decide what to work on,” Anand says. “We have to be leaders. In general, the responsibility of each employee is to move the company in a positive direction. The feeling of playing a critical role permeates the environment.”**

The company’s success certainly has a lot to do with its business model, he knows, but Anand says that success is also the direct result of the company’s internal culture, which isn’t as widely known.

“It has been the best place I have ever worked,” he says. “It has this very unique culture that no other company has.”

All new employees meet with CEO Reed Hastings within a few weeks of being hired to hear him explain the Netflix culture.

What is the Netflix culture? “The culture is based on two values: freedom and responsibility,” Anand says.

What that means, he explained, is that each employee plays a large role in the success of the company. This is because the culture tends to push decision-making down to the employees.

“In many teams like mine, without marketing direction, we must decide what to work on,” Anand says. “We have to be leaders. In general, the responsibility of each employee is to move the company in a positive direction. The feeling of playing a critical role permeates the environment.”

The company accomplishes that by eschewing titles for most of its employees. Engineers are engineers, for example, and in the eyes of

the company all are equal.

In fact, employees aren’t really employees, but “contributors.”

“When we hire people into an individual contributor position, they need to be equal with the rest of us,” Anand says.

The company provides no vacation time and no bonuses. Instead, employees are allowed to take vacation time as often as needed, on their own schedule. Employees can work at home, if need be. The

pay scale is intended to be generous enough that bonuses—and the internal politics of coveting them—are unnecessary.

Anand says this culture works remarkably well. Managers, whose time is a bit more structured, review employees based on the principles of this culture, which are summed up as courage, impact, communication, and curiosity.

The culture does thrive on experience. That means the company is quite selective on who is hired, despite the growing workforce.

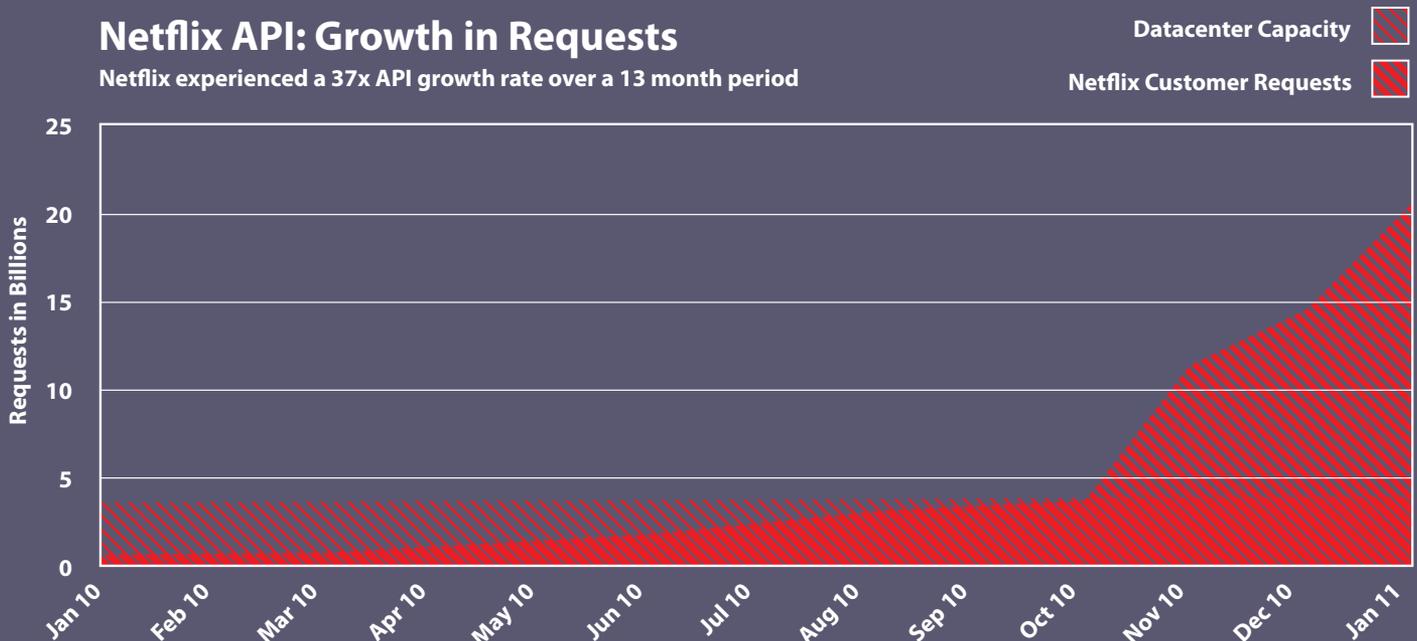
“We tend to avoid hiring people directly out of college,” Anand says. “Potential hires typically have 10 or more years of experience and that experience needs to be top notch. They must show a history of challenging themselves over those 10 plus years.”

And the company’s goals are no less direct, underlining the company’s focus on the future and its commitment to hiring the right people.

“We want to change the world,” Anand says. “You don’t achieve that by sitting in endless meetings. Reaching consensus is not the most important thing. It’s all about taking a stand, making it work, showing it working. If it doesn’t work you learn from your mistakes.” **CEM**

## Netflix API: Growth in Requests

Netflix experienced a 37x API growth rate over a 13 month period





# BETTER TOGETHER

BY SHARON TREGASKIS

**Graphic interface  
meshes engineering  
with architecture for  
greener buildings.**

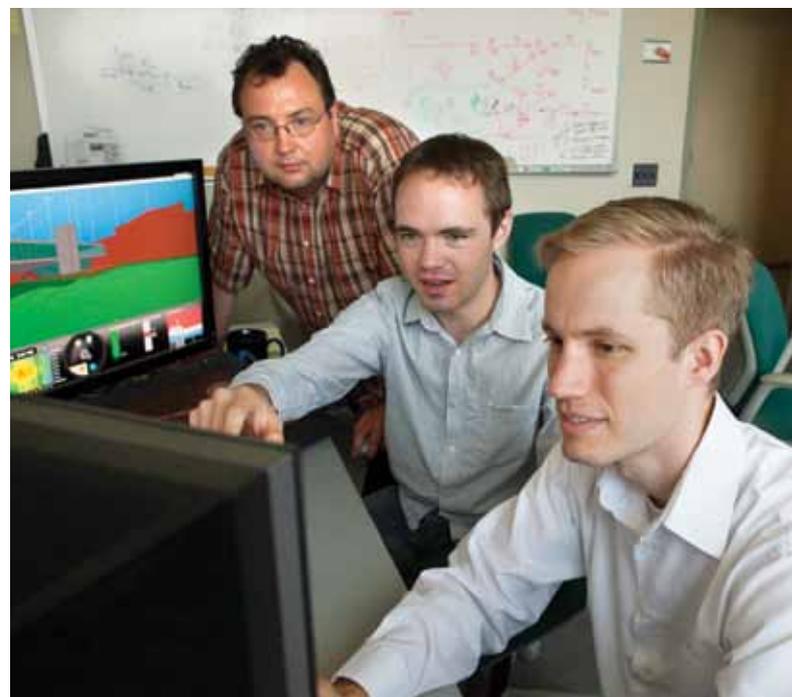


The Sustain developers: (l. to r., front) CS Prof. Donald Greenberg, Arch. Asst. Prof. Kevin Pratt, and M.S. student Nicolas Savva B.A. '11 CS, Physics; (rear) MAE Asst. Prof. Brandon Hency, postdoctoral researcher Zhao Dong, research support specialist Nathaniel Jones M.Arch. '09, research technician Dave Bosworth M.Arch. '09, M.Arch student Colin McCrone, and research support specialist Lars Schumann.

**CLICKING THROUGH AN ARRAY OF GRAPHIC ICONS, Nathaniel Jones, M.Arch. '09, animates the images on a trio of 27-inch monitors in a fifth-floor lab in Rhodes Hall. He clicks on a spinning satellite view of Earth on the screen to his left, then on a map of the United States, and last on a town near Chicago. On the screen directly in front of him, animation turns an architect's three-dimensional**

rendering of a geometrically complex house into a sundial of sorts. In less than 60 seconds, the time-lapse display—which incorporates cloud cover based on actual weather patterns in Chicago and even the building materials and room dimensions of the house—simulates the angle of the sun's rays as they fall on northeastern Illinois, tracing the sun's arc through the sky over the course of a year and mapping the shadows cast by the house and nearby trees. On the screen at Jones' right, a second 3-D rendering of the house turns red and blue as rooms heat and cool with the combined effect of sunlight and mechanical systems, while a collection of charts and graphs detail such corresponding data as interior temperature, the building's energy consumption, and even its carbon emissions.

Known as Sustain, the program simulating this hypothetical building's performance is the product of collaboration among Cornell faculty in engineering, architecture, and computer graphics. Their goal: promote energy-efficient building design and system engineering by giving architects access to robust, tailored simulations using an intuitive, user-friendly graphic interface early in the design process. The open-source program traces its roots to work begun by computer science professor Don Greenberg '55 CE, BCV '58, Ph.D. '68, when he was appointed founding director of Cornell's Program of Computer Graphics in 1972.



(l. to r.) Lars Schumann, Colin McCrone, and Brandon Hency collaborate in Sustain's rich visualization environment.

**T**oday, cloud computing and parallel processing have transformed the pace at which even the most complex simulations can be executed—and with energy a growing concern, Greenberg’s vision for computer graphics at the intersection of architecture and engineering has regained favor.

Computers were in their infancy when Greenberg—who also holds joint appointments in the College of Architecture, Art and Planning and the Samuel Curtis Johnson Graduate School of Management—joined Cornell’s faculty. Early on, he focused on how computer-aided design could integrate the fields to which he devoted his own academic training: architecture and

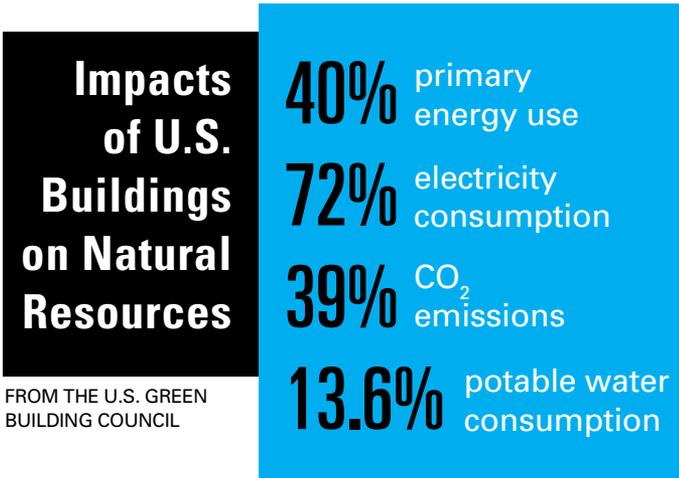
engineering. In 1974, *Scientific American* put his pixelated rendering of the not-yet-constructed Johnson Museum—in the middle of the Arts Quad—on its cover to illustrate the value of computer graphics for siting studies. Greenberg had grand visions for what computer graphics could achieve in the realm of modeling and simulations to optimize energy efficiency. Yet despite the drive for efficiency motivated by the oil embargoes and resulting energy crises of that decade, architects and engineers were loath to incorporate the new technology

as anything more than a drawing tool. Back then, simulations took too long and just weren’t that much better than what humans could do with pencil and paper. “The computational power wasn’t there,” says Greenberg, who has spent the last four decades refining computer graphics applications in healthcare, entertainment, and even ornithology. “It was too difficult.”

Today, cloud computing and parallel processing have transformed the pace at which even the most complex simulations can be executed—and with energy a growing concern, Greenberg’s vision for computer graphics at the intersection of architecture and engineering has regained favor. “I love animation and entertainment,” says the Jacob Gould Schurman Professor of Computer Graphics, “but I really think computer graphics can be put to better use, such as to improve the environment and enhance medical imaging and device designs.”

In 2008, the professor received pilot funding to develop Sustain from Cornell’s Center for a Sustainable Future (now the Atkinson Center) with assistant professor of architecture Kevin Pratt and professor Kenneth Torrance, his longtime collaborator in mechanical and aerospace engineering. In 2009, the trio parlayed data from the pilot project into a proposal and received a three-year, \$1.83 million grant from the Department of Energy to further develop Sustain. (After Torrance died of a heart attack in February 2010, Greenberg and Pratt invited Brandon Hency, an assistant professor of mechanical and aerospace engineering, to join them.)

Buildings account for 40 percent of the United States’ overall energy consumption and 72 percent of its electricity usage, according to the Green Building Council. Enhancing building efficiency could slash future energy demand and the carbon dioxide emissions that go along with burning fossil fuels. But achieving that goal requires more than new materials and a boost in alternative energy production—it requires a smarter approach to the information flow among architects and engineers that yields our built environment, says Pratt, who also has his own design firm in Ithaca. Historically, architects have conceived beautiful buildings, then handed off their designs to mechanical and structural engineers, who do their best to create systems to heat, cool, light, and shade the interiors. “Architects really need to know about engineering—we need good simulation information about how our buildings will perform early in the design process,” says the architect. “If you wait to



Donald Greenberg, the Jacob Gould Schurman Professor of Computer Graphics.

involve the engineers, it becomes a post-rationalization project to make the systems as good as you can based on the decisions that have been already made.”

Thus, while decisions about siting and orientation have a profound influence on energy consumption, they’re often immutable by the time engineers enter the equation. In that stepwise approach, engineers work within the parameters set by architects to guarantee comfort and functionality for a building’s eventual occupants; optimizing energy efficiency takes a back seat. “Sustain can give critical information to architects at the early design phase,” explains Hency. “Some buildings have this problem where one side is heating and one side is cooling, just because one side is in the sun and one is in the shade, so you’re using energy twice. How can you design the building so that doesn’t happen?”

An actual building simulation contains thousands of variables—from building orientation to window size and placement, as well as choice of construction materials and even landscaping and the relationships among existing buildings that provide shade and block winds. The Department of Energy’s legacy simulation program, EnergyPlus, has long been a valuable tool for understanding the influence of such features—but it works slowly and generates tabular results. Consequently, the program has typically been deployed by engineers, late in a building’s design, and not by architects intent on optimizing their design for energy efficiency.

Sustain aggregates an architect’s rendering—in Google SketchUp, 3ds Max, or Revit—with U.S. Geological Survey topographical site details, National Weather Service data, and building materials information; uses sophisticated graphics algorithms to speed the analysis by EnergyPlus; and presents the results pictorially. “We understand information much better when we see it graphically,” says Greenberg. “That’s important for input and output.” Thus instead of requiring users to type in latitude and longitude for a building site, for example, Sustain’s default setting employs a series of mouse clicks on the spinning



Research support specialist Lars Schumann talks with Arch. Asst. Prof. Kevin Pratt.

satellite view of Earth. Once a simulation is complete, users see the results in three dimensions—a color map for the temperature on different surfaces, for example. “You can see how warm or cold different surfaces are as time progresses,” says Hency. “You can play out the day and see how temperatures vary and the building behaves. Normally you would look at line plots. This is more seamless, not so manual.”

In addition to graphical interfaces, the group has prioritized the development of algorithms to briskly extract the most relevant information from complex data. In his graduate and postdoctoral research, Hency developed algorithms for online analysis of heating and cooling loads in existing buildings, using an electrical analogy for heat transfer. The work was a valuable foundation for his collaboration with Greenberg and Pratt. “You can take a very complex network that you would use to describe a building by directly using the geometry,” he explains, “and then simplify that



Attributes of the recently completed Milstein Hall are discussed as visualized in Sustain.

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Historically, the tools architects have used to design a building aren't compatible with the tools engineers use to analyze energy demand and design heating and cooling systems. The Sustain development team has found a way to bring them together.



The researchers discuss recent work on Sustain.

down to something that you can run very quickly.”

Historically, the tools architects have used to design a building aren't compatible with the tools engineers use to analyze energy demand and design heating and cooling systems. The Sustain development team has found a way to bring them together. Using tools and algorithms from the entertainment world—notably Greenberg's work with Pixar, Dreamworks, and other animation juggernauts in Hollywood—the team has replaced trigonometric calculations with pixel analyses, for example to calculate solar insolation and shading. Meanwhile, Hency has tackled methods to translate graphic representations of rooms into quantifiable data. “A building is just geometry—polygons,” he explains. “How do you take a bunch of polygons and say, ‘This is a room separate from

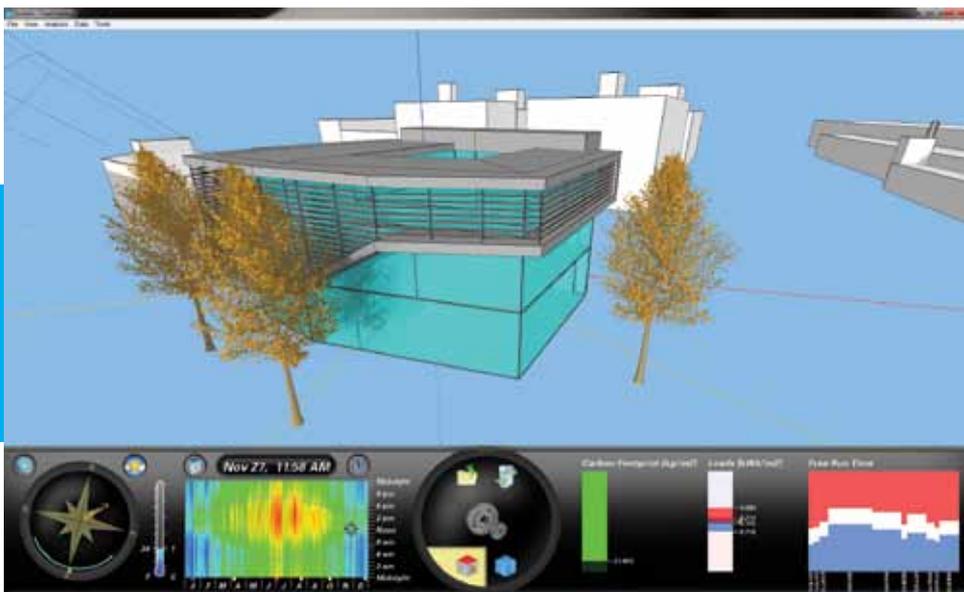
A screenshot of Sustain depicting its dashboard and rendering of a building with shading devices.

that room?’ It's a very simple idea, but there's no model out there. It's a very active area of research: How do we come up with algorithms that are able to understand what humans just do naturally—speech recognition, recognize an enclosed space?”

To further speed their simulations, the trio has focused on parallel processing—instead of sequentially analyzing thousands of state changes as a building absorbs heat from the sun or a furnace generates heat, they've broken those calculations into sets that can be analyzed simultaneously by multiple, remote computers, which are then reassembled for meaningful results. “Ideally, you could get a hundred-fold increase by running 100 processors,” says Hency. “But the idea of applying these concepts to buildings—how do you break them down and things like that—is not well understood. Modeling these systems is ultimately an art. At some point you have to make assumptions to simplify enough that you can actually calculate things.”

As a senior member of Cornell's faculty, Greenberg has his pick of collaborators. He chose assistant professors for two reasons: he thinks of mentoring younger faculty as part of his job and, perhaps more important, it's the best way to get things done. “My belief is that the risk-takers, the people really willing

to stick their necks out are the very old or the very young,” he says. “I'm still at the university because I love teaching and being with young faculty and students.” He also aims to perpetuate the work he started with Torrance by weaving it into the university's academic fabric. “My goal is to start an undergraduate major in sustainable design, teach a studio,” he says. “If you do research, it ends up being dependent on individuals; when that person leaves, it goes away. If you bring it to the academic enterprise, it's sustained.” **CEM**





Michal Lipson in the lab with computer engineering graduate students Jacob Levy and Hugo Lira.

TRIPPING

BY LAUREN CAHOON

# THE LIGHT

**Michal Lipson**  
**pioneers**  
**photonics**  
**research.**

FANTASTIC

MICHAL LIPSON HAS A WAY WITH LIGHT. While most of us merely turn light bulbs on or off, Lipson, an associate professor in the School of Electrical and Computer Engineering, has literally bent light to her will, achieving things that seemed impossible when she first entered the field of silicon nanophotonics a decade ago. This ability to forge new paths has garnered Lipson a place of esteem and recognition in her field. She was named a MacArthur Fellow, (the “Genius Award”) in September of 2010. “When I first started, I’d give lectures on the topic, and I would always have to show a bunch of slides simply justifying the field,” says Lipson. Now, thanks in part to the work she’s done, justification for silicon photonics is no longer necessary.



Michal Lipson meets with her research group to discuss the week's progress.

## FORGING THE FIELD OF SILICON PHOTONICS

Entering Lipson's office, you'd never know that nanophotonics had once been a risky endeavor. On the fourth floor of Cornell's Philips Hall, she has a suite of grad students working at stations outside her door, and, two floors down, a lab crammed full of humming computers and photonics equipment. Her lab is now one of hundreds around the country studying how to make light an effective messenger for computing—however, without Lipson's work, the field may have never gotten off the ground. "She is widely regarded as one of the most influential figures in the field of silicon photonics," says Fan Shanhui, associate professor of electrical engineering at Stanford University. "Many of her works represent some of the first experiments that opened important directions and are almost certain to have long-lasting impacts."

Prior to Lipson's discoveries, silicon was an electronic-only material. Thus, all computer chips, which are made out of the element, relied on electric signaling. Electric signaling suffers from intrinsic energy loss as electrons travel along wires. Light, on the other hand, doesn't experience the same energy drain—thus, researchers knew that light would be a much faster and efficient method for computing. But silicon was not a photon-friendly material—which was a

**H**er lab is now one of hundreds around the country studying how to make light an effective messenger for computing—however, without Lipson's work, the field may have never gotten off the ground.

problem; the infrastructure of the billion-dollar microelectronic industry is built for silicon.

Lipson took on the challenge, manipulating silicon so that its optical properties were amplified. After five years of hard work, her group was the first to demonstrate that silicon could be an optic material, ushering in a new field and new opportunities for science. "We made silicon into a very good optical material," Lipson says.

"When she started here, silicon optics was considered a very risky research field," says former ECE director Clifford Pollack, who hired Lipson to work at Cornell. "[Now] I think every engineering school in the world wishes they had hired her! She is a true visionary and leader in her field and almost everyone recognizes that."

Lipson also recalls the time when her career path was considered dicey. "I got a lot of advice from people not to pursue this field because it was too risky," recalls Lipson, who also joked that the field "didn't exist" when she first started looking into silicon photonics. She admits there were times where she was tempted to follow this advice. She was also without any strong female role models. "When I started in optics, I could count the number of women in the field literally on one hand."

She recalls how when she gave birth to her youngest son, six years ago, there was no paid maternity leave. "So I opted not to take maternity leave," she says. "Obviously I needed to continue the research—the research didn't stop." While maternity rules have changed since then, Lipson says women face a more subtle set of issues today.

Lipson says that the type of discrimination women now see in science and engineering is different from the overt sexism of times past. She's dubbed it

**L**ipson took on the challenge, manipulating silicon so that its optical properties were amplified. After five years of hard work, her group was the first to demonstrate that silicon could be an optic material, ushering in a new field and new opportunities for science.

“subtle discrimination,” and describes it as sometimes subconscious, often just out of ignorance or habit due to the fact that women are a minority in these fields.

She stresses that while it’s subtle, this type of discrimination can discourage women from pursuing a career in the sciences. After an incident of subtle discrimination, “a woman might go home and feel very small, and she won’t know why,” says Lipson. “When you are young and just starting your career, this can really change your outlook.”

While she’s now in a confident place, Lipson hasn’t forgotten what it’s like to be a woman just starting in the world of science and engineering research. She has a link on her Cornell Web site that provides resources for female students and young faculty looking for advice and information on their career steps. Lipson says she has numerous women contacting her for guidance. Her main advice on subtle discrimination? Be aware of it, but don’t internalize it. “Try to brush it off,” she says.

Lipson says it took success for her to finally feel comfortable in her field. “Women are looked at under a magnifying glass,” she says. But she doesn’t view this as a bad thing. “It was just a motivator—the bar was higher.”

So Lipson stayed motivated, graduating from the Israel Institute of Technology and delving into the silicon and nanophotonics field—first as a postdoc at MIT and then on to Cornell. “I was looking for the shortest path to the highest impact,” says Lipson, “and this was definitely the path.”

## SCI-FI EXPERIMENTS AND CELEBRITY STATUS

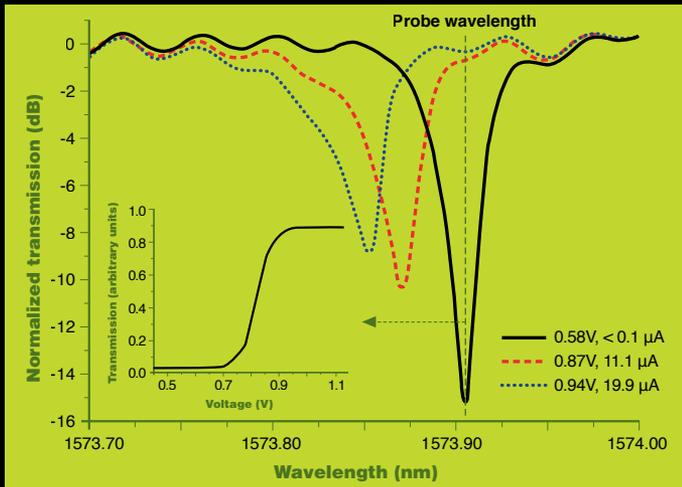
This path has taken some exciting turns, harnessing photons to do things that a mere decade ago would have been billed as science fiction. For example, by sending a light beam down a silicon tube, Lipson and her group used the physical force produced by photons to move microscopic objects. Lipson also worked with mechanical engineering professor David Erickson to use this as a biological tool for moving and examining cells. Lipson has also designed a nano-fabricated material which bends light around itself, making it effectively invisible—a nanoscale cloak of invisibility. While this technology has only been used to hide very small objects, Harry Potter wannabes can take heart; “it’s not impossible [to cloak larger objects],” says Lipson. “It’s really just a technological issue.” She explains that the main roadblock is the lack of nanotech

facilities designed to fabricate materials for these larger scales, but that there are people working on making it a reality.

While levitation and invisibility are exciting applications of Lipson’s research, her proudest achievement was her 2004 discovery published in the journal *Nature*, in which Lipson and her colleagues used nanoscopic waveguides to switch light on and off in a silicon chip. This work was followed by another *Nature* paper in

the following year which opened up more avenues for optical silicon chips. Other researchers took notice. “Her research [in 2005] is the





Graph showing the optical properties (transmission) of the electro-optic modulator. The black line shows that, when no voltage is applied to the modulator, light only at a specific wavelength (near 1573.90 nm, very low transmission) does not make it to the output of the device (a “zero”). When a small voltage (red, blue lines) is applied (which changes the optical properties of the device), light at 1573.90 nm is now allowed through the device (a “one”). This high/low transmission can be switched quickly, imparting zeros and ones to an optical signal, hence imparting data on the optical signal.

foundation on which researchers are currently developing large-scale optoelectronic interconnects,” says Shayan Mookherjee, an associate professor in electrical and computer engineering at the University of California, San Diego.

This work pushed the possibility of computing using optics for data transfer closer to reality. Computing using light would not only improve efficiency, but energy use as well—standard electric computer circuitry burns so much energy that large data centers like Google need to be placed near rivers for cooling. Light, Lipson says, would make them run cooler and faster. By replacing the electronic signals with photonic ones, energy use would go down while capacity would increase; bulky wires between processors would be replaced with a few streamlined optical fibers. While light-driven data centers may be the way of the future, Lipson says that the commercial industry will need to put in significant financial investment to make it happen.

Overall, it is this work in forging the information-processing capabilities of light that garnered Lipson the MacArthur award in the fall of 2010. According to the MacArthur Foundation Web site, “Lipson’s elegant solutions to a variety of theoretical and engineering challenges in silicon photonics are paving the way



Graduate student Jacob Levy adjusts the optical signal to a photonic sample positioned under an imaging system as Michal Lipson looks on.

for the future development of practical and powerful optical computing devices.” The award recognizes something those in her field have long known. “Michal is very well respected in the engineering community,” says Amy Foster, an assistant professor of electrical and computer engineering and a past graduate student of Lipson’s. “During conferences, she is like a celebrity; you can often see other members of the community taking photos of her with their phones when she is just attending a talk or having a discussion with someone.”

Lipson’s fiancé, Alex Gaeta, a professor at Cornell’s School of Applied and Engineering Physics, says her success comes from “the ability to focus with razor precision on the essence of problems.” He adds, “She also has exceptional taste for what is the next important and interesting direction for her field.” The two are colleagues who have collaborated extensively, with more than 30 joint papers published and numerous joint grants. “I cannot imagine a more complementary collaboration with just the right merging of talents and expertise,” says Gaeta.

As for Lipson, she’s ready for the next uncharted territory. “It seems like everyone’s doing silicon photonics, it seems like maybe it’s time to leave,” she says, joking. But she’s not walking away just yet. **CEM**



omputing using light would not only improve efficiency, but energy use as well—standard electric computer circuitry burns so much energy that large data centers like Google need to be placed near rivers for cooling. Light, Lipson says, would make them run cooler and faster.

# *¡Hola!* from Santander

By SHERRIE NEGREA

**Cornell Engineering and Universidad de Cantabria create model exchange program.**





Students from Cornell and Cantabria stand with faculty from Cantabria in front of the university's civil engineering building in Santander, Spain: (from l. to r., back row): Alvaro Martínez, Eladio López, Alvaro Sanz, Jennifer Williamson '09 CE, Zaheer Tajani '09 CE, and Juan Suárez; (middle row) María Maza, Christina Gaité, Javier Vilam, Pablo Higuera, Carli Flynn '09 EnvE; Pedro Serrano (Director of the School of Civil Engineering, University of Cantabria); Jose A. Laso (Subdirector for International Relations, University of Cantabria); (front row) Yamilet Echeverria '09 CE, Jose A. Revilla (former Director School of Civil Engineering, University of Cantabria), University Rector Federico Gutiérrez-Solana, Angel Agudo (Economic Minister of the Autonomous Community of Cantabria), Jessica Oribabor '09 CE, Haley Viehman '09 CE, and Heather Hunter '09 EnvE.

WHEN ZAHEER TAJANI '09 CE WAS HIRED AT S.S. PAPADOPULOS & ASSOCIATES, INC., a water-resource and environmental consulting firm in Bethesda, Md., three months after graduating, he did not expect he would use his ability to speak Spanish on the job. Yet beginning with his interview, he was asked about his year abroad studying engineering at the Universidad de Cantabria in Spain. And months later, he found himself speaking to contractors in Spanish and translating documents into English.

"Employers are much more inclined to hire someone who's had international education and language skills," says Tajani, who also did an internship at a company in the Canary Islands as part of his exchange program experience. "I think that my experience abroad highlighted the fact that I was someone who could work under pressure."

In September of 2007, Tajani arrived in Santander, a scenic city on the northern coast of Spain, as part of a contingent of Cornell Engineering students to inaugurate an international exchange program with the Universidad de Cantabria. For the next three weeks, he and seven other Cornell juniors honed their language skills in a Spanish immersion course while living with host families before beginning two semesters of coursework, taught predominantly in English. A year later, eight Cantabrian students who had been paired with the Cornell juniors embarked on two semesters in Ithaca, taking classes and living a college life much different from their Spanish university experiences.

While the college offers exchange programs in Hong Kong and France, what makes the partnership with Cantabria unique is its curriculum: the courses offered in Spain were designed specifically to meet the third-year engineering requirements at Cornell. Because



Heather Hunter '09 EnvE and others in the program listen to a lecture at the University of Cantabria.

“I wanted to know what it was like to live outside of the United States, because you can’t really tell what it’s like to live in a country until you actually have to live and function there, and rent an apartment, and buy groceries.”

MEGAN ROTONDO '11 CE

it provides a guarantee of matching classes while affording a true cultural exchange, the program won a 2011 Heiskell Award Honorable Mention for Best Practices in International Partnerships from the Institute of International Education in March. It is the first international program at Cornell to win the award. “It is an excellent model for partnerships,” says Shannon Harrison, assistant director of higher education services at the Washington-based institute. “It was a win-win, meaning that both sides got something out of the partnership.”

**F**OR MEGAN GRAY '11 CE, SPENDING HER JUNIOR YEAR at Cantabria literally expanded her horizons since the farthest she had ever traveled from Ithaca, where she grew up, was Toronto. In the exchange program, not only did she visit construction sites around Spain, observing how tunnels and bridges were being built, but she was also able to attend Midnight Mass on Christmas Eve at the Vatican and celebrate New Year’s at the Eiffel Tower.

“It made other cultures seem a lot closer,” says Gray, who will start a master’s degree in structural engineering and materials at Virginia Tech next fall. “In the U.S., I feel like it’s so big that you can get kind of consumed in your own world and think that things are really far away from you and not relatable. But going over there, I met people from all different countries and had discussions with them. So it did open me up to different cultures.”

For Iñigo Salazar, a fourth-year student from Spain’s Basque country, spending the past year at Cornell also transformed his outlook. “I have discovered a new way of life that makes you consider what you’re going to do in your later years,” he says. After traveling throughout the United States, Salazar has decided that living and working outside of Spain is now a possibility for him, an option he had never considered before.

Although Cornell has offered study abroad programs for undergraduates since at least the 1950s, the development of such programs for engineering students has been slower. Not only do already busy engineering students have to find time to master a second language if they don’t already speak one, they must also find engineering courses abroad that match Cornell’s requirements.

“It’s very difficult to go abroad without losing time because the courses that you are taking here aren’t given in the other places,” says David Gries, former associate dean for undergraduate programs. “This always raises the issue of whether the courses

are equivalent and whether the students will learn what they need to.”

Such obstacles have prevented engineering colleges across the country from embracing international education until the last few decades. “I think engineering schools have been seeking to internationalize their students’ experience, but in terms of large-scale participation, it’s only recently that they have made this a priority,” says Peggy Blumenthal, senior counselor to the president of the Institute of International Education. “It’s challenging to fit a study-abroad experience in a fairly tight and sequenced curriculum. But increasingly, engineering schools are realizing that the careers of their graduates are going to be global careers, so their students shouldn’t be disadvantaged when other students in the same institutions are getting study-abroad experience.”

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Professor Iñigo Losada (pointing) gives a tour of his Ocean Engineering and Coasts Laboratory at the University of Cantabria.

**T**HE CANTABRIA EXCHANGE PROGRAM EVOLVED FROM a collaboration between Edwin (Todd) A. Cowen, associate professor of civil and environmental engineering, and Iñigo J. Losada, a professor of hydraulic engineering at Cantabria, who had visited Cornell several times. In the summer of 2003 while Losada was visiting Cornell for six weeks, the two brainstormed an idea for an exchange program and hammered out the details a year later, while Cowen was on sabbatical at the University of Granada.

One of the reasons Cowen decided to take his first sabbatical in Spain was his hope that his two young children would become bilingual. Just as he wanted his children to learn Spanish, Cowen also believed engineering students should be exposed to the language and the culture. “If we think about important languages for American engineers, clearly Spanish is among the top,” he says. “It’s tied with English for the second most-spoken language in the world. Clearly, after English, it’s the most important language in the United States.”

Initially designed around the civil and environmental engineering curriculum, the exchange with Cantabria has always



been open to other majors and has attracted students from both biological and mechanical engineering. In 2009 two courses specifically targeted at mechanical engineering students were added and more engineering courses are being added in spring 2012. Students are required to have only a basic foundation in Spanish to apply to the program, either significant high school experience or completion of a year of Spanish at Cornell or the equivalent.

Megan Rotondo '11 CE had visited Spain after graduating from high school in Rhode Island and had taken two Spanish courses at Cornell. But she enrolled in the exchange program because she wanted to have the experience of living in Spain and of being able to practice her language skills.

"I wanted to know what it was like to live outside of the United States, because you can't really tell what it's like to live in a country until you actually have to live and function there, and rent an apartment, and buy groceries," says Rotondo, who plans to complete an M.Eng. in mechanical engineering at Cornell in the fall. "Just vacationing in Spain, you can't really get the feel of living in a country."

One main difference between the two universities that students from both schools discovered was the teaching styles used in the engineering classes. At Cornell, the students are assigned homework throughout their classes, while at Cantabria, in traditional courses the students are typically given only a final exam to determine their grade. The exchange program classes taught in Cantabria follow more of a Cornell course model, easing the transition for both Cornell and Cantabrian students.

"Here the classes are more practical. You have homework and you have projects," says Sergio Granado Niño, a civil engineering student from La Rioja, Spain, who spent the past year at Cornell. "I like this system more, because I think I learned more."

**I**N HIS CONCRETE CLASS LAST SPRING, FOR EXAMPLE, NIÑO met two students who were members of Cornell's Concrete Canoe Team, which built a floatable craft out of lightweight concrete. Niño traveled with the 15-member team to a race in Montreal in April, and the team won part of the competition. "It was a great experience," Niño says, "because we don't have those kinds of teams in Spain."

Students in the College of Engineering have participated in exchange programs at the École Centrale in Paris and Hong Kong University of Science and Technology. Yet the partnership with Cantabria has become the most popular since it was established four years ago, says Cowen, primarily because the curriculum is

"I wish we had more programs like it. The way we would get more students abroad is to have programs tailored to their curriculum."

**MELISSA HUTSON BAZLEY**

ASSISTANT DIRECTOR OF ENGINEERING ADVISING

designed for the Cornell students and Spanish language mastery is not a prerequisite.

"I wish we had more programs like it," says Melissa Hutson Bazley, assistant director of Engineering Advising. "The way we would get more students abroad is to have programs tailored to their curriculum."

Recognizing the value of study abroad, the college is expanding the number of international programs offered to undergraduates. It is now working on a new study abroad summer program at Peking University in Beijing, in which students from six top-ranked American engineering schools will take courses taught in English by faculty members from the participating institutions.

"Engineers, more than people in many other professions, are going to work in a global environment," says Bazley. "It might mean working with supply chains that wrap all around the world. It might mean that even if they don't leave the United States, they are still going to be working with people from other countries because engineering is such a diverse profession. So I really think that students should develop the cultural complexities they need to work in an environment like that." **CEM**

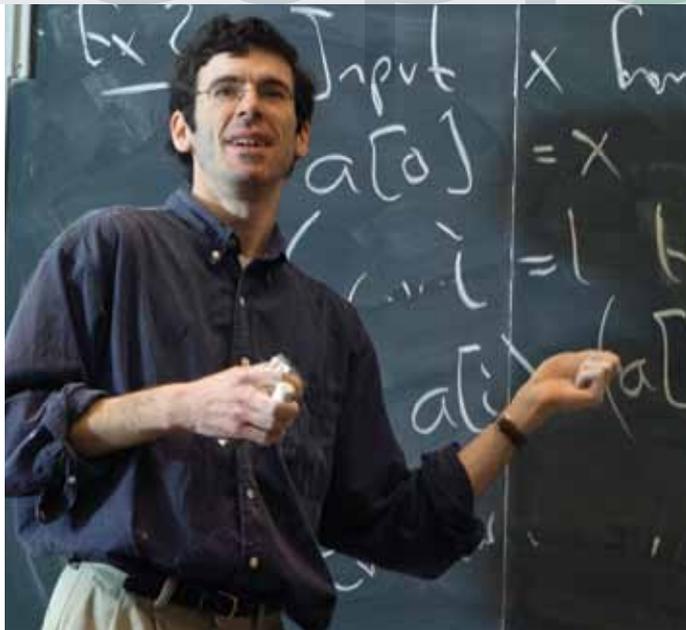
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Colorful boats adorn the harbor at Castro Urdiales, Cantabria, about 20 miles east of Santander.

Read about the experiences of Cornell Engineering students in Spain at the *Hola from Cantabria* blog: [blogs.cornell.edu/cantabria/](http://blogs.cornell.edu/cantabria/)





Jon Kleinberg

## KLEINBERG ELECTED TO NATIONAL ACADEMY OF SCIENCES

Professor **Jon Kleinberg** was among 72 new members of the National Academy of Sciences announced May 3. Election to the academy recognizes scientists' "distinguished and continuing achievements in original research."

Kleinberg, the Tisch University Professor in the Department of Computer Science, researches issues at the interface of networks and information, with an emphasis on the social and information networks that underpin the Web and other online media.

Kleinberg is a member of the National Academy of Engineering and the American Academy of Arts and Sciences. In 2005, he received a MacArthur "genius" fellowship from the John D. and Catherine T. MacArthur Foundation. He has also received Packard and Sloan Foundation fellowships and has been a recipient of the Nevanlinna Prize, ACM-Infosys Foundation Award, and National Academy of Sciences Award for Initiatives in Research.

**Paul McEuen**, the Goldwin Smith Professor of Physics and director of the Kavli Institute at

Cornell for Nanoscale Science and the Laboratory of Atomic and Solid State Physics, and Weill Cornell professor **Carl Nathan**, M.D., were also elected to the academy.

—Anne Ju



Éva Tardos

## TARDOS RECEIVES VAN WIJNGAARDEN AWARD

**Éva Tardos**, the Jacob Gould Schurman Professor of Computer Science, received the Van Wijngaarden Award from the Centrum Wiskunde and Informatica (CWI), the national research center for mathematics and computer science in the Netherlands, for her "exceptional contribution to mathematics and computer science."

Tardos' research focuses on "optimization," in which a computer is asked to find the most efficient way to organize a large number of elements. She has worked with airlines and the military on scheduling problems that require many elements—such as pilots, planes, airfield space, and passengers—to match up. Since the computer must try every possible combination to find which is best, and sometimes this can create a tremendous processing load, Tardos also works on ways to approximate ideal solutions and prevent the computer from becoming lost in unsolvable problems.

The Van Wijngaarden Award is presented every five years to two recipients. J. C. Butcher of the University of Auckland, New Zealand, is the other recipient this year.

—Bill Steele

## TWO ENGINEERING FACULTY MEMBERS RECEIVE CARPENTER ADVISING AWARDS

Vice Provost for Undergraduate Education Laura Brown announced in May that **Michel Louge** and **Mark Wysocki** are among the faculty members chosen for the 2011 Kendall S. Carpenter Memorial Advising Awards.

Louge, professor of mechanical and aerospace engineering, joined Cornell in 1985 and teaches courses in fluid-thermal sciences and mechanical synthesis. A member of the American Society of Mechanical Engineers, he is an industrial consultant on gas-solid flows and associate editor of the journal *Mechanics Research Communications*. His administrative posts at Cornell have included associate director for undergraduate programs in mechanical engineering.

His research group performs laboratory and field experiments, creates numerical simulations, models fluid mechanics and heat transfer, and develops new instrumentation for geophysical and industrial applications. Louge currently collaborates with the Université de Rennes and the University of Nottingham, and his research sponsors have included the National Science Foundation, the U.S. Department of Energy, NASA, Electricité de France, the International Fine Particle Research Institute, and the ACS Petroleum Research Fund.

Wysocki, M.S. '89, a senior lecturer in earth and atmospheric sciences, emphasizes the practical applications of meteorological concepts in his teaching. His research on air pollution includes evaluating environmental impact statements and studying effects on human health. Other research interests include weather forecasting and analysis.

He is director of undergraduate studies in atmospheric sciences, adviser to the Cornell student chapter of the American Meteorological Society, and a faculty

adviser to the Dean's Student Advisory Council. He has been lauded as a teacher, mentor, and adviser; one of his nominators described him as setting "an impossibly high standard as an adviser, certainly beyond my reach."

**Kora Bättig von Wittelsbach**, a senior lecturer in Romance studies, and **Antonio DiTommaso**, associate professor of crop and soil sciences, also received the award.

## MERRILL AWARDS SALUTE TOP STUDENTS' HIGH SCHOOL AND CORNELL TEACHERS

Since 1988 Cornell's most outstanding graduating seniors have been selected by their college deans as Merrill Presidential Scholars, and they, in turn, recognize the high school teacher who inspired their studies and the Cornell faculty member who most contributed to their university experience. This year 33 students—approximately 1 percent of graduating seniors—were selected.

The university invited the high school teachers to campus and honored the seniors and teachers with two days of events, May 24–25.

Biological and environmental engineering professor **Kifle Gebremedhin** and operations research and information engineering associate professor **Paat Rusmevichientong** were honored by two

students each. Mechanical and aerospace engineering professor **Charles Williamson** was cited for the 11th time.

The university also honors the high school teachers with Special Teachers Are Recognized (STAR) scholarships, a one-time \$4,000 scholarship in each teacher's name for a financially needy Cornell student from the teacher's high school or geographical area. STAR scholarships were established in 1989 by the late Donald Berens and his wife, Margi Berens, both Class of 1947. The late Philip Merrill '55 made the Merrill Presidential Scholars Program possible.

The 2011 Merrill Scholars from the College of Engineering, with their hometowns, followed by the names of the secondary school teachers and the Cornell faculty members the students selected for recognition:

- **Andrea Bowring**, Merion Station, Pa.; **Peter Kaczmar**, Lower Merion High School; **Darrell Schlom**, professor, materials science and engineering.
- **Bernard Cammarata**, Southborough, Mass.; **Timothy McPartlin**, Algonquin Regional High School; **Kifle Gebremedhin**, professor, biological and environmental engineering.
- **Eun Gi Chung**, Shinchundong Songpaku, South Korea; **Ryan Tyler**, Holderness School;

**Paat Rusmevichientong**, associate professor, operations research and information engineering.

- **Christopher Dembia**, Roslyn, N.Y.; **Scott Segal**, Roslyn High School; **Geoff Recktenwald**, graduate student, mechanical and aerospace engineering.
  - **Matthew Monaghan**, Hampton, N.J.; **Steven Delorenzo**, North Hunterdon High School; **Charles Williamson**, professor, mechanical and aerospace engineering.
  - **Madison Pearsall**, LaGrange, Ill.; **Anne Allaman**, Lyons Township High School; **Paat Rusmevichientong**, associate professor, operations research and information engineering.
  - **Mengliang Yu**, Shanghai, China; **Liubo Zhu**, Shanghai Yan'an Senior High School; **James Richard Shealy**, professor, electrical and computer engineering.
- George Lowery*

## DOUG JAMES RECEIVES GUGGENHEIM FELLOWSHIP

**Doug James**, associate professor of computer science, has received a Guggenheim fellowship to help support his research on computer sound synthesis.

In its 87th annual competition for the United States and Canada, the John Simon Guggenheim Foundation awarded 180 fellowships to artists, scientists, and scholars, chosen from some 3,000 applicants.

James conducts research on computer graphics with particular focus on creating animation that conforms to the laws of physics and synthesizing realistic sounds based on the physical properties of animated objects, so that sounds accompanying animation can be based on the animation itself rather than being dubbed in from recordings. He has developed algorithms to synthesize the sounds of splashing water, breaking glass and china, and the noisy vibrations of such objects as cymbals and garbage cans. The work has applications ranging from video games to virtual reality training simulations.

He will use the fellowship to support research during his coming sabbatical, which, he said, will include developing more realistic sound models and efficient algorithms, as well as work on a book on physics-based sound rendering.

The Guggenheim Foundation supports science and the arts with "a commitment to funding individuals at the highest level to do the work they were meant to do."

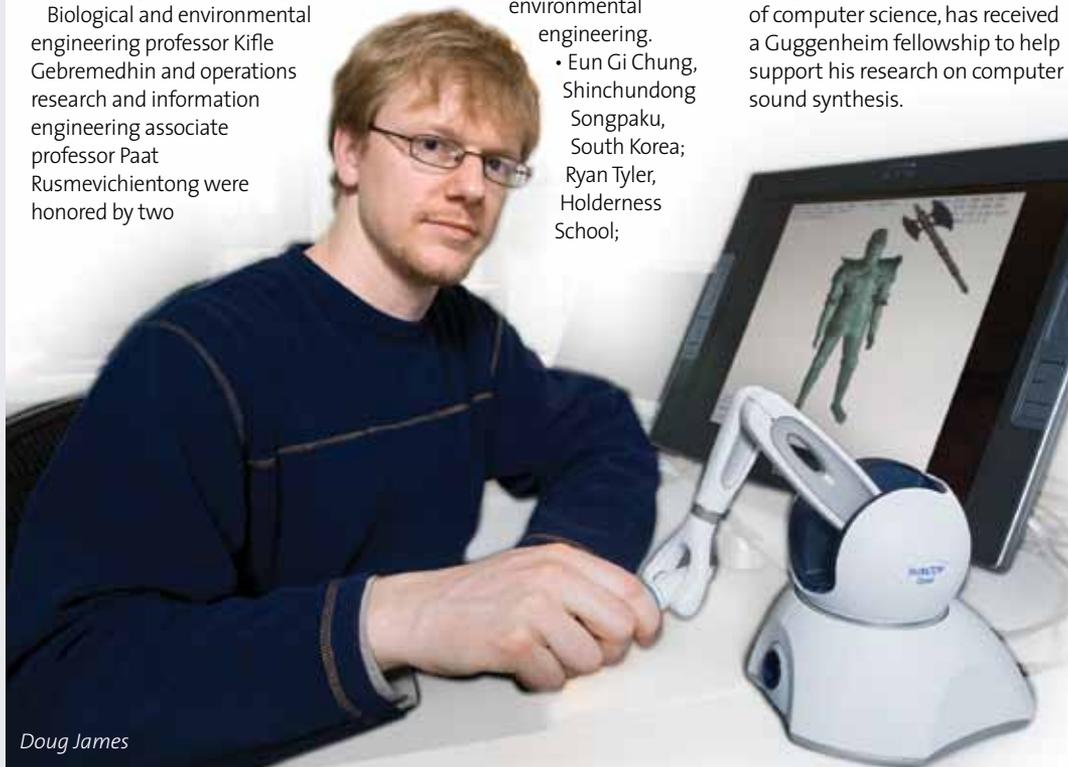
—*Bill Steele*

## TWO RECEIVE HUMBOLDT RESEARCH AWARD

Two Cornell Engineering faculty members have received a Humboldt Research Awards.

**David P. Williamson**, professor of operations research and information engineering, and **Johannes Gehrke**, professor of computer science, were recognized for "fundamental discoveries, new theories or insights" that have had "significant impact" on a certain discipline.

Williamson studies the design



Doug James



David P. Williamson

and analysis of polynomial time algorithms for the approximate solution of hard problems in discrete optimization, especially problems arising in network design, scheduling, facility, location, and routing. He focuses on the use of techniques from the area of mathematical programming for designing such algorithms, including such techniques as the primal-dual method and semidefinite programming.

Award winners are invited to spend up to a year cooperating on a long-term research project with specialist colleagues at a research institution in Germany. Williamson was nominated for the award by professor Martin Skutella of the Berlin Institute of Technology.

Gehrke is a specialist in database systems, data mining, data privacy, and applications of database and data mining technology to marketing and the sciences. He received the award to support a collaborative research project with Peter Druschel, scientific director of the Max Planck Institute for Software Systems in Saarbruecken, Germany.

The award of 60,000 euros (about \$80,000) enabled Gehrke to spend eight months in Germany, working with Druschel and other Planck Institute researchers on data-intensive distributed systems that make up



Johannes Gehrke

the software infrastructure inside such large Web companies as Amazon, Yahoo!, and Google.

The Humboldt Foundation, established by the Federal Republic of Germany in 1953, grants about 100 awards annually to enable foreign scientists to work in Germany and German scientists to work in other countries. Alexander von Humboldt (1769–1859) was an explorer and naturalist noted for his patronage of young scientists and scholars.

### ROANNA RUIZ RECEIVES DEFENSE DEPARTMENT FELLOWSHIP

**Roanna Ruiz**, a second-year Ph.D. student in the field of biomedical engineering, has been selected out of more than 2,900 applicants to receive a 2011 National Defense Science and Engineering Graduate Fellowship awarded by the Department of Defense.

The scholarship provides tuition and a stipend for three years of study. The fellowships are awarded “to individuals who have demonstrated the ability and special aptitude for advanced training in science and engineering,” in fields of interest to national defense.

Ruiz, a native of Boston, came to Cornell in 2009 after earning her B.S. in biomedical engineering from Harvard University. Her research at Cornell, advised by Dan Luo, professor of biological and environmental engineering, combines the specialty of the Luo lab—where DNA is used as a material for constructing nanoscale structures, and not as a genetic material—with microfluidic systems in which biological materials can be moved through nanometer-sized tubes on a silicon chip. She plans to create devices to develop novel drugs, produce proteins without requiring cells, and enhance point-of-care medical devices.

### SCHOEN AWARDED UDALL SCHOLARSHIP

**Andrew Schoen** ’12 has received a 2011 Morris K. Udall Scholarship, which is awarded to U.S. students with excellent academic records and an interest in careers in environmental public policy, health, and tribal public policy. This year, 80 scholars were selected from a pool of 510 applicants from 231 institutions.

Schoen, who is pursuing a dual degree in economics and science of earth systems (in the College of Arts and Sciences and the College of Engineering), focuses on solutions that make both economic and environmental sense. He founded a sustainable investment firm in 2008 called Adams Financial LLC, and is the managing director of the Cornell Venture Capital Club.

Before transferring to Cornell, Schoen studied the intersection of economics and the environment at Cambridge University (United Kingdom, summer 2010) and at Yonsei University (South Korea, spring 2010). Originally a student at the University of California–Santa Barbara, Schoen conducted university-sponsored research on the relationship between toxic emissions and economic output.

After graduation, his goal is to “develop a venture capital firm

that supports environmentally sound businesses and is itself run sustainably, [thereby] demonstrating that economic prosperity need not be built on environmental degradation.”

Karen Chi Lin ’13, an architecture student in the College of Architecture, Art, and Planning, also received a 2011 Udall Scholarship.

The Udall scholars garnered awards up to \$5,000 each. Since 1998, 31 Cornell students have won Udall scholarships.

### FOUR ENGINEERING STUDENTS RECEIVE XEROX SCHOLARSHIPS

Four Cornell Engineering students have been awarded a Technical Minority Scholarship by the Xerox Corporation. They are among 125 graduate and undergraduate students from across the country recognized for their high academic achievement in the fields of science, engineering, and technology.

The scholarship recipients and their majors are: **Matthew Cong** ’11, computer science; **José Carlos Hirshman Mateos** ’15, undeclared; and **Anil Singhal** ’13 and **Kimberly Yeh** ’14, chemical engineering. “I’m delighted that four of our undergraduate students are recipients of the 2011 Xerox Technical Minority Scholarship,” said Lance Collins, the Joseph Silbert Dean of Engineering. “This is an extremely competitive program, and Matthew, José, Anil, and Kimberly should feel very proud to have been chosen for such a prestigious award.”

The scholarships provide \$1,000–\$10,000 toward college tuition costs, depending on merit and need. They are available to minority students enrolled in technical degree programs at the bachelor’s degree level or above. Eligible students must have a grade point average of 3.0 or higher and show financial need. This year’s recipients were chosen from a pool of 733

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Allison Truhlar '11 BE

qualified applicants.

"At Xerox, we take seriously our responsibility to invest in tomorrow's multi-cultural leaders. It ensures a future workforce full of unique perspectives that will drive our business and our country forward," said Joseph Cahalan, president, The Xerox Foundation, which funds the scholarship program.

Since the program began in 1987, the Xerox Technical Minority Scholarship program has provided nearly \$2.6 million in funding to help approximately 1,900 students achieve their academic and professional goals.

## TRUHLAR '11 BE NAMED GATES CAMBRIDGE SCHOLAR

Allison Truhlar, a biological and environmental engineering senior at Cornell University, has been selected to be a Gates Cambridge Scholar. She was one of 30 new recipients of the full tuition scholarship for graduate study at the University of Cambridge announced last month.

Truhlar, from Stony Brook, N.Y., will study in Cambridge's Department of Zoology with Dr. David Aldridge. "My proposed project will investigate whether the valve movements of freshwater mussels can be used to detect pollution events," she writes on the Gates Cambridge

Trust Web site. "After Cambridge, I plan to work towards a Ph.D. in environmental engineering with the ultimate goal of becoming a professor of the subject."

According to the trust, Gates Cambridge Scholarships are awarded on the following criteria: intellectual ability, leadership capacity, a person's desire to use their knowledge to contribute to society throughout the world by providing service to their communities and applying their talents and knowledge to improve the lives of others, a good fit between the abilities and aspirations of the applicant and what the University of Cambridge can offer in its graduate program.

All applicants for the scholarship apply for—and must gain—admission to the University of Cambridge.



## SNAVELY NAMED MICROSOFT FELLOW

Noah Snavely, assistant professor of computer science, has been named one of eight Microsoft Research Faculty fellows for 2011.

The awards, previously known as Microsoft New Faculty Fellowships, are intended to support young scientists "who are advancing computing research in novel directions with the potential for high impact on the state of the art, and who demonstrate the likelihood of becoming thought

leaders in the field."

The fellowship includes a cash award of \$200,000 given over two years and access to Microsoft resources such as software, invitations to conferences, and engagements with Microsoft Research.

Snavely has applied the techniques of computer vision to still photographs to match the details of many photos and stitch them together into 3-D renderings. To demonstrate, he has created 3-D images of popular tourist destinations from the hundreds of images posted to the Flickr photo-sharing website and launched an online game, PhotoCity, in which Cornell and the University of Washington (where Snavely began his research as a graduate student) are competing to build 3-D campus maps. Microsoft has developed the technology into an application called Photosynth, which it ties in with Bing Maps.

There are uses for the technology, Snavely said, in online tourism and education, preserving art that might someday be lost, and showing how places change over time. A future direction, he added, will be to organize all the images that exist online into a calibrated set, "to combine all these cameras all over the world into a big distributed camera you can use to image anything you want."

He plans to use the Microsoft funding to expand his research



Noah Snavely

group. "I think this is a great opportunity to build a group that will be excited about these new ideas," he said.

Snavely joined the Cornell faculty in 2009. He earned his B.S. in computer science and mathematics at the University of Arizona in 2003, and his Ph.D. in computer science at the University of Washington in 2008.

—Bill Steele



3-D model of Uris Library, assembled from still photos taken by participants in the PhotoCity game.

## Water Woman

M.S. student helping develop environmental policy in Panama.

Casey Garland isn't just *thinking* globally. Supported by a fellowship from the Council of Women World Leaders, the BEE M.S. student from Canton, N.C., is working in Panama to develop policies to protect that country's natural resources.

"They have a lot of land use change," Garland says. "People are converting a lot of the forestland into agricultural land and so they're getting a lot of runoff and it's filling up the Panama Canal."

Garland started at Panama's environmental protection agency, the Autoridad Nacional del Ambiente, in August. So far she has been involved in developing an action plan for Reduce Emissions from Deforestation and Forest Degradation, a UN-funded program that provides developing nations funding to decrease deforestation. By creating carbon sinks through reforestation, the program aims to allow the 35 participating countries to participate in the emissions trading market while improving the environment.

"...they had a workshop at the Smithsonian Tropical Research Institute to review and brainstorm the proposal," Garland writes on her blog, *Cartas from the Isthmus*. "I was able to attend this along with other collaborators from the public and private sector."

Garland graduated magna cum laude from North Carolina State University in May 2010 with a Bachelor of Science in biological engineering with an environmental concentration. For her capstone design project, she worked with a team designing a multiplexer system to monitor

groundwater contaminants with high spatial and temporal resolution.

"What we wanted was to be able to set a unit down in the field and have it take samples automatically and wirelessly transmit the data," she explains. "We didn't want to go out there and sample every part of the field because of the time lag involved and our results would be limited to the time we were there. With this, you could sample every 10 minutes if you wanted to."

While at N.C. State Garland also worked in research and extension with local farmers. "I worked with a professor in swine houses and broiler houses trying to reduce the emissions that are coming out," she says. "For the broiler houses, we were testing bedding developed by the USDA to see if it actually worked or not. The swine houses were a solar wall project to see if we could get them heated more efficiently."

Garland was also involved with the International Student Program, and participated in cultural programs in India and Turkey. "I'm really interested in other cultures and I know that water is a big concern, and not just for people here, but everywhere in the world needs water," she says.

In high school, she worked for the Great Smoky Mountains National Park doing biodiversity research. "We caught salamanders because we were trying to find different species to see what was in there. I remember loving that," she says. "I was always interested in the environment and being outside and always loved water activities and it just kind of expanded into looking at the science of it."



PROVIDED

After her fellowship, Garland plans to conduct research on bacterial and chemical contaminants in rural water supplies in the Ethiopian Highlands with biological and environmental engineering professor Tammo Steenhuis.

"I'm very interested in international development and a lot of what I wanted to work on coming to Cornell was how I could use my environmental engineering experience in an international setting," she says. "And also, to be able to have my project overseas so that I would be working in that context. So I would get the experience of not only providing the information and assessing the problem, but also how to, in a practical sense, fix the problem—how it's actually going to work out as far as policy and working with different organizations because there's so many different players that have a vested interest in all these different projects."

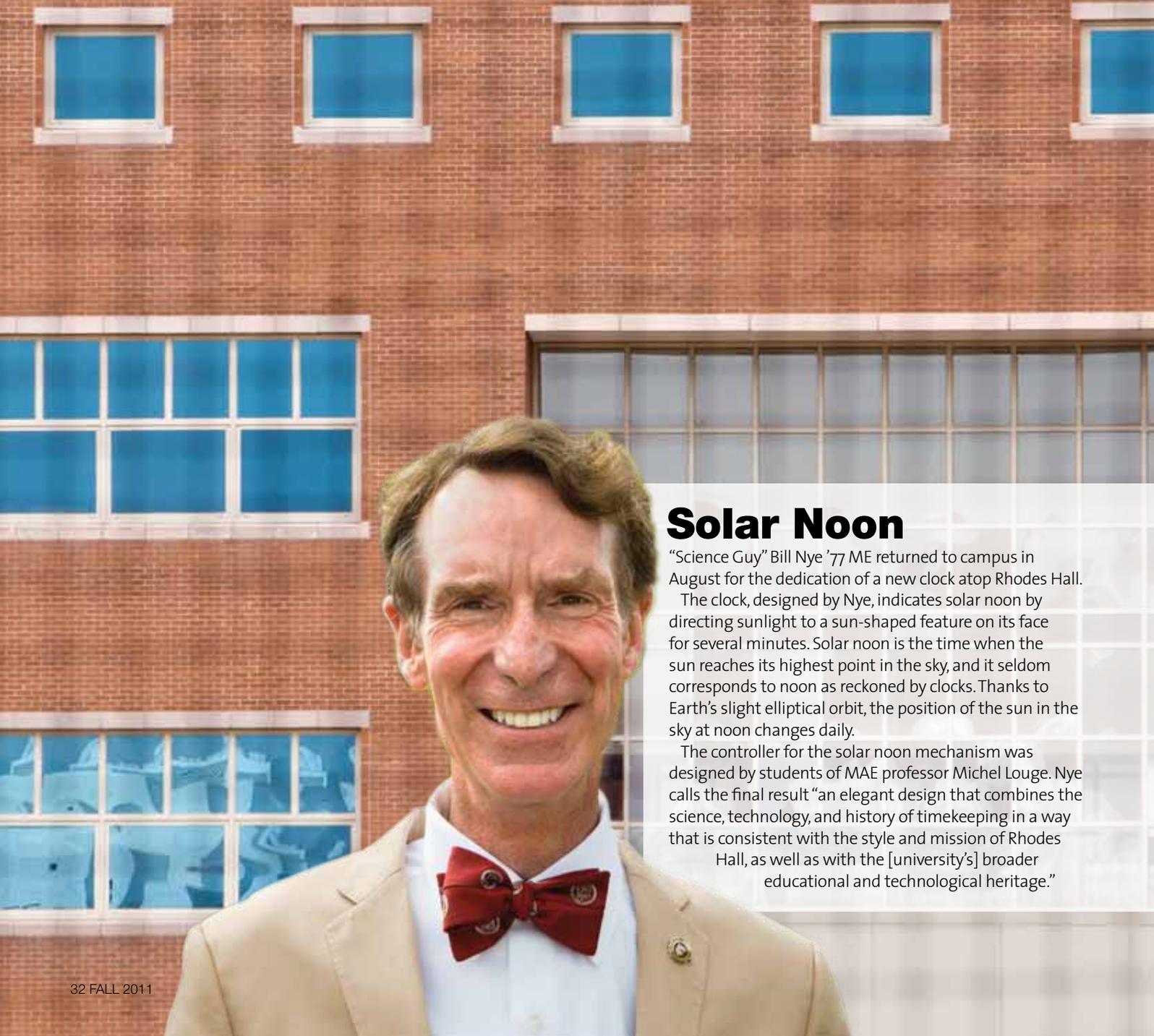
At Cornell, Garland is an active member of Alpha Epsilon and works with Community Building Works building sustainable, green housing in New York State and abroad. She has also joined Ithaca's community rugby team, the Avengers. "I did it in North Carolina. A friend got me into it," she says. "I was like I don't know, but then I came out to one practice and that was it. I was like, 'This is too good. They let me hit people and it's OK. It's encouraged.'"

— Robert Emro



Casey Garland drags a tackler as she carries the ball for the Avengers, Ithaca's community rugby team.

PROVIDED



## Solar Noon

“Science Guy” Bill Nye ’77 ME returned to campus in August for the dedication of a new clock atop Rhodes Hall.

The clock, designed by Nye, indicates solar noon by directing sunlight to a sun-shaped feature on its face for several minutes. Solar noon is the time when the sun reaches its highest point in the sky, and it seldom corresponds to noon as reckoned by clocks. Thanks to Earth’s slight elliptical orbit, the position of the sun in the sky at noon changes daily.

The controller for the solar noon mechanism was designed by students of MAE professor Michel Louge. Nye calls the final result “an elegant design that combines the science, technology, and history of timekeeping in a way that is consistent with the style and mission of Rhodes Hall, as well as with the [university’s] broader educational and technological heritage.”



## 7 Ways to

# Engage the Network

When it comes time to explore career options, Cornell Engineering students and recent alumni rely on the time and talent of their predecessors. Connecting the generations is a Cornell tradition that has enriched the lives of students and alumni since the university's founding. Today, there are many ways to engage. Mentoring-related opportunities can range from one day to several months. Learn more:

1. Engineering Co-op Program – Help student find 7-month jobs, housing, and fellowship



2. CCNET Mentors – Mentor students or alumni, or seek an alumni mentor



3. Extern Program – Job shadowing for upperclass students



4. FRESH Program – Job shadowing for first-years



5. Networking and Information Interviewing

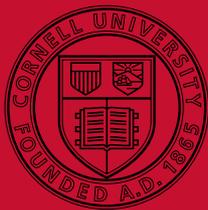


6. Summer Jobs and Internships



7. President's Council of Cornell Women (PCCW) Alumnae – Student Event





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# BETTER TOGETHER

Buildings use 40 percent of the energy consumed in the United States.

Cornell engineers, architects, and computer scientists are working together to change that.

PAGE 14

