SPRING
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CORNELL ENGINEERING
MAGAZINE

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nanoscale solutions
to Global Problems

contents

DEPARTMENTS

CORNELL ENGINEERING MAGAZINE/SPRING 2009

Features

news

Fuchs named provost; Ober interim dean

JASON KOSKI/UNIVERSITY PHOTOGRAPHY

Chris Ober began serving as interim dean Jan. 1, when former dean Kent Fuchs became Cornell provost.

W. Kent Fuchs, the Joseph Silbert Dean of Engineering since 2002, became Cornell's provost Jan.1.

"Kent brings to this post great knowledge of Cornell, strong leadership abilities, and a clear vision of the future," said President David Skorton when Fuchs was named provost in October.

In a prepared statement, Skorton said: "I am delighted that Kent Fuchs has accepted the challenge of being Cornell's next provost. He is a strong and respected administrator who has led the Engineering College with foresight, vitality, and innovation—attributes he will bring to his new appointment. I look forward to benefiting from his leadership and insight as Cornell's academic enterprise moves into an even brighter future."

Fuchs said: "I look forward to serving Cornell's faculty, students, and staff, and working to fulfill President Skorton's vision for our campus. We are blessed with wonderful leadership across the university, and I will devote all my energy and time to helping those leaders enhance Cornell's stature, scholarship, and teaching. The next few years are strategically important, and it is therefore a particular honor to be asked at this time to help guide the academic mission of our beloved Cornell."

Christopher K. Ober, Cornell's Francis Bard Professor of Materials Science and Engineering, began serving as interim dean when Fuchs became provost.

"Chris is an exemplary leader and faculty member at Cornell," then interim Provost David Harris said when Ober's appointment was announced last year. "He is well respected by his peers, and he is known for attention to detail. He will be deft in running the College of Engineering while the university proceeds in the dean search. I am delighted he has agreed to serve in this capacity."

Cornell Vice Provost John Siliciano chairs the Engineering Dean Search Committee, which has completed a position announcement for the deanship and is now working aggressively to identify potential candidates.

—*Lauren Gold*

TAM merging with MAE

The College of Engineering announced in December that the Department of Theoretical and Applied Mechanics (TAM) will merge into the Sibley School of Mechanical and Aerospace Engineering (MAE). The director of MAE assumed responsibility for all TAM resource decisions, including budget and space allocation, Jan. 1.

Provost Kent Fuchs, dean when the decision was announced, called the decision difficult but necessary in order to invest resources in strategically important areas. "This decision will allow Cornell to strengthen mechanics in the college, building on the heritage of faculty excellence in both TAM and MAE," he said. "In focusing our resources at this time, I know the college will emerge even stronger than we are now." President David Skorton expressed his support for the decision: "This merger is the result of considerable planning and discussion within the College of Engineering," Skorton said. "It is an example of the kind of strategic thinking we will rely on to make the best long-term decisions for the university, particularly as we face extraordinarily challenging financial times in the short term."

Fuchs appointed a faculty transition committee to develop detailed plans for implementing the merger. The graduate field of theoretical and applied mechanics and its associated degree programs are expected to continue. The college will maintain funding commitments to TAM students.

Cornell is the last of the top-ranked engineering colleges to maintain a TAM department.

AARON CHEN '09

Adrian Rami '10 (left) and Parry Grewal '10 with Bender, which placed first at the National ChemE Car Competition in Philadelphia, Nov. 16.

Cornell ChemE Car wins national competition

With their shoebox-size car powered by a hydrogen fuel cell, the 18-member undergraduate ChemE Car Team placed first at the American Institute of Chemical Engineers student-car competition in Philadelphia Nov. 16, beating out more than 30 other teams. The win propels them to the international competition in Montreal next August.

The car also made history by being the first ever to stop exactly at the target distance as outlined by competition rules. The car is called Bender, after the character from the TV show "Futurama."

The competition required students to build a $2,000 car, powered by a chemical reaction of their choice, that could travel 60 feet carrying a water payload of 250 milliliters. Within two minutes, it had to go the required distance and come to a complete stop—a rule the Cornell students call "the bane of many excellent cars (They just kept going and going and going...')." The stopping mechanism also had to be triggered by a chemical reaction—in other words, brakes are illegal.

The Cornell students designed their stopping mechanism around an iodine-starch mixture, which turns opaque after a certain time, depending on the amount of chemicals used. A photosensor detects the change, which trips a circuit that cuts the power from the fuel cell to the motor.

In addition to a $2,000 first-place prize and a trophy, the team also earned the "Best Consistency" prize, which took the average of two runs. After Bender's perfect first run, it again performed admirably, stopping within about 4 feet of the target.

"There's definitely an element of luck for all the teams, but the fact that we got 'Best Consistency' shows that our win wasn't a fluke," said Shihao Koh '10.

—*Anne Ju*

PROVIDED

New nano method opens novel playground

Cornell researchers have developed a method to self-assemble metals into complex nanostructures. Applications include making more efficient and cheaper catalysts for fuel cells and industrial processes and creating microstructured surfaces to make new types of conductors that would carry more information across microchips than conventional wires do.

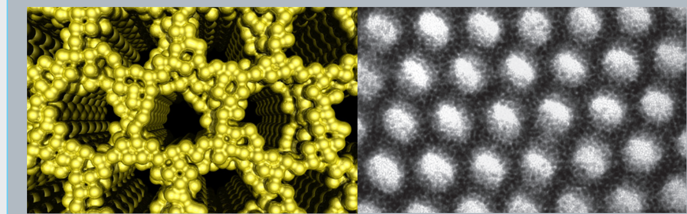
The method involves coating metal nanoparticles—about 2 nanometers in diameter—with an organic material known as a ligand that allows the particles to be dissolved in a liquid, then mixed with a block co-polymer (a material made up of two different chemicals whose molecules link together to solidify in a predictable pattern). When the polymer and ligand are removed, the metal particles fuse into a solid metal structure.

"The polymer community has tried to do this for 20 years," said Ulrich Wiesner, Cornell professor of materials science and engineering, who, with colleagues, reported on the new method in the June 27 issue of *Science*. "But metals have a tendency to cluster into uncontrolled structures. The new thing we have added is the ligand, which creates high solubility in an organic solvent and allows the particles to flow even at high density."

In addition to making porous materials, the researchers said, the technique could be used to create finely structured surfaces, the key to the new field of plasmonics, in which waves of electrons move across the surface of a conductor with the information-carrying capacity of fiber optics, but in spaces small enough to fit on a chip.

"This is exciting," Wiesner said. "It opens a completely novel playground because no one has been able to structure metals in bulk ways. In principle, if you can do it with one metal you can do it with mixtures of metals."

—*Bill Steele*



WIESNER LAB

Computer simulation (left) shows how platinum nanoparticles will fuse into a structure with tiny pores after the polymers that guide them into position are removed. Electron microscope photo of the actual structure (right).

Cornell Engineering sports new look

Cornell Engineering has launched a redesign of its communications as the result of a two-year project that included review of all the college's existing communication materials as well as an assessment to determine the distinctive characteristics that set Cornell apart from other engineering colleges. The goal was to develop clear and consistent messages to present the breadth and depth of the college.

Focus groups and surveys of all College of Engineering constituents pinpointed the dual strengths of the college's interdisciplinary, collaborative approach to innovation and its connection to the world-class resources of Cornell University.

This theme, promoting the collective strength of the college's departments as well as their individual specialties, has been carried out in a series of new publications for corporate partners, donors, prospective graduate students, and other key constituents.

This is the first issue of *Cornell Engineering Magazine* to incorporate the new design elements. The college's Web site will soon display the new look as well.

A near-space image showing the curvature of the earth, taken on one of Project Blue Horizon's launches.

Students pop balloon record

Early-career engineers at Lockheed Martin who are also earning engineering degrees at Cornell broke the world amateur high-altitude balloon record in a near-space flight that exceeded 125,000 feet.

The 19 graduate students are part of Lockheed Martin's Engineering Leadership Development Program. The balloon launch was the capstone effort of Project Blue Horizon (PBH), an educational component of the three-year program. The students are employed at Lockheed Martin Systems Integration in Owego, N.Y., while completing their systems engineering master's degrees at Cornell.

The students' flight beat the previous amateur altitude record by nearly 5,000 feet, according to the company. PBH is a space-flight program that incorporates amateur radio (also known as ham radio) technologies, explained Michael Baldwin, PBH chief engineer. Onboard Global Positioning Systems and amateur radio technology allow for monitoring of launch, ascent, descent, and recovery, with high-resolution images 20 miles above the earth's surface recorded.

The balloon is made of latex—not unlike those at birthday parties—and stretches up to 40 feet in diameter, according to Baldwin. Many agencies and companies are examining high-altitude balloon flight for exploration and surveying, as well as for detecting radio frequencies.

In two previous flights, the PBH team had discovered that optimizing the amount of helium in the balloon was a key component to a successful mission, Baldwin said. In the latest flight, the students also placed a blanket over the balloon's payload to reduce radiation exposure.

"We were all really enthused and wanted to do this, but there was no way one of us could have done this by ourselves," Baldwin said. "We really had to work together as a team efficiently."

Future teams will launch missions that include long-duration flights, trans-Atlantic flights, multi-balloon missions, and the release of unmanned vehicles from near-space altitudes, according to the company.

—*Anne Ju*

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Institute for Computational Sustainability launched with $10-million NSF grant

CONSERVATION FUND

Forest corridors like this could connect separated habitats of endangered species to enhance their survival. Balancing the cost of the land against the best routes is a problem in computer optimization.

The Institute for Computational Sustainability has been launched at Cornell with a $10-million grant from the National Science Foundation, under a program designed to pursue "far-reaching research agendas that promise significant advances in the computing frontier and great benefit to society."

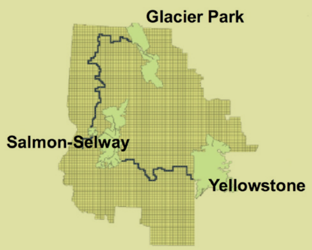
Directed by Carla Gomes, Cornell professor of computing and information science, the institute involves 14 Cornell faculty members along with scientists at Oregon State University, Howard University, Bowdoin College, the Department of Energy's Pacific Northwest National Laboratory, and the Conservation Fund.

"Our vision is that computing and information science can—and should—play a key role in increasing the efficiency and effectiveness of the way we manage and allocate our natural resources," Gomes said.

Many of today's problems in ecology and conservation involve juggling large numbers of variables, often to find the optimum way to balance them. Some are so complex, the researchers say, that they will require new advances in computer science. Gomes and her team hope to create a new field of computational sustainability, analogous to computational biology, that will stimulate new developments in the computer science areas of constraint optimization, dynamical systems, and machine learning. The researchers are also launching a new *Journal of Computational Sustainability*.

The institute will collaborate extensively with the Cornell Center for a Sustainable Future and a number of other sustainability programs on campus. But, said Gomes, "Our mission is to extend beyond the initial members of the institute, including graduate and undergraduate students in the Cornell community in other disciplines. If there is someone who has a nice computational problem about wind turbines or solar energy, for example, we want to collaborate with and help support them."

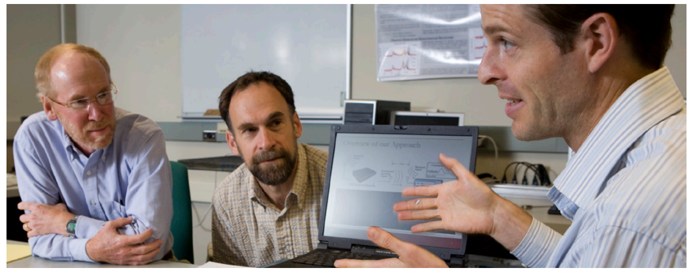
—*Bill Steele*



PROVIDED

Grizzly bears live in three widely separated areas in Idaho, Wyoming, and Montana. Computer optimization can balance distance and suitability against the cost of the land to design a connecting corridor, as in the example above.

Cornell engineers show GPS can be spoofed



ROBERT BARKER/UNIVERSITY PHOTOGRAPHY

Todd Humphreys Ph.D. '07 Aero (right) discusses with professors Paul Kintner (left) and Mark Psiaki how a GPS receiver can be "spoofed," based on the researchers' work at Cornell.

A group of Cornell researchers have shown that global positioning system (GPS) technology can be "spoofed," or tricked by fake signals.

The researchers, led by Paul Kintner, professor of electrical and computer engineering, and Mark Psiaki, professor of mechanical and aerospace engineering, presented a paper on their findings at a meeting of the Institute of Navigation, Sept. 19 in Savannah, Ga.

To demonstrate how a navigation device can be fooled, the researchers programmed a briefcase-size GPS receiver, used in ionospheric research, to send out fake signals.

Paper co-authors Brent Ledvina, Ph.D. '07 and now an assistant professor of electrical and computer engineering at Virginia Tech, and first author Todd Humphreys, Ph.D. '07, described how the "phony" receiver could be placed in the proximity of a navigation device, where it would track, modify, and retransmit the signals being transmitted from the GPS satellites. Gradually, the "victim" navigation device would take the counterfeit navigation signals for the real thing.

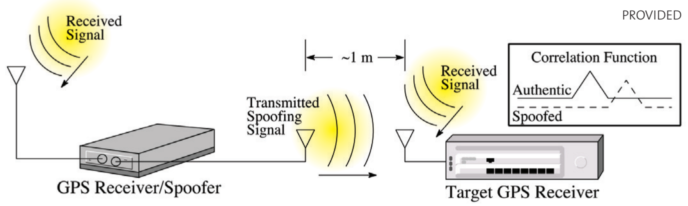
"GPS is woven into our technology infrastructure, just like the power grid or the water system," said Kintner, director of the Cornell GPS Laboratory. "If it were attacked, there would be a serious impact."

By demonstrating the vulnerability of receivers to spoofing, the researchers believe they can help devise methods to guard against such attacks.

"Our goal is to inspire people who design GPS hardware to think about ways to make it so the kinds of things we're showing can be overcome," said Psiaki.

—*Anne Ju*

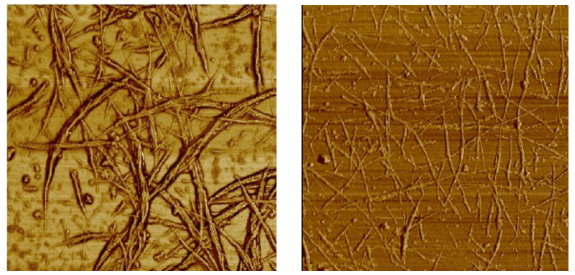
PROVIDED



An illustration showing how a GPS receiver/spoofer would transmit a false signal that a target GPS receiver could mistake for an authentic one.

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

Carbon nanotube 'ink' may lead to thinner, lighter transistors and solar cells



PROVIDED

An atomic force microscope image of both metallic and semiconducting carbon nanotubes, before the cycloaddition process of removing the metallic tubes (left). An atomic force microscope image of semiconducting nanotubes, after the cycloaddition process of removing the metallic tubes (right).

Using a simple chemical process, scientists at Cornell and DuPont have invented a method of preparing carbon nanotubes for suspension in a semiconducting "ink," which can then be printed into such thin, flexible electronics as transistors and photovoltaic materials.

The method, which involves treating carbon nanotubes with fluorine-based molecules, is reported in the Jan. 9 issue of the journal *Science* (Vol. 323, No. 234). The research was jointly led by Graciela B. Blanchet, a research fellow at DuPont, and George Malliaras, Cornell associate professor of materials science and engineering and the Lester B. Knight Director of the Cornell NanoScale Science and Technology Facility. Helen Lu, a research chemist at Dupont, and Mandakini Kanungo, a former Cornell postdoctoral fellow now at Xerox, also worked on the project.

Carbon nanotubes are good candidates for transistors in low-cost, printable electronics, but only after large quantities of them have been converted into semiconductors. When carbon nanotubes are grown in the lab, some are semiconducting but others are metallic, and they are difficult to separate from each other.

This mix is a major drawback in creating transistors from nanotubes, Malliaras said. The Cornell/DuPont team concentrated on a new, inexpensive way to eliminate the metallic tubes, preparing them for such applications as suspension in semiconducting ink for printing.

To do so, the researchers brought fluorine-based molecules into contact with the nanotubes. Through a process called cycloaddition, the fluorine molecules efficiently attacked or converted the metallic nanotubes, leaving the semiconducting tubes alone, and creating a perfect batch of solely semiconducting nanotubes.

"Our work suggests that careful control of the chemical reaction enables the complete conversion of metallic tubes without the degradation of semiconducting tubes," Blanchet said.

The work should lead to exploration of a wide range of devices, such as novel organic photovoltaic structures, Malliaras added.

—*Anne Ju*

Cornell researchers seek to save precious minutes in deploying ambulances

ANNE JU/CORNELL CHRONICLE

From left, Huseyin Topaloglu, Mateo Restrepo, and Shane Henderson in Henderson's office in Rhodes Hall. The laptop shows a simulation of ambulance calls that the researchers are working to perfect.

A National Science Foundation grant of almost $300,000 is allowing three Cornell researchers to perfect a computer program that estimates how best to spread ambulances across a municipality to get maximum coverage at all times.

Associate Professor of Operations Research Shane Henderson, Assistant Professor of Operations Research Huseyin Topaloglu, and applied mathematics Ph.D. student Mateo Restrepo are working on a computerized approach to take such available information as historical trends of types and incidences of calls, geographical layout, and real-time locations of ambulances to figure out where ambulance bases should be, and where ambulances should be sent once finished with a call.

Using their program, the researchers are recommending that ambulance organizations break the traditional setup of assigning ambulance crews to various bases and sending them back to their assigned locations once finished with a call.

Going back to base isn't necessarily the best option for maximum efficiency, say the operations researchers. It might be better to redeploy an idle ambulance to where coverage is lacking, even though no calls have yet been placed there.

"If everyone is constantly going back to the base assigned, they're ignoring what's going on in real time in the system," Henderson explained.

The concept is easy enough, but the solution is tricky, especially because of the enormous amount of uncertainty involved.

The field of operations research that deals with making decisions over time in the face of uncertainty is called dynamic programming, in which Topaloglu is an expert. The key is coming up with what's called a value function, a mathematical construction that estimates the impact of a current decision on the future evolution of the system. In this case, it's the impact of current ambulance locations on the number of future calls that are served on time.

"When you're trying to make a decision, you have to select the locations of your ambulances so the performance predicted by the value function is as good as possible," Topaloglu explained. "But it turns out that computing that function is very difficult, especially if you're talking about the scale of the problem we're trying to solve."

—*Anne Ju*

news

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

UNIVERSITY PHOTOGRAPHY

Claudia Fischbach-Teschl (right), assistant professor of biomedical engineering, with students in the lab.

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

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

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

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

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

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

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

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

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

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

—*Anne Ju*

Grad student invents groundbreaking ultrasound device

ROBERT BARKER/UNIVERSITY PHOTOGRAPHY

Ultrasound waves created by one of Lewis' devices leave the transducer, submerged under water, causing the water to bubble, spray, and turn into steam.

A prototype of a therapeutic ultrasound device, developed by a Cornell graduate student, fits in the palm of a hand, is battery-powered, and packs enough punch to stabilize a gunshot wound or deliver drugs to brain cancer patients. It is wired to a ceramic probe, called a transducer, and it creates sound waves so strong they instantly cause water to bubble, spray, and turn into steam.

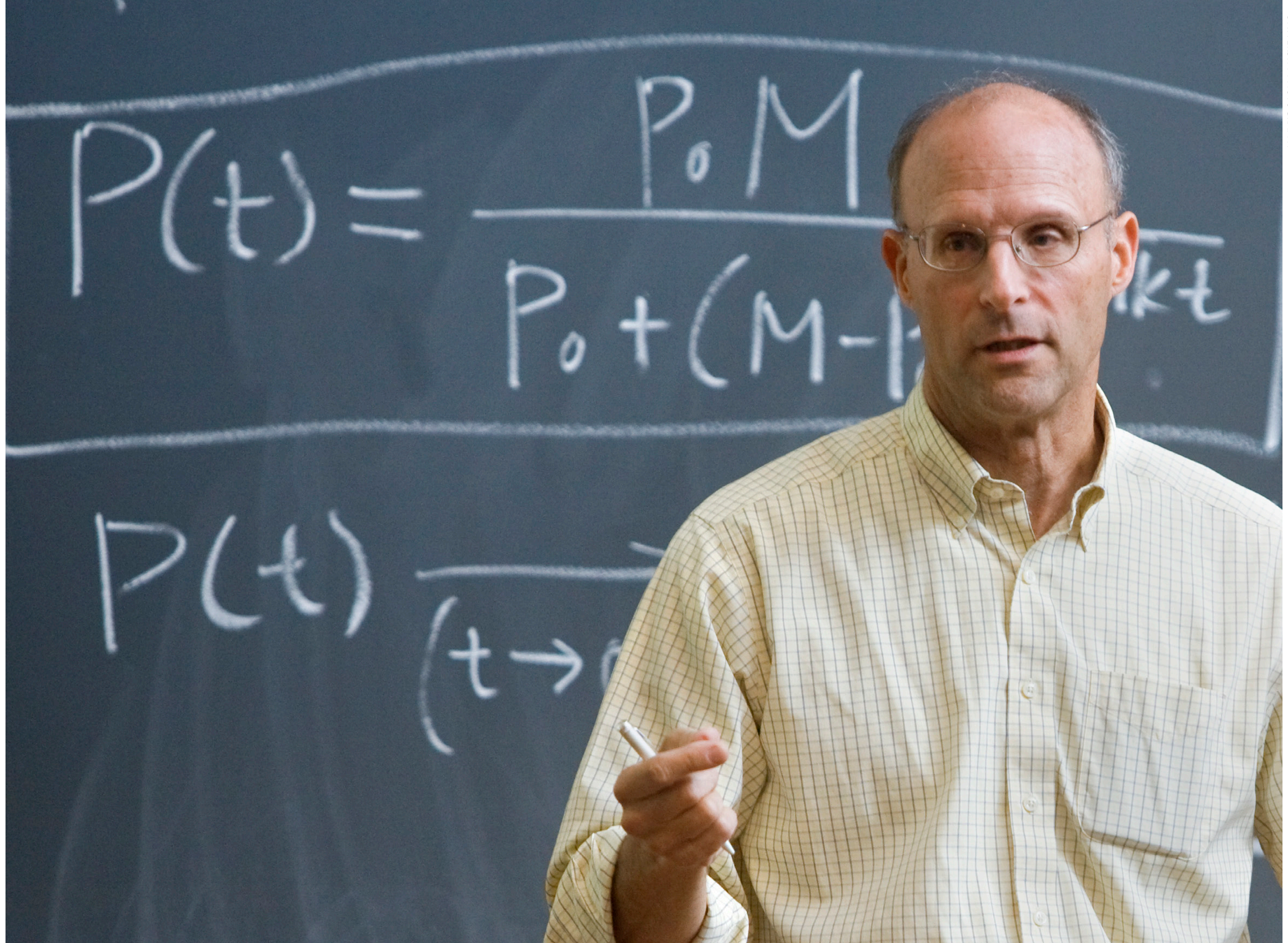
Tinkering in his Olin Hall lab, George K. Lewis, a third-year Ph.D. student in biomedical engineering and a National Science Foundation fellow, creates ultrasound devices that are smaller, more powerful, and many times less expensive than today's models. Devices today can weigh 30 pounds and cost $20,000; his is pocket-sized and built with $100. He envisions a world where therapeutic ultrasound machines are found in every hospital and medical research lab.

"New research and applications are going to spin out, now that these systems will be so cheap, affordable, and portable in nature," Lewis said.

The development of one of his portable devices is detailed in the journal *Review of Scientific Instruments* (79-114302), published online Nov. 11. Lewis, whose paper is co-authored by his adviser, William L. Olbricht, professor of chemical and biomolecular engineering, also presented his research in a talk at the November meeting of the Acoustical Society of America.

Ultrasound is commonly used as a nondestructive imaging technique in medical settings. But the higher-energy ultrasound that Lewis works with can treat such conditions as prostate tumors or kidney stones by breaking them up. His devices also can relieve arthritis pressure and even help treat brain cancer by pushing drugs quickly to the brain following surgery.

—*Anne Ju*



UNIVERSITY PHOTOGRAPHY

Sharing Creative Passion

Medical device inventor Richard Newman '68 ME returns to teach biomedical engineering

By Charley Hannagan

Richard W. Newman '68 ME spent 40 years inventing medical devices that help doctors see inside the body.

By any measure he had a successful career. He is the inventor on 13 patents, he won the 1994 Holley Medal from the American Society of Mechanical Engineers, and has nine patents pending.

When he retired in 2008, his former employer, medical device maker Welch Allyn Inc., named its new research facility at Syracuse University the Richard W. Newman Innovation Center.

In retirement he's consulting on a device for the early detection of Alzheimer's disease.

But, none of that compares with what he does now.

At 62, Newman has just realized a lifelong dream: to teach.

"I wanted to teach in general, but if I could go back to Cornell, that's a bonus," says Newman, with the grin of a man who's having the time of his life.

For Newman, being a lecturer in the Department of Biomedical Engineering is a return home.

His grandfather, Byron B. Robb '11, M.S. '13 studied what became known as agricultural engineering and eventually chaired that department, now called Biological and Environmental Engineering.

In all, 53 of Newman's relations, in-laws and outlaws, have graduated or attended the university.

His oldest daughter, Jill K. Schaffer, holds undergraduate and graduate degrees in computer science from Cornell, and now works in engineering admissions.

The youngest of his three daughters, Susan E. Newman, graduated in 2008 with a bachelor's degree in science communications. They are the fourth generation of the family to go to Cornell.

Richard Newman didn't go to Cornell because his grandfather, his mother, his father, his aunt, his two older brothers, and a sister went there.

The disposable vaginal speculum invented by Newman, shown with an illumination system, eliminates the time and expense of sterilizing and reduces the chance of cross-contamination.

He went because as a boy he wanted to fix things like his uncle, Ronald E. Bowman, who graduated from the university in 1939 with a degree in agricultural engineering.

Bowman married Frances Robb, Newman's aunt, also a Cornell grad. The Bowman and Newman clans grew up near each other in Cayuga, N.Y.

"My dad (Paul Newman) was a businessman and if anything needed fixing he called Uncle Ron," Newman says.

Bowman could fix anything from the furnace to the lawn mower, he says.

By the time Newman reached high school his guidance counselor advised him not to go into agricultural engineering, but to take mechanical engineering instead because there were more opportunities there.

Newman tagged along with his older brothers, Robb and Larry, as they checked out Lehigh, Lafayette, and Bucknell universities, before both entered Cornell.

When his turn to choose a college came, Newman toyed with the idea of going to Purdue University, his father's alma mater. Instead he sent only one application to the college where he had wanted to go since the eighth grade.

He entered Cornell in 1964, one of 600 engineers. At the time there were two kinds of engineering that interested him, he says. You could either be a civil engineer and build bridges and roads, or you could be a mechanical engineer and make things.

Newman wanted to make things.

"That's always fascinated me. How do things work?" says the man who after retirement planned to take apart the hard drive from his computer to see how it works.

Welch Allyn's Klinic diagnostic set includes an otoscope and an ophthalmoscope designed by Newman.

During the summers of his junior and senior years, Newman worked for Welch Allyn, then a small manufacturer in Skaneateles, N.Y.

The Vietnam War was at its height. Many engineers who graduated at that time moved into jobs in the defense industry, Newman says. "It was the middle of Vietnam and everyone wanted to go to the aircraft companies."

But defense work wasn't for him. "I wanted to work on something that the better job it did, the more lives would be saved, not more lives would be lost, " he says. "I wanted to make a contribution to society, make people's lives better, and not design bombs and napalm, and bullets, and fighter jets."

Then a high school friend died in the fighting during Newman's senior year at Cornell. June 1, Newman graduated with distinction with a bachelor of science in mechanical engineering. A day later he received notice from the draft board; he was 1A.

"I didn't want to die over there," he says.

Newman intended to work on his Ph.D. degree, but by then the government had stopped granting deferments for graduate students. Instead, he took a job at Welch Allyn. The company got its start making ophthalmoscopes and otoscopes, devices that doctors use to look in patients' eyes and ears. A small company offered him the opportunity to work on a product from its conception through to the factory and marketing.

After he was hired at Welch Allyn, then company president Chuck Evans sent a letter to the draft board asking that it grant Newman a deferment because he had the necessary skills to benefit the health and welfare of the American people. Evans wrote that an endoscope Newman was working on would ultimately save 10,000 lives a year.

"It was a great letter," Newman said.

The draft board granted the deferment, and by 1983, that Welch Allyn endoscope, which he helped create, was indeed helping doctors save 10,000 lives a year.

The idea of working for a bigger corporation where he would be the designer of one small part in a larger product didn't appeal to him, Newman says.

However, Newman wanted to continue his education too. At the time Cornell didn't offer the option of taking classes part time to work toward a master's degree.

While he was interested in the new field of biomedical engineering, no local New York universities at the time offered such a degree.

Newman turned to Syracuse University where he and a professor created a graduate mechanical engineering program that was essentially a biomedical engineering degree.

For five years Newman worked at Welch Allyn in the morning and then drove 20 miles to Syracuse, where he took engineering classes at SU and medical classes at Upstate Medical University. Class over, he drove back to Welch Allyn to finish out his workday.

From filing cabinets built under the window seat of his home office in Auburn, Newman pulled out a several-inch-thick textbook with ragged yellow sticky notes to illustrate the kind of technical reading he did at night for class.

"I had zero social life for five years," he says, with a laugh.

Newman graduated from SU in 1973 with a master's degree in mechanical engineering.

He moved up at Welch Allyn from project engineer to vice president of Advanced Solutions at the time of his retirement.

Newman's always looking for ways to make better medical products. It was not uncommon when his three daughters were at Auburn High School for friends to see him reading an obscure scientific journal while waiting for a school orchestra concert to begin.

"He's always thinking, so he sees applications in science and technology that others do not, " says Al Di Rienzo, president and chief executive officer of Blue Highway LLC, a newly created Welch Allyn subsidiary dedicated solely to research.

"He has more enthusiasm and energy than some of the college kids I've seen. He didn't lose his passion," Di Rienzo says.

If you've ever had a colonscopy, then you've benefitted from one of Newman's inventions. He was one of three people at Welch Allyn who developed the color video endoscope. The device gave doctors the ability not only to see inside the colon, but to view it in color.

Newman was one of the first people on whom a doctor tested the scope.

The device was so ground-breaking that the team of Dominick Danna, William Moore, and Newman won the 1994 Holley Medal from the American Society of Mechanical Engineers.

The society awards the medal to those who, by a great or unique act of engineering, have created something that has benefited the public. Henry Ford won a Holley Medal.

Even in retirement Newman can't turn off his creative juices. He is currently consulting on a Welch Allyn device to test for Alzheimer's. There are patents pending on the device, which is in second-phase clinical trials.

About half the baby boomers who, on average, live to be 85 or older will have the disease, putting a tremendous strain on the medical system and on the people who will care for them, Newman says.

Pharmaceutical companies are spending millions of dollars to find a drug that will slow the progression of the disease. A device that could diagnose Alzheimer's before someone begins to exhibit symptoms means the patient could begin taking drugs earlier, slow the disease, and remain active longer, he says.

Newman invented this lighted otoscope for diagnosing ear diseases.

New medical products spring from the latest research, and as an alum, Newman says he used his Cornell connections to remain at the forefront.

"It takes people outside of academia to say 'that's a great idea and I can use it over here," he says.

Cornell wanted something from Newman too. Fifteen years ago, the engineering dean asked Newman, who has served on the Cornell Engineering Alumni Association board, what he would do to change the school.

You need to allow students to obtain a master's degree by taking classes part time, Newman told him. Every student should be able to take biology. And you need a course that contains information, other than engineering, that engineers need to know, such as intellectual property and contracts, he added.

By 1995, Newman was lecturing occasionally at Cornell and SU. In 2004, he became an adjunct professor at the SU law school, teaching intellectual property and the commercialization of products.

By that time he was winding down his career at Welch Allyn. "I was no longer working for money, I was working because I liked it. From that, I knew I liked teaching and I could be good at it," Newman says.

Last March, Michael Shuler, the chair of Cornell's biomedical engineering department heard Newman speak and offered him a position as a visiting lecturer.

He lectures in BME 5500, biomedical engineering design, and BME 5910, a fifth-year course for graduate students who work in teams to develop new products from concept to market.

"He speaks with a lot of authority," Shuler says. "He speaks about things he's done and experiences he's had. He knows what he's talking about."

Newman compares himself to a coach.

"There's a big bridge between knowing what to do and doing it," he says. "I know how to do it and now I want to teach them how to do it." ●

Invention gets personal for Newman

The Humphrey FDT Matrix Visual Field Analyzer uses Welch Allyn's Frequency Doubling Technology, which is used in the early diagnosis of glaucoma and, potentially, Alzheimer's disease.

Richard Newman's last invention for Welch Allyn may be his most personal. It was while working on a more accurate glaucoma testing device that Newman stumbled on an inexpensive test for Alzheimer's disease.

And his mother, Julia Robb Newman, helped him do it.

Previous glaucoma tests measured the pressure in an eye to determine if a patient had the disease. Those tests were about 60 percent accurate, Newman says.

Newman read the literature on glaucoma and attended an international meeting of ophthalmologists seeking the latest information on the disease. In one of the 3,000 papers presented, a researcher presented a theory that glaucoma was caused only indirectly by the buildup of pressure in the eye, but more importantly by the death of specific eye cells.

Moving ahead with that theory, Welch Allyn researchers developed a device to check for glaucoma in a different way. Seven years and $7 million in development costs later, the company put the test on the market and now it's the standard of care for early diagnosis of glaucoma.

It was during the research on that device that Newman found a way to test for Alzheimer's.

As he has done in the past, Newman tested the new device on his family. His brothers and sister, wife, and three daughters passed.

As expected his dad, Paul, who had already been diagnosed with glaucoma, failed.

But his mom, Julie, who had not been diagnosed with the disease failed too. Newman tested her twice more, and she failed both times.

Newman urged her to see her ophthalmologist, but the doctor's tests came back negative for the disease.

Newman checked his mother's medical records and sure enough, she didn't have glaucoma according to the other tests. Why had she failed the test with Welch Allyn's device, he wondered.

"Two years later she started coming down with all these signs of Alzheimer's and I said, 'I wonder if there's a connection there?'" Newman says. His mother died seven years after she first started showing signs of the disease.

"That's why we looked at it, and said, 'There's something here to this. Let's figure out how Alzheimer's works and how we can diagnose it early,'" he says.

Newman began reading through books and papers on the subject, and ideas came together.

Alzheimer's is not easy to diagnose. The current tests, such as two-hour battery of questions from a psychiatrist or magnetic resonance imaging, are costly.

Welch Allyn has developed a device now in clinical trials that will hopefully prove to be as good as a $1,000-per-test MRI, but costs about $50 per test.

Researchers believe the device may also pick up Parkinson's, multiple sclerosis, and brain injuries, he says.

—Charley Hannagan

Q&A

By Robert Emro

KATHRYN DIMIDUK first director of the Teaching Excellence Institute

Fulfilling a strategic planning objective, the College of Engineering has established the Teaching Excellence Institute to enhance the educational effectiveness of the engineering faculty.

An advisory group of engineering faculty and staff led the creation of the institute, in the works for the last two years. It is funded in part by Mike Goguen '86, who created an endowment to support the institute, and James M. McCormick '69, M.Eng. '70, who provided additional start-up and continuation funding.

Kathryn Dimiduk '79, formerly a senior lecturer in the Department of Physics and Astronomy at the University of New Mexico, began Aug. 15 as the institute's new director. A campus leader in the promotion of effective and innovative teaching, Dimiduk received two university-level teaching awards. She helped transform introductory-level physics at UNM by creating a new course and teaching style to support struggling students.

Dimiduk graduated from Cornell with a B.A. in physics in 1979 and earned her Ph.D. in applied physics at Stanford. She is the daughter of Dick Conway, B.M.E. '54, Ph.D. '58, an emeritus Cornell faculty member who served many years in Engineering and the Johnson School.

The institute's launch coincides with that of the university-wide Cornell Center for Teaching Excellence. The Teaching Excellence Institute will focus mainly on engineering, but collaborate with the center on strategies, best practices, and coordination of services.

Cornell Engineering Magazine: Why did you want to lead the Teaching Excellence Institute?

KD: It's an exciting opportunity to basically create a new program and to be able to work with faculty and courses beyond just what I was doing. Where I was, I was teaching three courses a semester and then on the side working with the faculty to show them how to incorporate active learning strategies. So I was already trying to do pieces of this and this was a chance to jump in and do a whole lot more of it.

CEM: What is active learning?

KD: In a basic lecture the information is one-way. The instructor puts it on the board, talks about it, the students take notes, and there's a lot of info put out, but it's very passive on the students' part and it tends not to be very well retained. People have learned that way, but it doesn't require the students to process as much, so what we try to do with active learning is get the student more engaged in the material so that they're processing it, talking about it, and not just hearing it. … If you can get them thinking about something and then guide their thinking through how to do something you can add a lot more value to the class time.

CEM: Can you give an example?

KD: One of the simplest ways is to use the clicker system, where the students have individual response pads. And the instructor will pose a question and if it's well done, it's not a real easy one; it's one you've got to puzzle over a bit. One of the nice things is, instead of one student, all 200 students get to answer it and then you can put up a graph of how many students picked each answer. At that point they're much more vested in the answer. They had to think about it and they're not just sitting and writing. And I found when I'm teaching, if I give a demonstration, I can visibly see the whole class lean forward instead of sitting back and relaxing thinking, 'Oh, I don't have to take notes.' Now it's, 'What is it? Did I get it right?' …Those are the easiest to implement.

CEM: Why do we need these new types of educational strategies?

KD: The lecture style works well for a certain kind of learner and a lot of us were educated successfully with it, but it's a very small slice of the population that thinks and learns that way. To increase science literacy, you need to broaden your ways of teaching and in doing that we find that the learners who do get a lot out of lecture get even more out of the new style because they're using different parts of their brain. And they learn the material more deeply. We've got 10 to 20 years of research on teaching and how the brain processes information that is being incorporated into these active learning strategies. Yes, you can certainly learn the old way, but why not use this research to improve that? We don't ride in the same car as 20 years ago. A car today is more efficient and safer. It still gets us to work, but it's got other attributes as well. It's the same with education. We've got more research and knowledge; why not use it to make a better product?

CEM: How will you bring those strategies to Cornell?

KD: I've started working on a couple of areas. This is a multi-year project; it's not going to happen right away. One of them, for example, is the use of clickers. A lot of our faculty know about it, but to introduce that in your class takes time. You have to learn the system; you have to learn how to write questions. …So I've got a system in my office that I can take to a professor's class. I'll offer to come beforehand and you can talk about the lecture and I'll help write out questions. And I'll run that part of it so it doesn't interfere with your class. You can see what kinds of information you can get and how the students respond without it demanding a lot of your time. You can ask all sorts of questions and get that feedback so you can start adapting the course. And put in that context, the faculty seem much more interested and willing to try it themselves.

We're going to have teaching workshops for new faculty and hopefully the time they save on the mechanics of teaching they'll be able to spend thinking about incorporating some of this active learning. …The idea is to do this in a way that works for the faculty. I want to let each of them find something that works for them and help them make their idea, their piece of it, work in that class.

Long term, we want to get some funding to help faculty redesign courses. A lot of NSF grants are expecting some education components now. We want to help make that part of the grant writing easier and showcase ideas that work so everyone doesn't have to keep reinventing the same thing.

CEM: What are some of the challenges you face?

KD: Faculty buy-in is one. They've got a lot of competing demands on their time, so how do they find time to not only teach their class but actually work with creating new components, in addition to all the other stuff they have to do? They can't just stop teaching to develop a course. So I'm looking at incremental changes that they can incorporate. …Also, the research has been done in some courses, but there are others for which we only know basic strategies. In Intro Physics there's a lot of data, but I don't think engineering, or even the rest of physics, has been researched to the same level. You can't go download a set of questions for upper-level courses. … It's this intro sequence that lots of people have put lots of time and effort on. The idea is now to take it beyond that. That's one of the places where I'd like to see Cornell take the lead.

CEM: What would give you the greatest sense of accomplishment?

KD: It would be when I can walk through a building and see that not every classroom has just one person at the chalkboard. If I walk past and see people engaged in different things, that would make me very happy.

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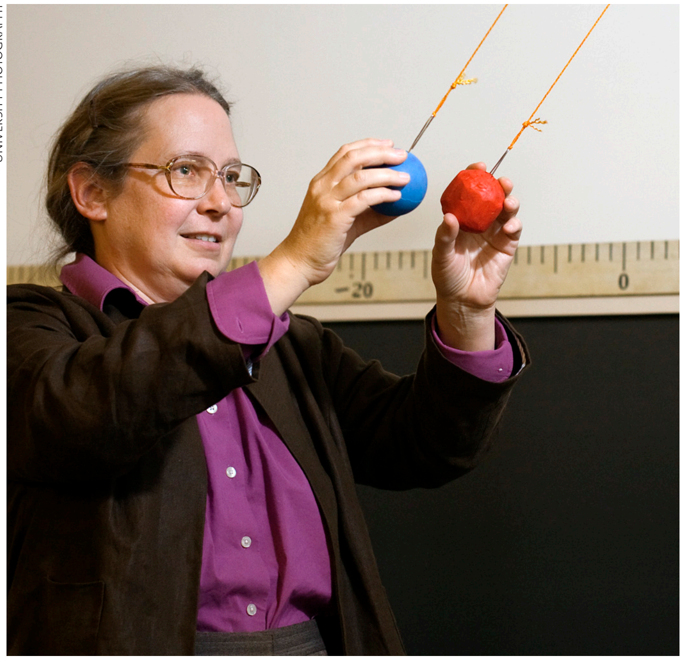
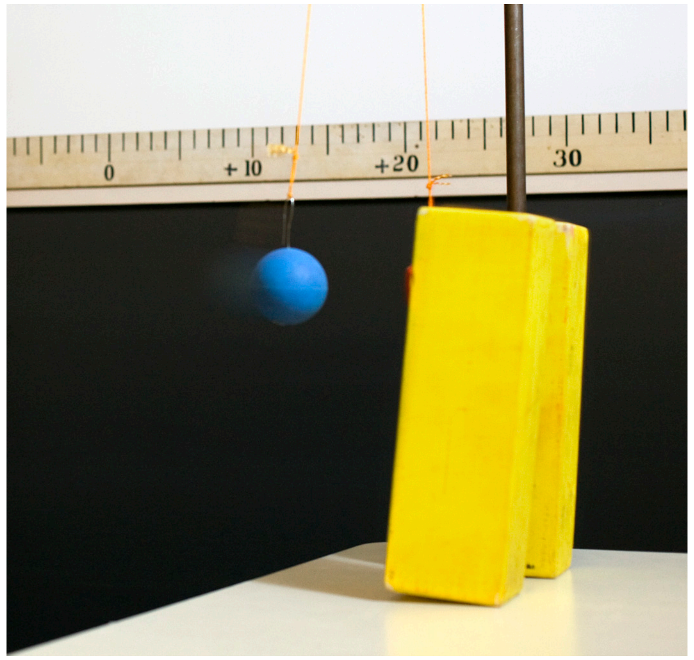
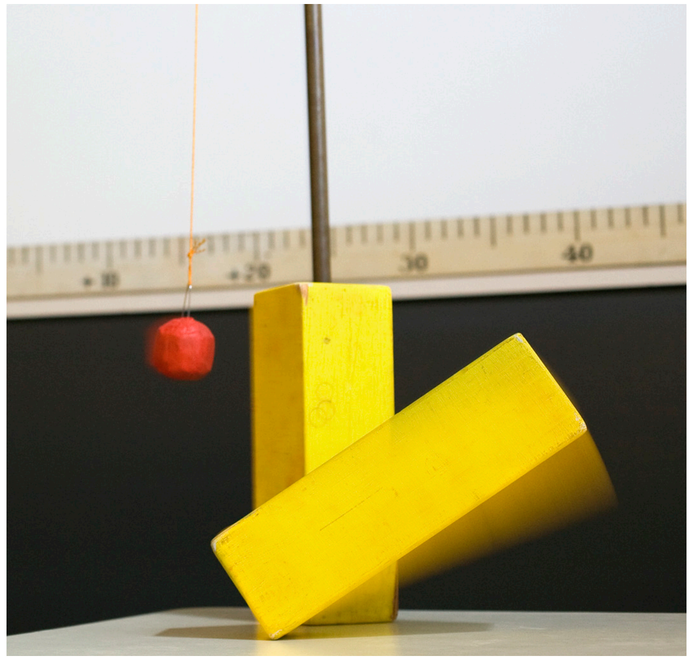


Kathryn Dimiduk performs a demonstration designed to engage students in active learning. The class is asked to predict the effect of the collisions of two pendulum bobs of equal mass—one springy and one deformable—on the freestanding yellow blocks.



Immediately after the collisions, the blue rubber bob bounces back and the red clay bob hangs at rest, mostly concealed behind one of the blocks.

Students log their answers with a "clicker."



The block struck by the blue bob is knocked over. Such demonstrations entice students to discuss the reasoning and validity of their predictions or listen to the professor's explanation.

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STIRRING THE POT

RESEARCHERS AT THE NEW KAUST-CORNELL CENTER FOR ENERGY AND SUSTAINABILITY ARE COOKING UP NANOSCALE SOLUTIONS TO SOME GLOBAL PROBLEMS.

By Robert Emro

Graduate student Robert Rodriguez prepares polymer beads for use in novel nanocomposites under development at the KAUST-Cornell center as co-Director Emmanuel Giannelis looks on.

WHEN YOU SERVE A BOWL OF SOUP, you probably stir the pot to get a good mix of vegetables and broth. Like soup ingredients, inorganic nanoparticles don't want to stay mixed in organic materials, which is one reason why nanocomposites have yet to fulfill their potential. But Cornell researchers have found a way to evenly distribute nanoparticles in a polymeric broth. Varying the ingredients could make soups to soothe several of the world's ills.

> "I made the material and I saw that it flowed at room temperature. So with the naked eye I had some proof. It's the joy of discovery when you do something like that."
> — THANOS BOURLINOS, NIMS CREATOR

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KAUST-Cornell center co-Director Lynden Archer in his Olin Hall lab with graduate students Laura Olenick and Praveen Agarwal.

The new materials so impressed an international review committee appointed by the King Abdullah University of Science and Technology that it awarded $25 million to establish the KAUST-Cornell Center for Energy and Sustainability. Working with experts at other institutions and in industry, the center will apply the new technology to four critical problems: solar energy, water filtration, carbon capture, and oil production.

"Energy and sustainability, those are the questions of today," says co-Director Emmanuel P. Giannelis, Cornell's Walter R. Read Professor of Engineering and director of the Department of Materials Science and Engineering. "Those are the questions that scientists worry about; those are the questions that nonscientists worry about."

Materials scientists have long been tantalized by polymer nanocomposites. By combining the processability, low-density, and light-weight characteristics of polymers with the functionality of inorganic structures like clays and carbon nanotubes, these hybrids offer unprecedented performance, design flexibility, and lower costs. Market forecasts estimate industry will use $500 million to $800 million worth of nanocomposites in 2011. But mixing problems have so far kept them from widespread applications.

> "This is one of those once-in-a-generation type of projects. For the last 20, even 30 years, people in our community have recognized the benefits of hybrids, but the challenge had always been how do you make these systems reproducible, homogeneous, reliable."
> —LYNDEN ARCHER

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Emmanuel Giannelis co-directs the KAUST-Cornell center.

> "What is really exciting about these materials is their tunability. You have many different knobs that you can turn to give them a set of properties, and that makes us believe that there are hundreds of potential applications."
> —EMMANUEL GIANNELIS

"This is one of those once-in-a-generation type of projects," says co-Director Lynden Archer, the M.L. Hart Professor of Chemical and Biomolecular Engineering. "For the last 20, even 30 years, people in our community have recognized the benefits of hybrids, but the challenge had always been how to make these systems reproducible, homogeneous, and reliable."

Instead of simply dissolving nanoparticles in a solution, the Cornell researchers bind them inside a polymer cocoon using ionic charges. They call them nanoparticle ionic materials, or NIMs. "The NIMs are beautiful because the polymer is covalently attached to the particle. Whether it likes the particle or not, you force it to be there," says Archer. "We feel that this new system of making composites the NIMs way finally gives us a chance of realizing some of these promises."

Besides being perfectly mixed, NIMs have properties profoundly different from conventional nanocomposites. They can behave as liquids at temperatures well below the melting point of either the polymer or the particle, undergo reversible phase changes, form solutions with other liquids, and act as solvents without evaporating.

Getting Out of the Way

Thanos Bourlinos first had the idea for creating NIMs in 2003, when he was a postdoctoral researcher working for Giannelis. His main research thrust at the time was modifying the surface of nanoparticles, which have been called "artificial atoms" because when they are small enough, their free electrons can only occupy certain energy states, just like those of molecules or atoms. Bourlinos wondered what other characteristics nanoparticles might share with molecules.

"Some properties had already been taken to the nanoscale so I was trying to figure out some new properties," says Bourlinos, speaking by telephone from the National Centre of Scientific Research "Demokritos," in his native Greece, where he works at the Institute for Materials Science. "The first thing that came to mind was liquid or melting behavior, a common molecular property."

When Bourlinos first suggested liquefying nanoparticles, Giannelis was skeptical. "I was rather negative about it because I just couldn't see with my preconceived notions, my prejudices, how it could work," he says.

But the young researcher wasn't deterred. "I'm not that kind of person," he says. "I tried to convince him; I had to convince him."

Giannelis let Bourlinos run with his idea, even though he thought it was a dead end. "One of my responsibilities is to make sure we remain disciplined and focused but at the same time allow for this creativity," says Giannelis. "At the end of the day, my accomplishments are the accomplishments of my students and postdocs. So I do know that the best thing I can do is get out of the way."

Bourlinos knew he would need to use a light nanoparticle like silica—aka sand—otherwise it would be too heavy and settle. He'd also need to use a soft organic material that would be able to focus, so he chose polyethylene glycol, a common ingredient in liquid soap and lubricants. At first he tried to combine them directly, but that yielded poor results. Then he tried modifying the surface of the particles with silane, a coupling agent in other composites, before initiating ionic binding with the polymer. "It was instant inspiration of the moment," he says.

After just six months, Bourlinos had created the first generation of NIMs. "I made the material and I saw that it flowed at room temperature. So with the naked eye I had some proof," he says. "It's the joy of discovery when you do something like that."

But Giannelis was still skeptical. "He persisted," says Giannelis. "He would come and we'd say, 'Well, let's do this control experiment; let's do that control experiment,' and he would come back with a story that still held true."

Soon Giannelis was convinced. "He started rethinking the whole situation," says Bourlinos. "He became very supportive and he had some nice ideas how to show the results."

The two turned to Archer, an expert in rheology, the science of how matter flows.

"As we discovered more and more things about these materials we started appreciating more and more their uniqueness, their usefulness, their possibilities" says Giannelis. "At some point, Lynden and I looked at each other and said, 'There is something here.'"

Playing with Knobs

The researchers tried the process with other nanoparticles, including silicon dioxide, titanium dioxide, and fullerenes. They found that by altering the polymer, which envelops the nanoparticle like a corona, they could create not just liquids, but glass solids, stiff waxes, and gels.

"What is really exciting about these materials is their tunability," says Giannelis. "You have many different knobs that you can turn to give them a set of properties, and that makes us believe that there are hundreds of potential applications."

The inorganic nanoparticle at the core is another knob. "It can be conducting, thermally or electrically; it can be magnetic. It can have the right refractive index to give you optical effects," says Giannelis.

The organic coronas are a third. "We're thinking NIMs give us the ability to marry the best of both worlds," says George Malliaras, an associate professor of materials science engineering who heads up the center's photovoltaics research. "We're using cores that are inorganic, including silicon, and organic coronas that have advantages in terms of functionality as well as processing."

> "Typically, a solar panel today needs to run for two to three years to pay back the energy that went into fabricating it. With organic cells, it's just a couple of months."
> —GEORGE MALLIARAS

Solar cells haven't supplanted fossil fuels because current photovoltaic technology is so inefficient and expensive to produce that the cost per kilowatt hour is too high. The efficiency of the best commercially produced photovoltaics today tops out at around 16 percent. The unique properties of nanoparticles could allow solar cells to convert more of the sun's energy to electricity. But conventional nanocomposites are difficult to use in photovoltaic cells because the inorganic nanoparticles are mixed with organic molecules to keep them from clumping together. "By and large those organic molecules are insulators and prohibit electronic communication," explains Malliaras, the Lester B. Knight Director of the Cornell NanoScale Facility. But with NIMs, in which the organic molecules aren't just mixed but actually bound to the nanoparticle, their insulating effect is eliminated.

NIMs-based photovoltaic cells could be produced more inexpensively, says Malliaras, because they wouldn't require enormous energy inputs or scarce high-quality silicon wafers. "Typically, a solar panel today needs to run for two to three years to pay back the energy that went into fabricating it," he says. "With organic cells, it's just a couple of months."

Because a photovoltaic cell is essentially a diode that turns light into electricity, any

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Materials Science and Engineering Associate Professor George Malliaras (left) discusses fabricating NIMs-based organic solar cells with graduate student Vladimir Pozdin.

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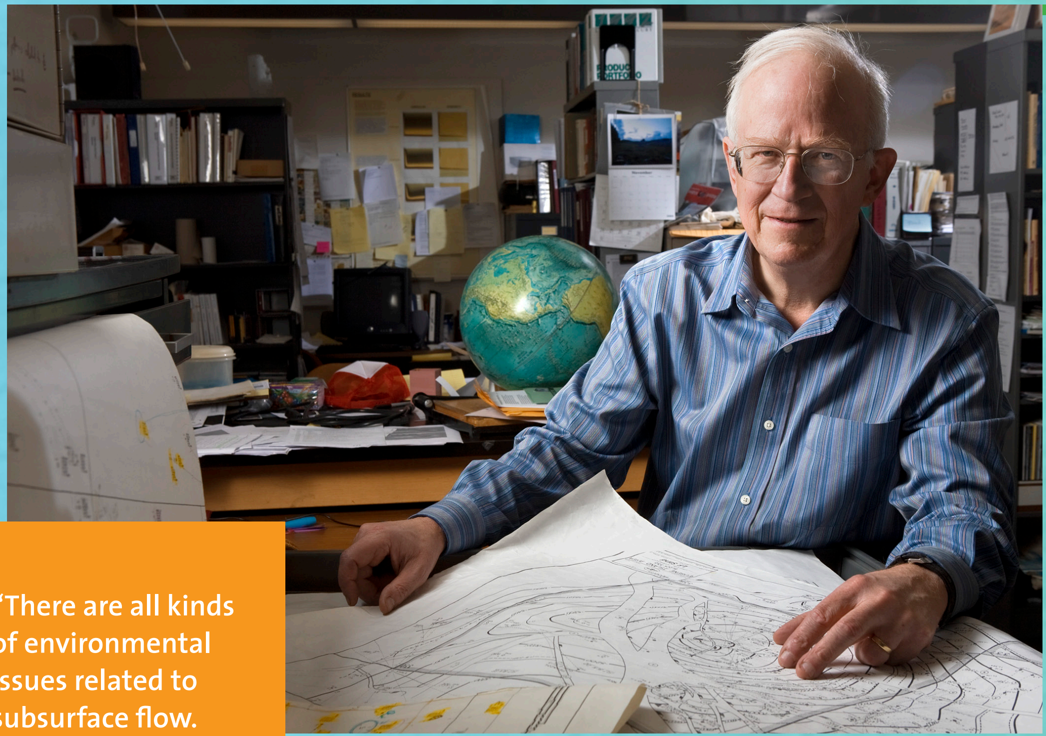

Earth and Atmospheric Sciences Professor Lawrence Cathles heads the center's oil extraction efforts.

> "There are all kinds of environmental issues related to subsurface flow. Flow channels and diffusion are absolutely fundamental, and this technology is barking up exactly that tree."
>
> —LAWRENCE CATHLES

improvements NIMs bring to solar panels could also boost energy conservation by producing more efficient LED lighting. "If you optimize it one way, it gives you good energy harvesting," says Malliaras. "If you optimize it the other way, it gives you a good light source."

Big Beach Balls

NIMs could also bring greater efficiency to oil production. Current oil drilling practices leave at least 50 percent in the ground. That's because of a phenomenon called fingering that happens when water is pumped into the ground to drive the oil toward the well. "You can get preferential pathways—fingers of water—that connect the injection well to the production well," explains Earth and Atmospheric Sciences Professor Lawrence Cathles, who leads the center's oil production research.

Because NIMs are much larger than most molecules, they don't diffuse rapidly, making them useful as tracers. "They're sort of like big beach balls that don't leave their trajectory very much. They just go along with the flow," says Cathles. "The first step is to tap this tracer capability to understand better where the fingers are. The second step is to develop a range of capabilities to deploy NIMs in a remediative fashion to reduce fingering's impact."

Surfactants, which, like soap, make oil and water more likely to mix, are the current solution to fingering, and NIMs could make them better. "To prevent fingering you try to get your injection fluid to have less distinction from oil so that it will displace the oil," says Cathles. "It's just very unusual that you get a new technology coming along that really lets you do some very established things in a new way."

NIMs could also help with problems like groundwater pollution. "There are all kinds of environmental issues related to subsurface flow," says Cathles. "Flow channels and diffusion are absolutely fundamental, and this technology is barking up exactly that tree."

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Chemical and Biomolecular Engineering Professor Donald Koch leads the center's carbon capture and sequestration effort.

Carbon Rocks

While enhancing oil production would provide a stopgap until more sustainable alternative energy sources could be developed, it would also result in more climate-warming atmospheric carbon dioxide. NIMs, however, could help here too, by providing new materials for carbon capture and storage.

Ethanol amine is a popular fluid for capturing carbon from power plant stacks, but it's volatile, so the hot gases must be cooled first, adding considerable expense to the process. NIMs could do the job for less because they can withstand high temperatures without losing their organic components to evaporation. "The advantage of using the NIMs is that they have essentially no vapor pressure," says Chemical and Biomolecular Engineering Professor Donald Koch, who heads the center's carbon sequestration research.

NIMs made with ethanol amine coronas would have extra incentive for absorbing carbon because it would put the "fuzzy" long chain molecules in uncomfortable positions from which carbon could free them. "These chains have to fill the spaces between particles, since nature abhors a vacuum," he says. "In some cases the hairs have to kink and squirrel around in strange ways."

Captured carbon could be removed and pumped underground, or it could be turned into rocks. "With the right nanoparticle catalyst, it could be combined with a mineral containing calcium or magnesium to form carbonates," says Koch. "The other idea we are pursuing is to turn it into polymers that could potentially make useful products."

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Materials Science and Engineering Professor Ulrich Wiesner is leading the effort to create NIMs for water desalination and filtration.

Goo-be-gone

Applied to water filtration, NIMs could be used to create better reverse osmosis membranes. "We hope that with the composites based on these materials we will get to a level of pore size control as well as surface chemistry control that is unprecedented," says Ulrich Wiesner, Spencer T. Olin Professor.

Wiesner leads the team investigating a host of advantages NIMs-made membranes might offer, including faster filtration, salt rejection, better tolerance to pH changes, resistance to fouling, and self-cleaning capabilities. "Chemical oxidants, for example, can degrade the membrane. If they were more tolerant, they could last longer," says Wiesner. "Or you could use chlorination as a means of preventing the growth of all kinds of goo on the membrane."

Any improvements to the current technology would be welcome. "There's a huge need for materials that can produce clean water at lower cost and at lower energy," says Wiesner. "That would help everybody."

While all the KAUST-CU Center researchers have high hopes for NIMs, they also point out that this is a brand-new materials platform. Some unforeseen stumbling block could stymie its application to real world problems, just as the mixing difficulties have thwarted most attempts to harness the capabilities of more conventional nanocomposites. It will be years before anyone knows what useful applications NIMs will yield, but it's already certain they will help produce the next generation of engineers and scientists. "These materials are wonderful platforms to educate students in complex fluids, in polymers, and in composites," says Giannelis. "Even if the technology fails—which I don't think it will—we will still have produced a good number of students and experienced postdocs. And that, after all, is our primary business." ●

> "There's a huge need for materials that can produce clean water at lower cost and at lower energy. That would help everybody."
>
> —ULRICH WIESNER

SARAH ELIZABETH LONG ’09 CE/ (left) conducted water quality management research with Civil and Environmental Engineering Professor Christine Shoemaker and Paul Muller ’09.

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FIRST TASTE

UNDERGRADUATES CONTRIBUTE TO REAL RESEARCH

By Laura McGrath

Once a rarity, undergraduate involvement in faculty research has increased steadily over the past two decades, thanks to a National Science Foundation initiative. Cornell Engineering is at the forefront of this movement. Today, nearly half of Cornell engineering undergraduates do hands-on research in faculty labs, working for a semester, a summer, or longer.

The college’s Engineering Learning Initiatives office makes it easy for students to connect with faculty by providing structured opportunities for undergraduate research. “Getting their feet wet in academic engineering research is really powerful for our students,” says Lisa Schneider, ELI director. “It does amazing things for their lab and research skills, as well as giving them confidence and a sense of their own capabilities. Then, too, these projects allow them to assess their interest in pursuing a research career, either in academia or in industry.”

ELI works with the Intel Foundation and others to fund undergraduate engineering projects. One of Intel’s goals is to retain students in science, technology, engineering, and mathematics disciplines and foster their interest in pursuing graduate degrees in these fields. “Our own self-interest is in ensuring that we have an ongoing supply of brain power to stay at the leading edge of the semiconductor and information technology industry,” says Intel Foundation’s Kimberly Sills. “But it’s much bigger than that. It’s about investing in a global future we all share.”

Part of that future is in the hands of Sarah Elizabeth Long ’09 CE, whose summer work Intel helped to support. “I didn’t expect to be involved in such big deal research,” says Long. She worked on a project run by Civil and Environmental Engineering Professor Christine Shoemaker for the U.S. Department of Agriculture titled “Integrating Sensor Network Design with Weather Forecasts and a Watershed Model to Predict and Manage Water Quality.”

> “I DIDN’T EXPECT TO LOOK AT A STREAM AND SEE SO MANY NUMBERS, OVER AND OVER. I DIDN’T SEE THE CONNECTION AT FIRST, BUT WHEN I REACHED THE END… WELL THAT WAS OOOOKAY!”
>
> —SARAH ELIZABETH LONG

“We are looking at sustainability issues,” says Shoemaker. “One of the major water quality problems facing central New York is caused by excess phosphorus. With a few big storms, you get more phosphorus in the water supply than if the rainfall is evenly spread out. So we are looking at thousands of weather files to understand not only the total amount of rainfall, but also the timing and magnitude of high-flow events.” Developing an improved model and computational analysis will enable Shoemaker and other scientists to better understand complex environmental systems and ultimately recommend the best practices to manage them.

The computational analysis is where Sarah Long fits in. Working as an intern with Surabhi Guar, a second-year master’s student, Long applied her programming and analytical skills. She ran massive amounts of rain data from the Cannonsville watershed—the third-largest of nine reservoirs that supply drinking water to New York City—through SWAT (a Soil and Water Assessment Tool). This powerful software is the USDA’s model for quantifying the impact of land management practices in large, complex watersheds. In this case, it extrapolated rain data taken near ground level to the higher amounts found at higher elevations, providing a more accurate picture of rainfall’s impact on the environment. Long then transferred those data into a spreadsheet in order to plot trends over time. Getting the software programs to work together proved to be one of her biggest challenges, requiring her to fix some of the code. “I didn’t expect to look at a stream and see so many numbers, over and over. I didn’t see the connection at first, but when I reached the end,” she pauses and grins, “…well that was ooookay!” Guar was impressed—and grateful. "My work was coming along, but once Sarah came on board, we really picked up speed," she says.

Long found the work very rewarding. "It felt good to know I could contribute to results that will ultimately help people," she says. The experience was beneficial to her personally, too. Doing some real world data analysis "will help me decide whether I want to go into the computational and theoretical side of engineering or do more hands-on, applied work," she says.

An experience like Long's often begins at the ELI Web site, which gives students guidance on exploring opportunities, finding a mentor, getting a grant, and learning about a large number of research opportunities beyond those offered through the College of Engineering. A student looking for a unique summer experience can find information on scores of NSF-sponsored Research Experiences for Undergraduates programs at campuses around the world.

"Our large undergraduate research program sets us apart from many other schools," says Chris Ober, interim dean and Francis Bard Professor of Materials Engineering. Ober himself participated in research as an undergraduate, and the experience influenced his decision to pursue a faculty position. Now he uses undergraduates in his own research every year.

ELI provides resources for research mentors, too. When targeted opportunities arise, Schneider contacts faculty individually to encourage them to involve students in their research and to inform them of the funding that is available. She keeps the grant application process simple for busy faculty members. "We ask for a brief proposal that tells us what they want to do, how they will mentor the student, and how the money will be used. There's a lot of latitude; the grant funds can go toward a stipend for a student or can help cover project expenses."

Ramya Tadipatri '10 BEE received support for her research expenses from the college's Annual Fund. She came to Cornell fairly certain that she wanted to pursue medical research. By the beginning of her sophomore year, she was poring over descriptions of faculty projects and found herself particularly drawn to Biomedical Engineering Assistant Professor Claudia Fischbach-Teschl's cancer research. She began helping out in her lab at the end of her sophomore year and applied for her first research project in the summer.

> "THE SPREAD OF CANCER CAUSES DEGRADATION TO THE BONE, MUCH LIKE OSTEOPOROSIS DOES."
>
> —RAMYA TADIPATRI

Her project is one of several aimed at understanding how the bone microenvironment affects cancer cells—particularly the breast cancer cells that metastasize to bone. "People have studied how biochemical factors are involved in metastatic breast cancer. What we're adding to the picture is to look at the matrix itself," says Fischbach-Teschl. "We recreate biomineralized scaffold structures that mimic certain properties of bone and seed those with tumor cells, then we analyze how the tumor cells' behavior is influenced by these conditions."

The first part of Tadipatri's project was to manufacture two versions of the polymer scaffolds: one incorporating hydroxyapatite, a calcium compound that makes up 70 percent of real bone, and one without the mineral.

Her next step was to expose both versions of the scaffold to macrophages, cells that turn into bone-dissolving osteoclasts. "The spread of cancer causes degradation to the bone, much like osteoporosis does," she says. "That degradation is associated with higher osteoclast activity."

At the end of the summer, Tadipatri began to introduce live cancer cells into the scaffolds, grow the cultures, and finally cut up the scaffolds. She then treated them with chemicals to break up the cells and release the DNA, which allows her to estimate and compare the number of cells in each version of the scaffold. If all goes well, the numbers will give some indication whether bone's physiochemical properties are a factor in cancer's destructive process.

How can a sophomore participate in such sophisticated research? Fischbach-Teschl, who consistently involves three or four undergraduates in her lab, gives them very specific assignments and has a system for using them. Her lab manager trains the undergraduates in the fundamentals of cell culture, sterile technique, and some specific aspects of the project. Then each undergraduate works directly with a graduate student or postdoc on an ongoing basis. Each research project team meets every two weeks, bringing their results, questions, and problems together, and determining next steps. Fischbach-Teschl encourages undergraduates to co-author a publishable paper on their work. The whole process provides a path for students like Tadipatri to develop increasing levels of skill and knowledge, participate in a complete academic research experience, and earn some credentials that will serve them well in applying to medical or graduate schools.

UNIVERSITY PHOTOGRAPHY

RAMYA TADIPATRI '10 BEE/ helped Biomedical Engineering Assistant Professor Claudia Fischbach-Teschl investigate how the microenvironment of bone affects breast cancer cells that metastasize to it.

In addition to corporate support and donations to the Annual Fund, designated alumni gifts also allow undergraduates to conduct research. "Some corporations who want to hire our students are eager to enhance their educational experience and encourage them to go on to graduate school. They can benefit, too, by enhancing their visibility with people they hope to hire in the future," says Schneider. "Others—and this includes corporations and individual alumni—just see that undergraduate research provides very exciting and meaningful opportunities for students, and they want to help make them available."

Jim Moore '62, B.E.E. '64, funds several student projects each year. As an undergraduate, he worked with Electrical Engineering Professor Ralph Bolgiano Jr. '44 EE, Ph.D. '58 at the old radio astronomy lab next to the Tompkins County Airport for several summers. He also worked for Electrical Engineering Professor Simpson Linke, M.Eng. '49 EE, devising a means to interrupt large DC currents. "I like to tinker and build stuff," Moore says, "and I learned so much from working with these people on gadgets that were pretty important. They reinforced my interest in engineering." So when Moore wanted to do something philanthropic, funding undergraduate research projects seemed like the perfect match. Junior Goodwin "Win" Wharton was one of several students who benefited from Moore's generosity last summer.

"I'M MORE ENGAGED IN WHAT I'M STUDYING. A LONGER-TERM PROJECT WITH GREATER DEPTH IS A FANTASTIC THING!"

—WIN WHARTON

Wharton spent the beginning and end of his summer at a computer, but in the middle were two sun-soaked weeks in Greece, working in the field with Earth and Atmospheric Sciences Associate Professor Christopher Andronicos. A Science of Earth Systems major, Wharton feels like he has learned a new language—not Greek, but the vocabulary of structural geography. Indeed, he comfortably explains his project on "Archaeoseismology of the Halai Neolithic Site, Central Greece."

Wharton's goal was to identify active faults and the principal stress axes in a 900-square-kilometer area, information that may lead to an improved ability to predict earthquakes. In addition to using traditional geologic techniques, Wharton interfaced with an ongoing archaeological study; the tilt of the buildings at an 8,000-year-old Neolithic archaeological site may be an indicator of seismic activity.

All of this fits into a project that Andronicos has been working on for about two years. With a long history of involving undergraduates in research, Andronicos knew just how he could use Wharton's assistance. "I'm fortunate that in field geology, it's pretty easy to identify compact projects where undergraduates can make a real contribution. Win's experience is fairly typical of how I've worked with students: during the summer we go into the field, I provide some training, and together we collect data and do geologic maps. When we come back, they use computers to turn their data into a product."

Wharton began by compiling earlier data, developing a working knowledge of the geology of the region, and identifying areas of interest for investigation during the field work. One of his first tasks was to convert paper maps published by the Greek Geological Survey in 1968 into digital maps enabled with geographic information system technology. They took these maps into the field.

In Greece, Wharton and Andronicos worked six days a week, using a Brunton surveying compass to measure the "strike" and "dip" that describe the orientation of a plane in three-dimensional space. They noted these measurements in field notebooks, identifying each location with a hand-held global positioning device. They talked geology all day, every day, as they gathered data. But the evenings provided learning opportunities of a different sort. They camped alongside 17 archaeology, architecture, and classics students from France, Serbia, Bulgaria, and the U.S.— including several from Cornell—at a field camp run by retired Cornell Classics Professor John Coleman. Their primary entertainment: conversation.

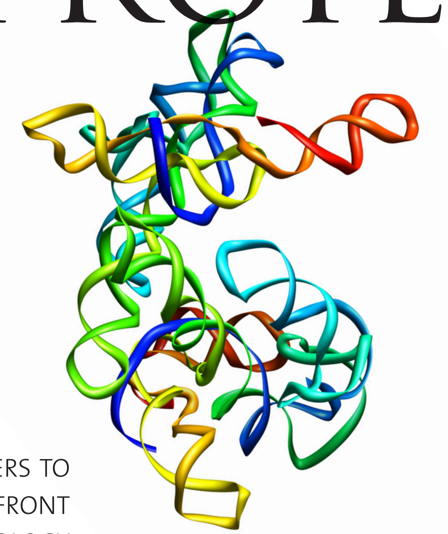
Back in Ithaca, Wharton entered and analyzed data from his field maps and notebooks and wrote a report. The project has opened his thoughts about career options, in addition to teaching him a lot of geology. "The question I'm trying to answer is what happens after I graduate: grad school or work."

Wharton, Tadipatri, and Long are all slightly awestruck at being so intimately involved in important research. Most of all, they are genuinely grateful for the opportunities to work with their professors. Their summer projects have added depth to their learning and a level of personal involvement they had not experienced in other aspects of their education. Tadipatri notes, "This gave me a real sense of independence and responsibility." Says Wharton, "I'm more engaged in what I'm studying. A longer-term project with greater depth is a fantastic thing!"

UNIVERSITY PHOTOGRAPHY

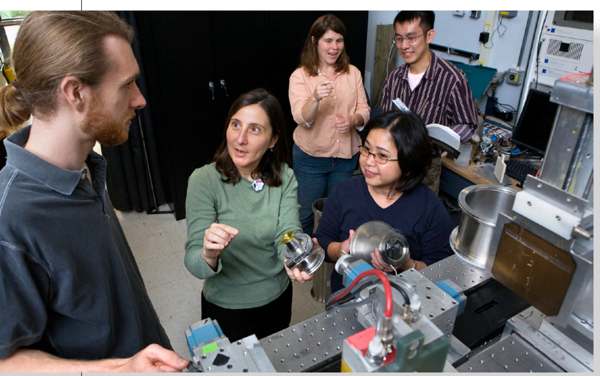
WIN WHARTON '10 SES/ learned the language of structural geography while helping Earth and Atmospheric Sciences Associate Professor Christopher Andronicos identify active faults and principal stress axes in Greece.

Of Whispering RNA and Waltzing Proteins



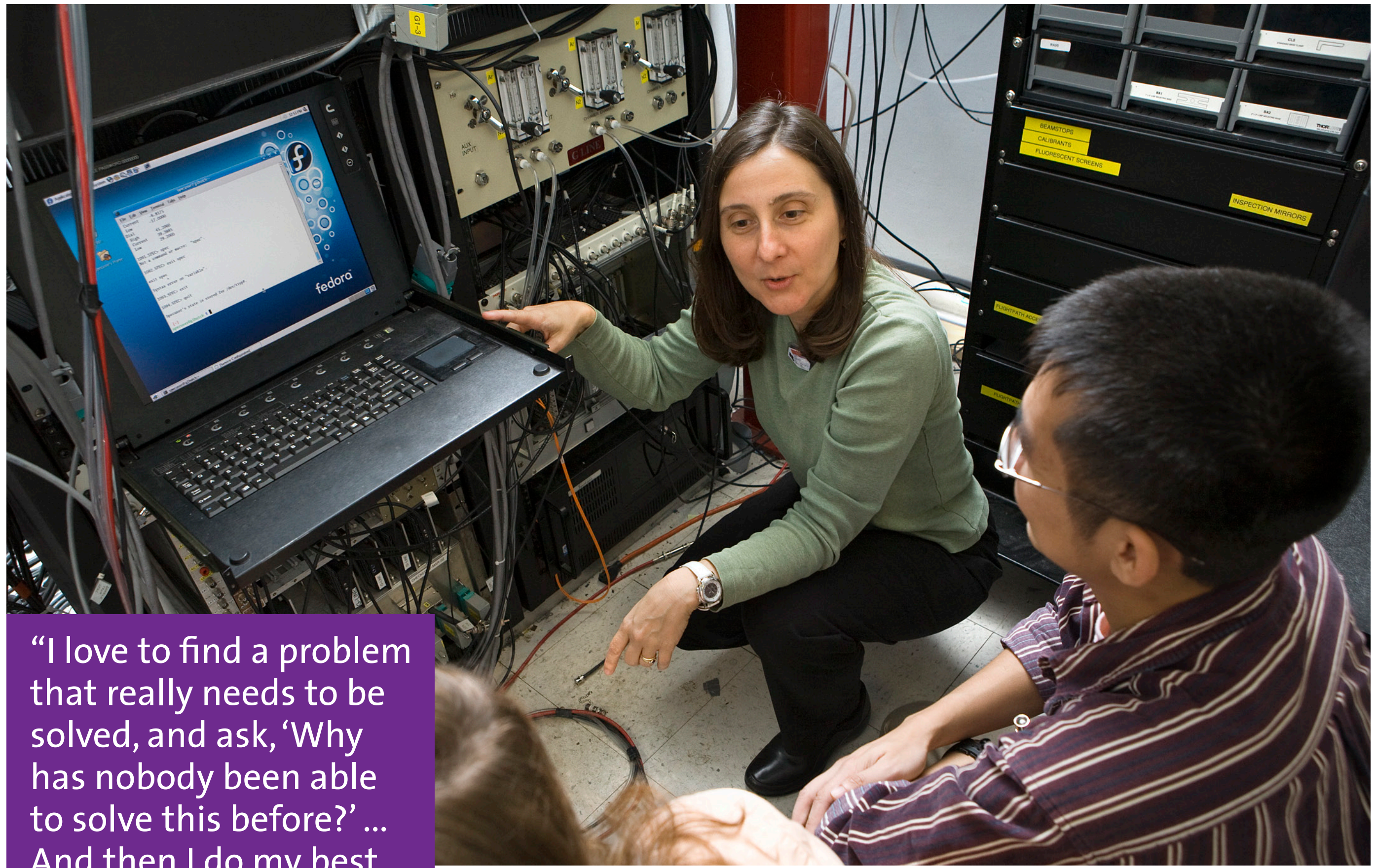
Lois Pollack seeks answers to questions at the forefront of molecular biology

By Sourish Basu



Graduate student Steve Meisburger (left), postdoctoral associate Suzette Pabit (right), and Associate Professor Lois Pollack (center) discuss beamline components in the CHESS G-1 station. In the background, graduate students Jessica Lamb and Lee Li look on.

Lois Pollack loves to build tools. One of her favorites is a paper-thin purple square of silicon, less than an inch across, with channels thinner than a human hair. "This is one of the earlier mixers I built," says the associate professor of applied and engineering physics. Looking at it, it's hard to believe that this "mixer"—two microscopic channels etched cross-ways—in the late 1990s became a new window on how proteins danced their tangled dance during the first few moments of folding.



"I love to find a problem that really needs to be solved, and ask, 'Why has nobody been able to solve this before?' ... And then I do my best to build a tool to solve that problem."

—Lois Pollack

Proteins, which account for about a fifth of our weight, are polymeric chains of up to 20 different amino acids. Each protein is hundreds to tens of thousands of amino acids long and performs a very specific function in our body; hemoglobin in our blood carries oxygen, and myosin in our muscles gets us moving. To perform such specific functions, proteins have to fold up in specific three-dimensional structures and sometimes toggle between different ones. A protein called VIVID, for example, found in a bread mold, changes its conformation when exposed to light to keep the fungus' Circadian rhythms in sync with the sun.

A protein—forged as a linear chain—must find its correct structure from several billion possible folded forms. Counting on a protein to do that regularly is like expecting a mile-long yarn to knot up in precisely the same tangled ball every time—yet the protein usually succeeds. "Somehow the instruction as to how a protein is going to fold up is chemically written into the pattern of amino acids," says Pollack, but it's a writing that we haven't learned to read yet. How a protein acquires its biologically active structure, and how it responds to stimuli—such as VIVID to light—have therefore been open questions in biology for several decades.

Proteins and their structural polka are half of Pollack's research; interacting RNA and DNA strands make up the rest. What they have in common are the tools she builds to study them. "I love to find a problem that really needs to be solved, and ask 'Why has nobody been able to solve this before, and what's been limiting progress?'" she explains. "And then I do my best to build a tool to solve that problem. But it doesn't always work." No wonder, once you look at some of those problems. How does the flu virus fool our immune system every year? What controls our circadian rhythm? How do our cells decide when to make certain proteins?

Today, we know these to be questions at the forefront of molecular biology. Hard to believe, then, that Pollack slipped down this path perchance while flipping through a magazine, waiting to collect data for her real research, more than a decade ago.

Early Years

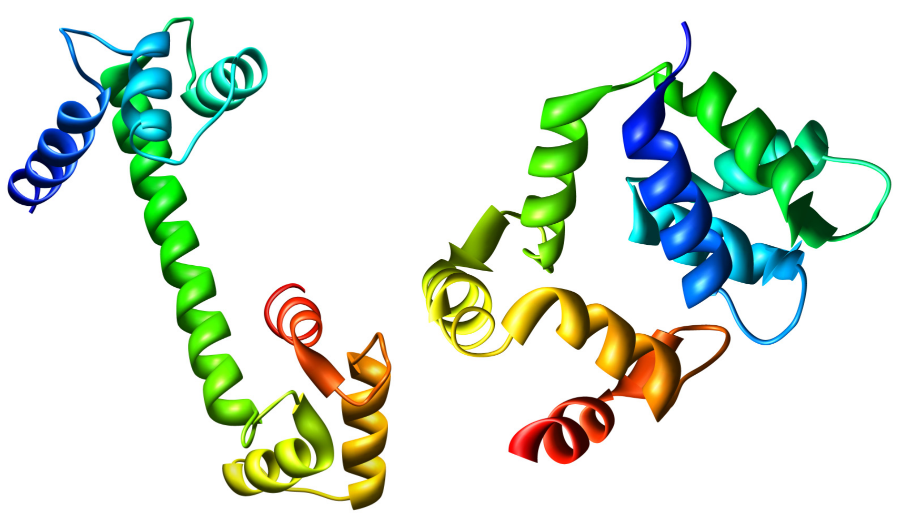
Pollack received her Ph.D. from the Massachusetts Institute of Technology, working with Thomas Greytak. In 1989, she came to Cornell to work with Physics Professor Robert Richardson as a post-doctoral associate. A low temperature physicist by training, she started studying nuclear spin ordering in 1995.

Her experiments with Richardson involved extremely long spin relaxation times; each run would take several hours, even days, to finish. During one such run, Pollack picked up an issue of *Physics News* and flipped to an article on protein folding. Within half a page, she had found her calling.

In 1995, the "energy landscape" picture of protein folding was just beginning to emerge. Each possible structure of a protein, the picture says, has a specific energy. Just as a ball will roll downhill to the point of lowest energy, a protein switches through many possible structures until it finds its lowest energy structure, which is also its biologically active structure.

What makes protein folding a hard nut to crack is that it's impossible to see a protein

MOLECULAR GRAPHICS IMAGES WERE PRODUCED USING THE UCSF CHIMERA PACKAGE FROM THE RESOURCE FOR BIOCOMPUTING, VISUALIZATION, AND INFORMATICS AT THE UNIVERSITY OF CALIFORNIA, SAN FRANCISCO (SUPPORTED BY NIH P41 RR-01081)



Pollack's group studies the dance that proteins like calmodulin (CALcium MODULated proteIN) perform when they change from being bound with calcium (1CLL.pdb, left) to not being bound with calcium (1QX5.pdb, right).

fold. Typical protein molecules—between a few and several hundred nanometers long—too small to be seen with light microscopes. Instead, scientists look at how a protein scatters X-rays to paint a picture of its complex contortions. A change in pH initiates the dance. The first steps begin in just milliseconds, so the pH must be changed very rapidly. Otherwise the pH-change's effects will show up in the painting. The scattered X-rays must be measured just as quickly. When Pollack first turned her attention to the problem, the pH change took longer than the folding. "Proteins fold in the blink of an eye," says Pollack. "They were too fast to be detected by the tools you could buy, and those were the tools that everybody was using."

Pollack had an idea for building a much better tool: a micro-flow mixer—a tiny square wafer of silicon with channels etched out in the center—that could change pH 1,000 times faster and allow rapid X-ray measurements. She came up with the design in collaboration with Robert Austin of Princeton University and Sol Gruner, director of Cornell's High Energy Synchrotron Source and Austin's former colleague at Princeton. Luckily for Pollack, she was near one of the few synchrotron sources in the United States.

X-rays produced inside the synchrotron come out in an extremely narrow beam. Focusing this beam on her mixer, Pollack produced snapshots of the first milliseconds of folding, offering a peek into the part of a protein's life that had been invisible. "In fact, it was the only experiment I've ever done in my life that worked the first time," she fondly reminisces. "The first time I did that experiment, I took data that was almost immediately publishable and really astonishing."

Protein Functions

For many proteins, how they perform their functions is as poorly understood as how they fold. Armed with her tool that could take time-resolved X-ray snapshots of proteins, Pollack, with Microbiology and Immunology Associate Professor Gary Whittaker, Chemistry and Chemical Biology Associate Professor Brian Crane, and Applied and Engineering Physics Professor Watt Webb, has been studying the functional stage of some proteins.

Hemagglutinin (HA)—the 'H' in the infamous bird flu-virus H5N1—a so-called viral fusion protein, is a trickster. When a flu virus invades, "the cell realizes that it's a foreign body, and feeds it to the cell's internal digester, a compartment called the endosome," explains Pollack's graduate student Jessica Lamb. The endosome acidifies the virus in an attempt to digest it. Unlike most proteins, however, HA is triggered by acidity to attain its active structure. It fuses the virus with the endosome boundary and the viral genetic material tumbles out inside the host cell.

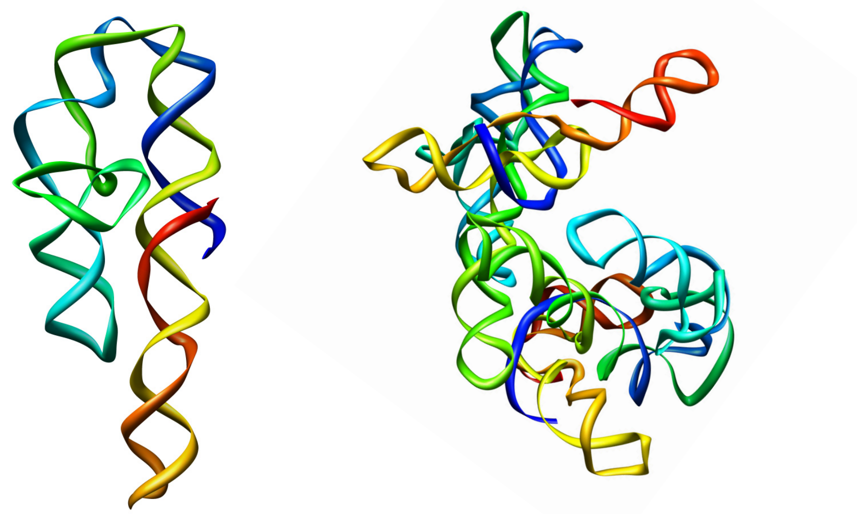
More importantly, says Lamb, "Hemagglutinin is the thing that evolves to evade our immune system every year," requiring a new flu vaccine every season. Scientists are baffled how, despite its annual mutation into a structurally different protein, HA still retains its functionality. Nor do they understand why HA is triggered by acidity. With her toolkit, Pollack hopes to see HA at work, literally, and demystify this unique protein.

Proteins like HA catalyze structural changes, such as the fusion of the viral and endosome membranes. Others are molecular motors, such as myosin in our muscles and dynein in bacterial flagella. Yet other proteins, such as VIVID and phototropins in plants, respond to external stimuli such as light. The response of these proteins is very often a structural change, easily detectable by the suite of tools Pollack has at her disposal. Lately, she has trained those tools on two proteins that respond to stimuli.

VIVID, a protein found in bread mold, controls the mold's circadian rhythm, the same physiological rhythm that makes us sleepy at night. The Pollack group, in collaboration with the Crane group, observed that two VIVID molecules merge when hit with blue light, starting a cascade of reactions that ultimately makes the mold's biological clock tick. Although VIVID itself is found in only a few organisms, it "is one of a larger family of proteins that is found in everything" including mammals, says Lamb. These proteins don't always control circadian rhythm, she clarifies. For example, a very similar protein NPH1 in *Arabidopsis* is responsible for the tendency of plants to grow towards light, or phototropism.

Calmodulin, on the other hand, senses calcium ions. "The body works a lot like a circuit, and ions carry the currents in the circuit," Pollack explains. The flow of calcium ions across the cell membrane plays an important role in muscle contractions. Calmodulin senses these ions and converts their concentration into chemical signals, which trigger motor proteins in charge of muscle functions. Such proteins that convert or "transduce" one kind of signal into another are fairly common in biology. Understanding how VIVID and calmodulin work, therefore, will provide insight into two of biology's most important processes; photodetection (how organisms respond to light), and signal transduction.

While protein functions kept her fascinated, Pollack realized quite early that studying them one after another had the danger of becoming monotonous. "It occurred to me that I could spend my entire life studying different proteins," she says. As a physicist, she craved diversity in the problems she tackled. In 2002, armed with her microsecond imaging tools, the tool-builder looked around for



They also study how small pieces of RNA (1GID.pdb, left) acquire their structure within larger folded RNA, like the tetrahymena ribozyme (1X8W.pdb, right).

another problem that needed solving. "And then I found RNA folding," she remembers.

RNA: The New Frontier

Up until the late '70s, the central dogma of biology was quite clear: proteins did all the work and were made by translating the genetic code in messenger RNA (mRNA). The mRNA, in turn, fetched the code from a DNA library—and that was about all the RNA did.

Then in 1978, scientists discovered introns—certain sections of mRNA that excised themselves and spliced the remaining mRNA pieces back together. "An intron, to cut itself out, has to form a specific three-dimensional structure" exactly like a protein, explains Lamb, which at that time went against all established notions of genetics. And it blew everyone away.

Nor was the intron the only "active" RNA; by 2000, scientists had discovered another stunner. The ribosome, the cell's protein-making factory, is itself a complex of RNA and proteins; bacterial ribosome, for example, has three RNA and 50 protein molecules. Electron microscopy revealed that those three RNAs, and not the 50 proteins, catalytically joined amino acids to churn out proteins.

RNAs perform both these functions by acquiring the "correct" structure for the job, like proteins. Since Pollack had already built the tools to study folding proteins, using them to see folding RNA was the natural next step. But their protein-like folding was not the only fascinating aspect of RNAs; as Pollack says, "About every decade there's a revolution in what people know about RNA." Once thought to be mere messengers, RNAs were found to regulate gene expression, inhibit and trigger protein production, and mimic antibodies to fight infections. For Pollack, these diverse functions were signatures of interacting RNA; if she could decipher how RNA strands talked to each other and to other molecules, she could understand what drove their folding, or how they inhibited protein production—in short, what made them so versatile.

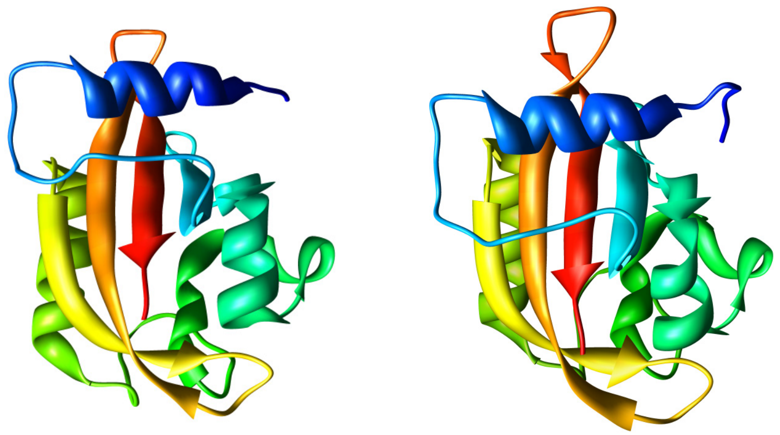
Further, Pollack explains, much of RNA interactions boil down to the force between charges—something physicists have been studying for several centuries. In solution, RNA—and its sidekick DNA—exist as long strands of negatively charged ions. Their electrostatic forces dominate all other forces and reduce the problem of RNA folding into something deceptively simple: how does a line of charge behave in the presence of an ionic background? "It's all about electrostatics. I can solve Coulomb's law to find out how RNAs interact," she explains.

Since RNA strands always exist in ionic solution, however, the problem is not a simple one. The negatively charged RNA attracts proteins and positive ions that surround it and screen its charge. So any force the RNA exerts on other molecules is always through a veil of screening charges and depends on the exact geometry of this screening cloud.

To "see" this cloud, Pollack resorted to small-angle X-ray scattering of DNA strands (they're electrically similar to RNA, but a lot cheaper). "We've also measured the effective charge on DNA helices using some other techniques," says Pollack, "and it's surprising that nobody has done that before."

With the screening charge distribution mapped out, Pollack's group is figuring out how electrostatic forces galvanize these nucleic acid chains to function as gene regulators and antibodies. In time, they hope to have a crack at their original problem—how RNA folds up to function like a protein.

"Our cells have lots of tiny RNAs, but people thought they were insignificant—and now they're turning out to be really important. So it's a great time to be studying RNA!" exclaims Pollack. While biologists discover newer roles for RNA, she digs into what makes them tick. With her toolbox of micro-flow mixers, X-rays, and fluorescence markers, this tool-maker eavesdrops on RNA strands whispering to each other and spies proteins waltzing from structure to structure, so that we may learn their secrets.



The group measures the structural change that the fungal protein VIVID (2PD7.pdb, left) undergoes when it senses light (2PDR.pdb, right), which keeps a mold's biological clock in sync with the sun.

people

Chen leads School of Electrical & Computer Engineering


PROVIDED

Tsuhan Chen

Tsuhan Chen, an expert in visual computing from Carnegie Mellon University, joined the Cornell faculty in January as director of the School of Electrical and Computer Engineering.

Chen succeeds Clifford Pollock, the Ilda and Charles Lee Professor of Engineering, who had served as director since 2001.

"[Cornell's] depth and history immediately got my attention," Chen said. "But what really impressed me is how the faculty have stayed so dynamic over the years, constantly finding new ways to do things—staying out in front."

Chen joined Carnegie Mellon's engineering faculty in 1997 where he served as associate department head of electrical and computer engineering and co-director of the Industrial Technology Research Institute Laboratory, a collaborative research program with ITRI in Taiwan. His group worked in the area of visual computing, which includes computer vision and pattern recognition, computer graphics, and multimedia coding and streaming.

"This is an opportunity for the department to bring in a fresh perspective from the administrative point of view while also attracting a research star who can take the department in new directions," said interim Dean Chris Ober.

Chen earned his B.S. from National Taiwan University and M.S. and Ph.D. from the California Institute of Technology, all in electrical engineering. He worked at Bell Labs before Carnegie Mellon.

—*Laura McGrath*

Ph.D. student wins IBM award for women in engineering


PROVIDED

Animashree Anandkumar (right) with IBM fellow emerita Fran Allen.

Engineering Ph.D. student Animashree Anandkumar has received the 2008–09 IBM Fran Allen Ph.D. Fellowship, which promotes the advancement of women in technology fields.

The award, named for an IBM fellow emerita, includes a $30,000 grant to Cornell to encourage participation of women in engineering and computer science, according to the award letter. Anandkumar accepted the award at an October ceremony.

A student in Electrical and Computer Engineering Professor Lang Tong's Adaptive Communications and Signal Processing Group, Anandkumar studies areas of inference on graphical models, networking, and information theory.

Anandkumar is currently a visiting graduate student at the Laboratory for Information and Decision Systems at the Massachusetts Institute of Technology. She received her B.Tech. degree from the Indian Institute of Technology Madras, Chenai, India in 2004.

Attracting and supporting more women into her field is "hugely important" to Anandkumar. "Although I have really good role models and a support system, I have heard from many women students that they could use a little more help or mentorship in the very beginning, when it's most needed," she said. "In that aspect maybe this award will help toward achieving that."

— *Anne Ju*

Students going to ACM world finals


PROVIDED

Cornell Team 1 at the 2008 ACM regional programming contest, from left, Hooyeon "Haden" Lee, Eric First, and Vincent Chan, took second place in a "barnburner," decided 12 minutes before the end of a five-hour competition.

A Cornell team is going to the 2008–2009 Association for Computing Machinery (ACM) International Collegiate Programming Contest in Stockholm, Sweden, April 18–22. The team qualified with a second-place finish in the regional contest for greater New York in October.

Eric First '09 ECE, Vincent Chan '09 CS, and Hooyeon "Haden" Lee '10 CS made up one of three teams Cornell sent to the regional contest at St. Joseph's College in Patchogue, N.Y. They were given eight complex, real-world problems, with a grueling five-hour deadline. The team that solved the most problems in the least time won. They solved seven and held first place until just 12 minutes before the end of the contest, when a team from SUNY Stony Brook solved the eighth.

In Stockholm, 100 world finalist teams will compete for awards, prizes, and bragging rights at KTH–the Royal Institute of Technology. Huddled around a single computer, competitors will race against the clock in a battle of logic, strategy, and mental endurance.

"These teams represent the best of the great universities on six continents—the cream of the crop," according to an ACM fact sheet.

Dustin Tseng, a third-year Ph.D. candidate, coaches the teams. Overall standings were better than last year, Tseng noted, even though the teams included many "rookies" who had never been in the contest before.

A Cornell team took first place in the ACM regional last year, and Cornell has placed in the top two for the last three years.

—*Bill Steele*

Student receives outstanding undergraduate award

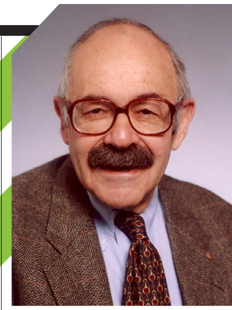

ROBERT EMRO

Tal Rusak

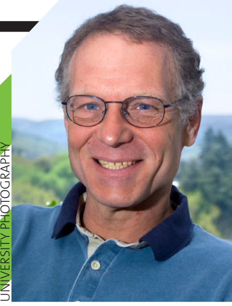
Tal Rusak '09 CS is the 2009 winner of the Computing Research Association's Outstanding Undergraduate Award. The award includes $1,000 and a plaque. He will also receive financial assistance to attend a major computing research conference.

The Outstanding Undergraduate Awards are given to one male and one female undergraduate in North American universities who show outstanding potential in an area of computing research. Rusak has been involved in research since freshman year, resulting in seven first-authored publications and presentations. His current research focuses on understanding the structure of low-power wireless networks by deriving novel properties of the time variations in network links. This work was advised by Assistant Professor Philip Levis of Stanford University. Concurrently, he has focused on building a computerized system to audit major requirements in collaboration with other Cornell undergraduates and Professor David Gries, associate dean for undergraduate programs.

He has served as a teaching assistant and peer tutor for undergraduates and serves on the Student Library Advisory Council. He also volunteers at an after-school program for elementary school students in Ithaca.



Alfred Blumstein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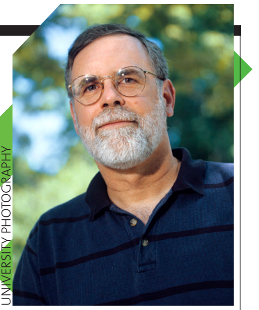
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James Gossett

OR alumnus studies criminal justice

Alfred Blumstein '51, Ph.D. '60, a self-described "missionary" of operations research to the criminal justice system, has spent 40 years offering a systems perspective for informing decisions and policies in crime-reduction efforts, incarceration, and cost effectiveness.

Blumstein, the J. Erik Jonsson University Professor of Urban Systems and Operations Research at Carnegie Mellon University, described his research at a recent meeting of the Institute for Operations Research and the Management Sciences Boston chapter.

Blumstein's work over the past 20 years has covered such aspects of the criminal justice system as crime measurement, criminal careers, sentencing, deterrence and incapacitation, prison populations, demographic trends, juvenile violence, and drug-enforcement policy.

During his talk, Blumstein, who received his bachelor's degree from Cornell in engineering physics and Ph.D. in operations research, described how feedback modeling of criminal careers has led to a number of policy insights in recent years, such as the notion that sentencing decisions should take into account the "residual career length" of convicted law-breakers to avoid wasting prison space.

He noted that the primary factors driving growth in prison populations have not been increases in crime or arrest rates, but in length of sentences and in the proportion of arrests resulting in prison. He also discussed the unintended consequences of incarceration—an increase in drug offenders in prison, recruitment of young replacements by crack markets, the proliferation of guns to protect the markets, and the tendency of young men to "resolve disputes by fighting" with much more lethal weaponry. In fact, Blumstein posited, the entire homicide rise from 1985 to 1993 can be explained by the increase in killings by young people with handguns, many in the drug trade.

Blumstein has served as president of the Operations Research Society of America, the Institute of Management Sciences, and the organization resulting from their merger—INFORMS. In 1998 he was elected to the National Academy of Engineering.

—*Mark Eisner*

Kozen honored as AAAS fellow

Professor of Computer Science Dexter Kozen M.S. '76, Ph.D. '77, was among five Cornell faculty members named fellows of the American Association for the Advancement of Science, the world's largest general scientific society and publisher of the journal *Science*.

The researchers were recognized Feb. 12 at the annual AAAS meeting, held this year in Chicago.

Kozen, the Joseph Newton Pew Jr. Professor in Engineering, is cited for outstanding contributions to the foundations of computer science, including the theory of computability, computational complexity, algorithms, and program logic and verification. Kozen is especially interested in the complexity of decision problems in logic and algebra, logics, and semantics of programming languages and computer security.

The other fellows were Thomas J. Burr, professor of plant pathology; Richard Durrett, professor of mathematics; Sally McConnell-Ginet, professor emeritus of linguistics; and John C. Schimenti, professor of genetics.

—*Krishna Ramanujan*

Gossett honored for landmark publication

Professor of Civil and Environmental Engineering James M. Gossett received the Outstanding Publication Award from the Association of Environmental Engineering and Science Professors.

Gossett received the award with his former student David Freedman, who is currently a faculty member at Clemson University.

The award is given annually "to recognize the authors of a landmark environmental engineering paper that has withstood the test of time and significantly influenced the practice of environmental engineering."

Gossett and Freedman were honored for their 1989 *Applied and Environmental Microbiology* paper entitled, "Biological Reductive Dechlorination of Tetrachloroethylene and Trichloroethylene to Ethylene under Methanogenic Conditions."

They were the first investigators to report the complete conversion of chlorinated ethenes to non-toxic ethylene, forming the basis for now widely used bioremediation technologies to address a common class of groundwater pollutants—chlorinated solvents.

people

Rhodes on Board of New Saudi University

Cornell President Emeritus Frank H.T. Rhodes has been named to the board of trustees of King Abdullah University of Science and Technology (KAUST) in Saudi Arabia. Set to open in September 2009 with a class of 250–350 international and Saudi students, KAUST will train a cohort of graduate students, all on full scholarships. It will be co-educational and have women on its faculty, which will be guaranteed academic freedom. Instruction will be in English.

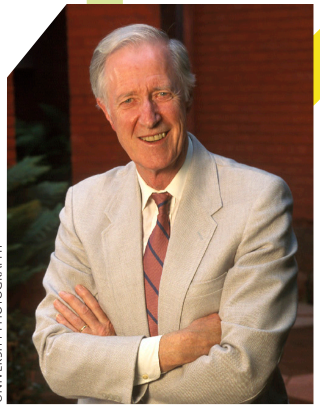
Rhodes' involvement with KAUST began a couple of years ago when he was asked to write a charter and bylaws for the new university.

"King Abdullah—who is financing this and whose name it bears—wanted to build a university that would advance the interests of the people of Saudi Arabia in the era when petroleum is no longer the dominant basis of the economy," Rhodes said. King Abdullah bin Abdul Aziz Al Saud, who also serves as prime minister, has been the royal head of the kingdom since 2005.

Rhodes consulted the constitutions of many universities, including those in the United States and Britain, and over three months produced a document that introduced such new ideas into Saudi higher education as co-education and women faculty; an independent, self-electing board of trustees; strong guarantees of academic freedom; and endowment income free of the influence or control of government ministries.

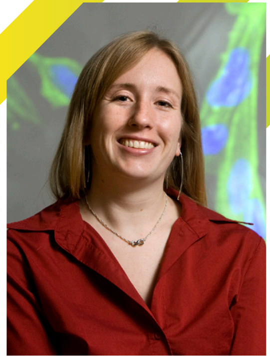
"King Abdullah has a very elevated vision for a great university that could become world-class in science and engineering," said Rhodes, who led Cornell from 1977 to 1995.

—George Lowery



UNIVERSITY PHOTOGRAPHY

Cornell President Emeritus Frank H.T. Rhodes



Cynthia Reinhart-King

Moonsoo Jin

Jonathan Butcher

Seven Receive Heart Association Grants

Three biomedical engineering faculty members were among seven Cornell researchers to receive new grants from the American Heart Association to help fight heart disease and stroke, the No. 1 and No. 3 causes of death in the United States. Six Cornell researchers already have funding from the AHA.

Cynthia Reinhart-King, assistant professor of biomedical engineering, received a scientist development grant for $198,000 over three years for her research, "Regulation of endothelial cell function by extracellular matrix elasticity."

Moonsoo Jin, assistant professor of biomedical engineering, received a scientist development grant for $308,000 over four years for his research, "VLA-4 (a4b1 integrin) activation-specific antagonist."

Jonathan Butcher, assistant professor of biomedical engineering, received a scientist development grant for $308,000 over four years for his research, "The biomechanical regulation of valvulogenesis."

Also receiving new AHA grants were Huai-hu Chuang, assistant professor of molecular physiology; Suraj Saksena, postdoctoral research associate in the Weill Institute for Cell and Molecular Biology; David Infanger, graduate student in biomedical sciences; and Raga Krishnakumar, graduate student in molecular biology and genetics.

—Lauren Gold

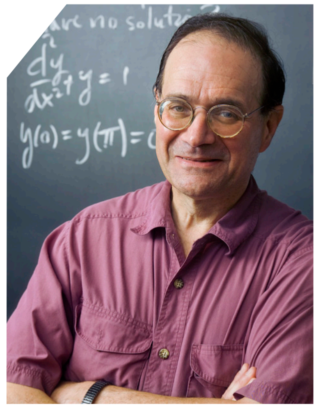
Rand a 2008 Weiss Presidential Fellow

Richard Rand, professor of theoretical and applied mechanics, was among four Cornell faculty members chosen for the 2008 Stephen H. Weiss Presidential Fellowships for excellence in teaching and advising undergraduate students and outstanding efforts to improve instruction on campus.

The awards—$5,000 a year for five years for each faculty member—are named for Stephen H. Weiss '57, the late emeritus chair of the Cornell Board of Trustees, who endowed the program. The awards honor excellence in teaching and advising, and outstanding contributions to undergraduate education. To date, 50 faculty members have been named Weiss fellows.

The 2008 recipients will be honored at a ceremony in May by the board of trustees.

Rand, a member of the faculty since 1967, "has gained a reputation as an inspiring, enthusiastic, and brilliant lecturer and a dedicated and patient adviser to students. By any measure, he is one of the best teachers in the College of Engineering," the Weiss committee noted. A former student wrote that he was "easily the most lucid and compelling instructor I have had to date." The committee wrote, "Letters from undergraduates emphasize his kindness and patience and his willingness to meet with them outside of regular office hours."



Richard Rand

Rand is the recipient of numerous teaching awards, including eight citations for excellent teaching by the engineering honor society, two dean's prizes for innovation in undergraduate teaching, and two College of Engineering Excellence in Teaching Awards.

Also chosen were Bruce Ganem, professor of chemistry and chemical biology; Ronald Harris-Warrick, professor of neurobiology and behavior; and Mary Beth Norton, professor of history.

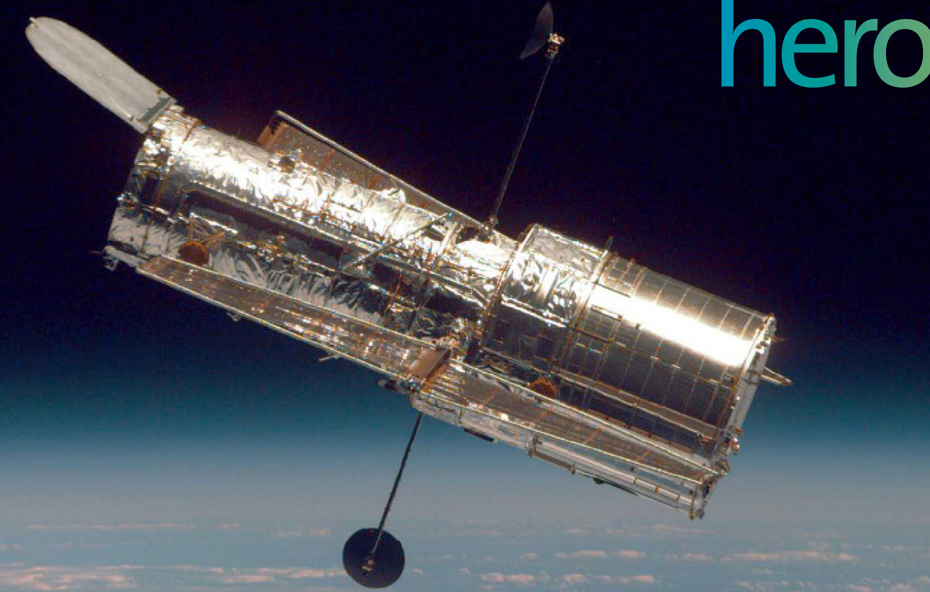
—Susan Lang

hometown hero

ROCKET MAN: LANDIS MARKLEY

NASA

Landis Markley '61, B.E.P. '62 (right), receives the American Institute of Aeronautics and Astronautics Aerospace Guidance, Navigation, and Control Award at the 2008 AIAA GN&C Conference in Honolulu.



When fellow rocket scientists are asked to describe their colleague F. Landis Markley Jr. '61, B.E.P. '62, it usually comes back to brainpower. "He's the brightest person I ever met," says John Crassidis, a former student of Markley's. "He would solve stuff in five minutes that would take another person hours upon hours."

The praise isn't unwarranted; Markley has a life-list of accomplishments that have garnered him awards and a symposium in his honor—yet he is abashed at all the recognition. "It feels humbling," says Markley. "I feel that there are probably many other people who are equally deserving."

At age 69, Markley has built a successful career in astronautical engineering, still working as a lead mission engineer for NASA's Goddard Space Flight Center in Greenbelt, Md. His expertise in physics and engineering has enabled breathtaking snapshots of galaxies, data on global change, and proof of dark matter and energy. However, this wasn't the realization of a childhood dream—in fact, Markley claims he simply "fell into" the field. After teaching physics for six years at Williams College in Massachusetts, Markley failed to get tenure—so he left to take a position with a software company writing computer programs for spacecraft. "That's when I got interested in space—because it was a job," says Markley with a laugh. "It isn't very inspirational."

Despite this modest debut, Markley soon made his mark on the world of space engineering. He transitioned from his software job to work fulltime at Goddard, where he focused on attitude determination—the engineering that tells spacecraft where they're pointing in space, and how to point at something else. "It's a beautiful application of mathematics," says Markley. "I would get obsessive about a problem and come home and write on big pads of paper—my daughter and my wife would say 'Oh, he's squiggling again.'"

Markley's obsession paid off—he wrote a now famous and widely cited paper on attitude determination that established the modern application of the field. "We never had a need for attitude determination until we started launching spacecraft," says Crassidis, a professor of aerospace engineering at the University at Buffalo. "We had a new field, and Landis is essentially a pillar of this new field."

While Markley earned his status as a scholar by refining attitude determination, he gained a reputation as an ace mission engineer as well—fellow NASA colleagues recall Markley's rescuing the Hubble telescope. The spacecraft's gyroscopes, (which are used to measure and maintain orientation) were "dropping like flies," says Markley, which could have caused the telescope to drift away from the sun, its only source of power. If the Hubble lost power, NASA could have lost the control of the craft altogether.

Markley's team quickly analyzed and fixed the glitch before the Hubble was lost. "He kept it from being a problem," says Julie Thienel, an aerospace engineer with the U.S. Naval Academy who worked under Markley. "He does that routinely. When there's trouble—they typically call Landis."

If you ask him, Markley notes that one of his career's high points was helping to design the Wilkinson Microwave Anisotropy Probe, a research satellite designed to measure temperature differences in cosmic radiation. "I had a clean sheet of paper and I could say what an attitude control system should look like," he says. Since then, WMAP has been working smoothly and has "returned the baby picture of the universe," says Cliff Jackson, an instrument systems engineer at Goddard. Lauded as "the breakthrough discovery of the year" by *Science* magazine in 2003, WMAP produced the earliest image of the cosmos—at less than 400,000 years old.

Markley's latest project is the James Webb Telescope, scheduled to replace the Hubble in 2013. The infrared-optimized space telescope will look farther back in time than any other telescope has before. Its 21.3 foot-diameter mirror and tennis-court-sized sunshield will have to be folded up inside the rocket for launch—and then successfully emerge and unfold once out in space. "It's an amazing piece of machinery," says Markley.

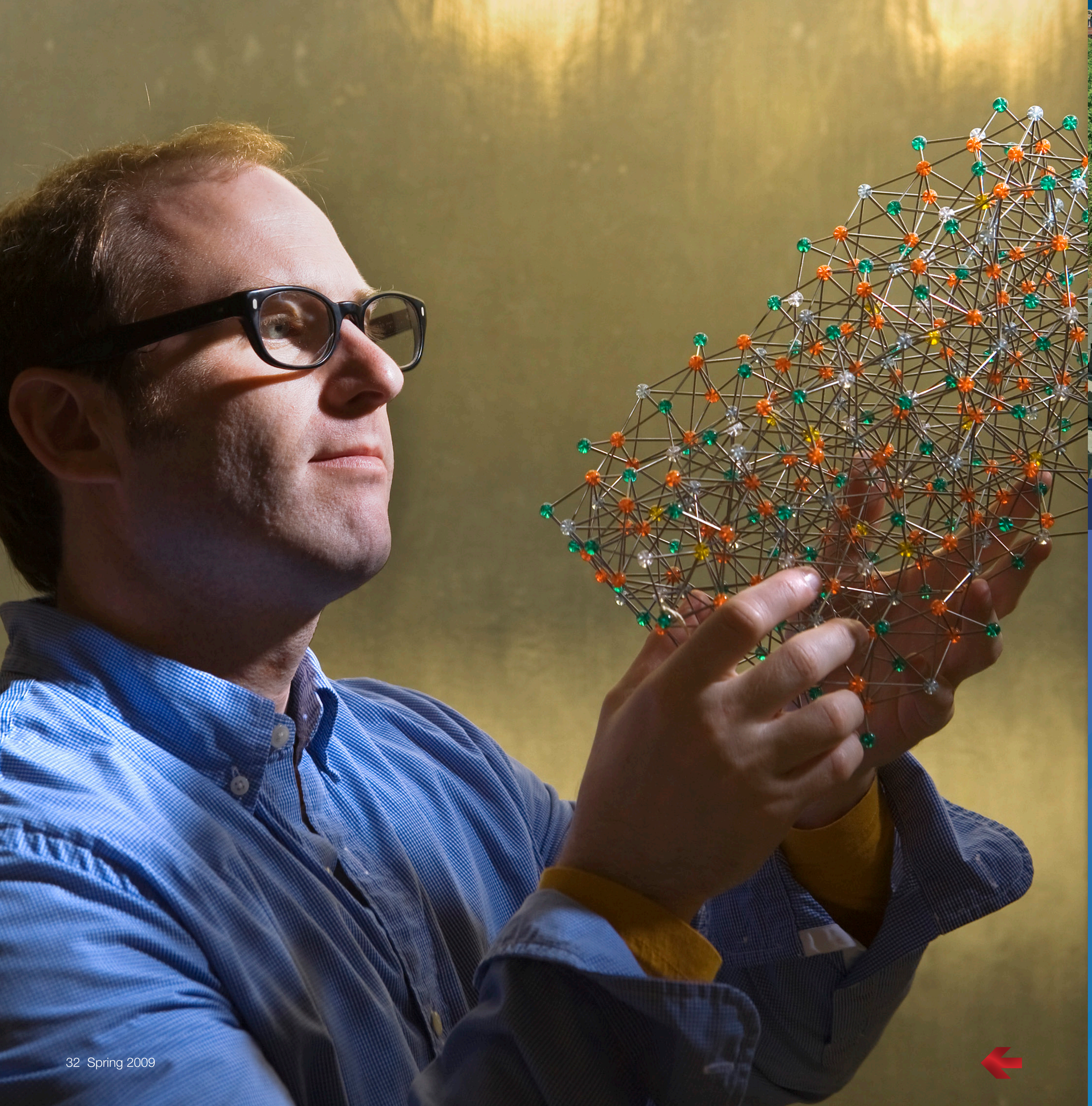
The most enjoyable part of the whole thing, says Markley, is "having something you had a hand in designing go up into space and work. I like to keep track of them," he says with a dash of paternal pride. "I do like to think of them as my babies."

—Lauren Cahoon

Materials by Design

Discovering new materials is a laborious process of trial and error. From hundreds of thousands of possible combinations of elements, scientists choose one they think might have the properties they are looking for, determine how to synthesize it, and then test for the desired properties. More often than not, they're wrong. But with advances in computing power, a deeper understanding of physics, and the ability to manipulate individual atoms, scientists are beginning to design materials they know will have the desired properties.

Cornell's Craig Fennie, assistant professor of applied and engineering physics, is working to make materials by design a reality. By using first-principles quantum mechanical techniques he gains insight—not easily obtained through experimentation, if at all—into the physics of complex oxides in order to predict new properties. Superconductivity, ferroelectricity, and magnetoelectricity are just three of the exotic properties of complex oxides. They could someday be used in multipurpose semiconductors for hard drives, sensors, and other applications.



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