College of Engineering
University of California, Berkeley Spring 2002

Forefront

Charting a course

Women engineers navigate the tides of a changing profession

College of Engineering

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FOREFRONT reports on activities in the College of Engineering at the University of California, Berkeley. It features developments of interest to the engineering and scientific communities and to alumni and friends of the College.

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On the cover

Even as the numbers inch up, women faculty still remain a small and relatively isolated entity within the College. For a deeper understanding of some of the issues they've encountered – first as young girls with a passion for math and science, later as academic engineers moving toward tenure and beyond – we sat down with Fiona Doyle (on the cover), Jasmina Vujic, and Jennifer Mankoff in a forum that proved to be remarkably frank and refreshing. Their discussion clarifies some of the unexpected challenges, nuances, and inspirations these women faced while charting the course of their professional lives.

For the story, see page 16.

Cover photo by Peg Skorpinski

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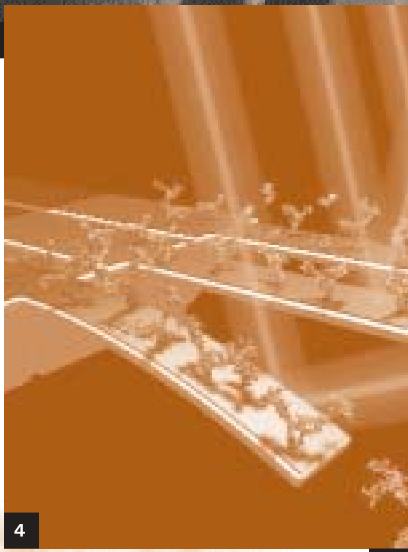
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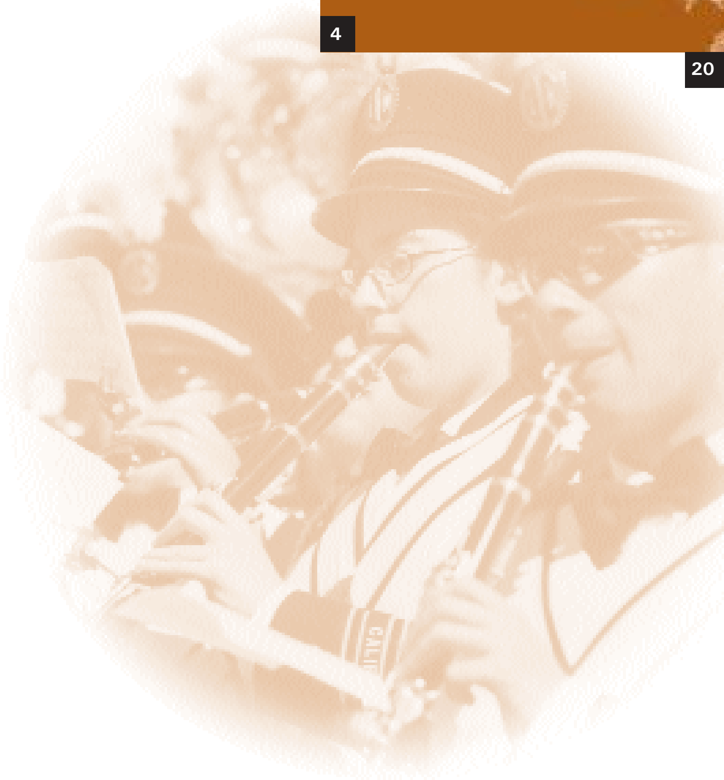
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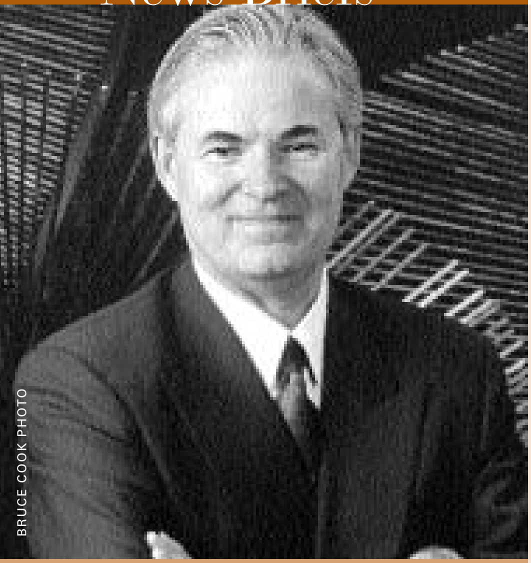


BRUCE COOK PHOTO

From the Dean

In this issue of *Forefront*, our newly formatted magazine now published three times a year, we begin a series on Berkeley women in engineering.

The series opens with a story on faculty members in the College. In January, *Forefront* invited Fiona Doyle (MSE), Jennifer Mankoff (EECS), and Jasmina Vujic (NE) to an informal discussion at the Women's Faculty Club. What followed was a lively hour of provocative insights and anecdotes – excerpted here – highlighting some of the obstacles and inspirations these women encountered in their careers.

We are working hard at the College to recruit more women students and faculty. In fact, four of the nine faculty we have hired since July 1, 2001, are women – our most productive year ever. The percentage of women students in the College is also at its highest recorded level. Creating a culture of inclusion for traditionally underrepresented groups in engineering is one of our top priorities.

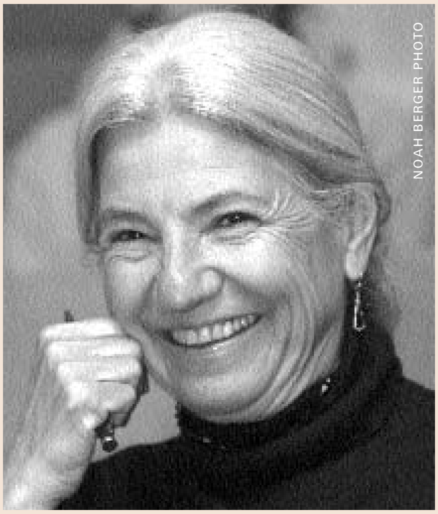
It is my pleasure to announce the launch of the Engineering@cal online community for alumni and friends of the College. One click to engineeralum.berkeley.edu opens the College's portal page, where you can register to use e-mail forwarding, an alumni database, a mentoring program, and more. Over the next few months, watch as our site and services evolve and expand. Please take this opportunity to continue or renew your online relationship with engineering at Berkeley.

– A. Richard Newton
Dean, College of Engineering
and the Roy W. Carlson Professor of Engineering

Prominent scientist heads CITRIS

Pioneering researcher Ruzena Bajcsy, the former head of the Directorate for Computer and Information Science and Engineering at the National Science Foundation (NSF) took the helm of the Center for Information Technology Research in the Interest of Society (CITRIS) last November as the center's new director.

CITRIS joins four UC campuses – Berkeley, Davis, Merced, and Santa Cruz – with private industry to develop innovative technology that tackles some of society's most pressing problems, such as health care, air traffic control, disaster preparedness, and energy efficiency. It is one of four California



NOAH BERGER PHOTO

Ruzena Bajcsy

Institutes for Science and Innovation established in the last two years by Governor Gray Davis.

"We're fortunate to be able to attract someone of Ruzena's expertise," says Dean A. Richard Newton. "You've got to have someone who has a national reputation as well as management experience. But the most important thing is that she is absolutely passionate about what we're going to do at CITRIS."

Bajcsy helped establish NSF's Information Technology Research program, which funds innovative, high-impact research supporting infrastructure in information technology.

A top scientist in her own right, Bajcsy has more than 40 years of research experience, most notably in the fields of robotics, artificial intelligence, and machine perception. At the University of Pennsylvania, Bajcsy served as director of the General Robotics and Active Sensory Perception Laboratory (GRASP), a world-renowned research lab she founded in 1978. She is a member of both the National Academy of Engineering and the Institute of Medicine.

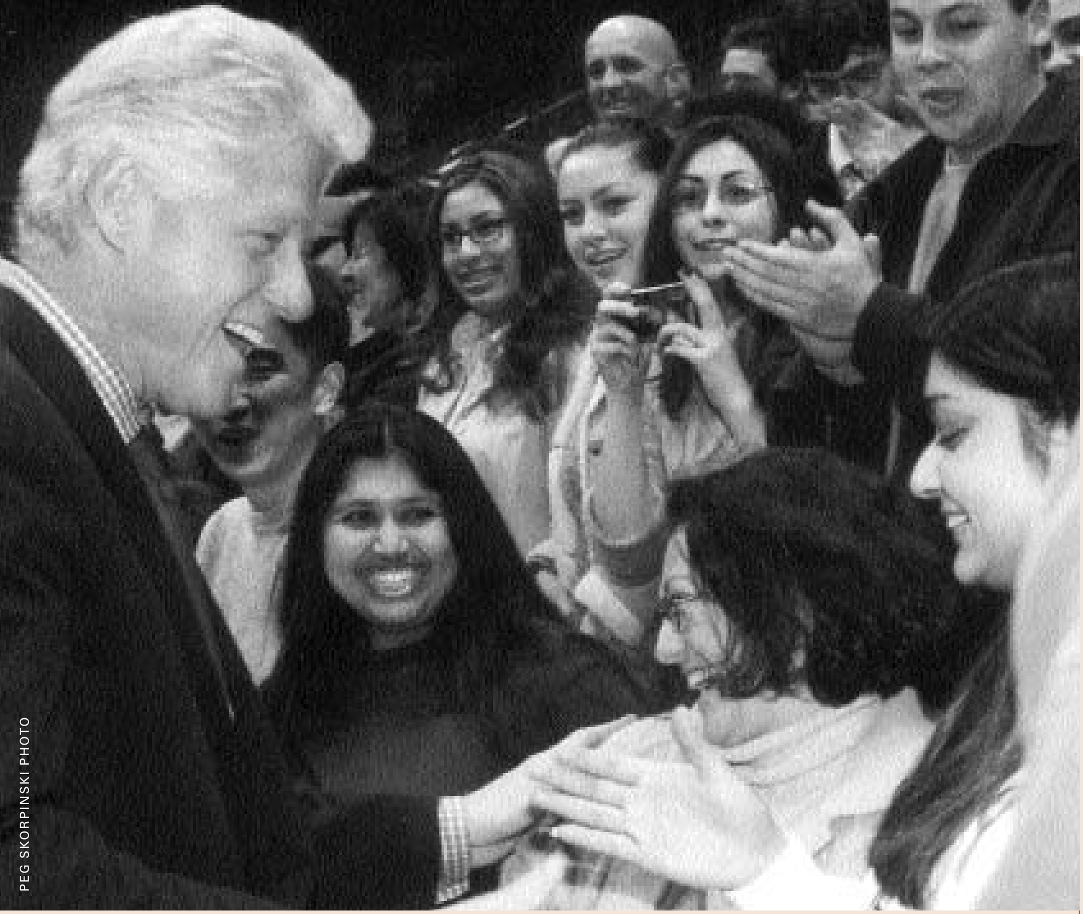
But Bajcsy's extensive professional credentials reveal only part of her story. Born Jewish in Slovakia at the time when Adolf Hitler rose to power, Bajcsy and one younger sister were orphaned as children, and were the sole members of their family to survive the Nazi invasion. Bajcsy's love of engineering came from her father, a civil engineer. Her interest in medicine and helping others came from her mother, a pediatrician. And the drive to flourish in a field that to this day is underrepresented by women and minorities came from her entire family.

"I grew up in a family where women were expected to hold their own," she says. "My mother and my aunt were among the first female medical doctors in the central Czech area. My grandfather believed women should be educated."

Bajcsy received her master's and doctoral degrees in electrical engineering from Slovak Technical University in Bratislava in 1957 and 1967, respectively. In 1972, she earned a second Ph.D., this time in computer science, from Stanford University.

Bajcsy emerged from her training determined to make a positive impact on society. "I'm a scientist, first and above all, but I am also a scientist with great social consciousness," she says. "That is partly why I am so excited about CITRIS. Its aim is to investigate how this technology I've been developing all my life is going to benefit society. Otherwise, why are we designing all these artifacts if they're not going to help people?" F

BY SARAH YANG



PEG SKORPINSKI PHOTO

Former president Bill Clinton shakes hands with Berkeley students in the overflow room at Haas Pavilion.

Clinton slam-dunks Berkeley visit

That's the nicest welcome ever given to a Stanford parent," joked Bill Clinton about the standing ovation he received after Chancellor Robert M. Berdahl presented him with the Berkeley Medal on January 29.

More than 2,000 people filled Zellerbach Hall to hear the former president speak. In the Bay Area for a fund-raising event, Clinton was invited to campus by the Graduate School of Journalism and the Chancellor's Office, for which he waived his usual $100,000 fee.

Also attending was Governor Gray Davis, who – along with Clinton – congratulated Berkeley for its role in the Center for Information Technology Research in the Interest of Society (CITRIS) and the Bioengineering, Biotechnology and Quantitative Biomedical Research Institute (QB3), two new UC-based centers for science and innovation.

Clinton spoke for a fact-filled 30 minutes about globalization's positive and negative effects. "We've torn down the walls and spread information and technology around the world," he said, speaking without notes or a TelePromp-Ter. "But half the people on earth were left out of this expansion. One billion go to bed hungry every night; 1.5 billion never get a clean glass of water."

Such poverty is the root of current terrorist activity, according to Clinton. In a passage that set off waves of applause, he said, "I do not believe that a law enforcement and military strategy alone is enough to build a world that we want our children to live in. I don't want the walls we've torn down to be substituted with barbed wire." The solution, he continued, is to "spread the benefits and shrink the burdens" around the world. Returning to his Stanford-parent joke, Clinton reminded the audience that focusing on our racial, religious, tribal, and ethnic differences, instead of our common humanity, would forever keep peace at bay.

After the speech Clinton sat down with journalism dean Orville Schell for a question-and-answer session about his view of the media and why the right wing detests him. He seemed relaxed and articulate.

When told that an overflow audience had watched a video simulcast next door in the Haas Pavilion, Clinton headed over to shake hands for another half-hour. Passed a basketball to sign, he went for a 20-foot free throw, missing on the first try – but sinking the second, to the crowd's delighted roar. F

BY BONNIE POWELL

PEG SKORPINSKI PHOTO

Three-story building rides out Northridge-sized tests

A full-scale three-story woodframe apartment building with tuck-under parking sustained only minor to moderate damage after Berkeley engineers put it through a series of powerful shake tests at Berkeley's Richmond Field Station in December, observed by an enthusiastic throng of reporters, students, and researchers.

Engineers retrofitted the structure with steel frames, then subjected it to motions equivalent to those recorded during the 1994 magnitude 6.7 Northridge earthquake.

"The structural performance of the building was excellent," says civil engineering professor and lead investigator Khalid Mosalam. "Current seismic building codes call for these woodframe structures with tuck-under parking to be built with steel frames, but as a retrofit, that had never been put to the test before."

The shake test is part of a larger $6.9 million project funded by the Federal Emergency Management Agency through the California Office of Emergency Services. The Consortium of Universities for Research in Earthquake Engineering (CUREE) manages the project under subcontract to the California Institute of Technology.

In the Northridge quake, 24 people died as a result of damage to woodframe buildings, including 16 people in one building with tuck-under parking. In addition, damage to woodframe structures caused more than $20 billion in property loss, exceeding the financial loss from any other single type of building construction from the quake.

Microchip seeks out prostate cancer

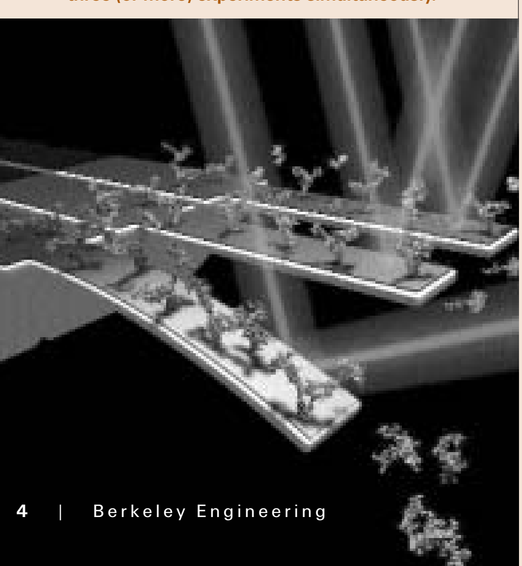
A clever technique for detecting proteins by inducing them to stick to and bend a microscopic cantilever – essentially a diving board the thickness of a human hair – is sensitive enough to serve as a diagnostic test for the protein markers characteristic of prostate cancer, a team of scientists from universities and research laboratories across the country reported in a recent issue of the journal *Nature Biotechnology*.

The protein markers, called PSAs for prostate-specific antigens, are found at elevated levels in the blood of men with prostate cancer, the number two killer of American men.

"The technique is sensitive enough to detect levels 20 times lower than the clinically relevant threshold," says Berkeley mechanical engineering professor Arun Majumdar, a lead author of the report. "This is currently as good as, and potentially better than, the so-called ELISA, enzyme-linked immunosorbent assay, which is the standard today for detecting protein markers like PSA."

The microcantilever technique has far broader applications, however. Any disease, ranging from breast cancer to AIDS, characterized by protein in blood or urine, could conceivably be assayed by arrays of these microcantilevers. A microcantilever array would be one of the first "protein chips," analogous to the DNA chip used broadly today in research labs and the biotech industry to conduct hundreds of DNA analysis simultaneously.

Three cantilevers coated with antibodies to PSA, a prostate cancer marker found in the blood. The left cantilever bends as the protein PSA binds to the antibody. Although Majumdar and his team did not conduct the current experiment with three adjacent cantilevers, the illustration represents some of the individual experiments they performed. The group currently is making a chip that can do all three (or more) experiments simultaneously.



KENNETH HSU/UC BERKELEY & THE PROTEIN DATA BANK

"This could lead to fast screening and molecular profiling for many diseases and a possible chip for detecting cancer," says Majumdar.

"A big advantage of this technology is that one could look at multiple markers in a single reaction, whereas currently available assays require a separate reaction for each analyte," says colleague Richard J. Cote, M.D., professor of pathology and urology at the Keck School of Medicine of the University of Southern California and the USC/Norris Comprehensive Cancer Center. "So the cost of performing a cantilever assay as opposed to a typical ELISA assay is potentially much, much lower." F

BY ROBERT SANDERS

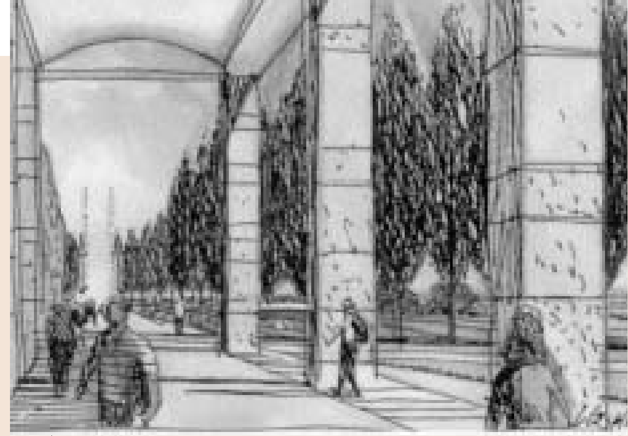
Technology venture to help Merced students

A new technology venture between the Berkeley and Merced campuses is gearing up to make the content of Berkeley's lower-division computer science courses available online. Thanks to this effort, UC Merced will graduate its first computer science class only two years after it is slated to open its doors in 2004.

The project is being developed by the new Center for Information Technology Research in the Interest of Society (CITRIS), a partnership of four UC campuses – Merced, Davis, Santa Cruz, and Berkeley.

As interest in distance learning heats up, course offerings in the computer science division, like those of other top universities, increasingly have moved into the spotlight. But until now, Berkeley instructors have held off in favor of more proven forms of teaching.

"We didn't see how even Berkeley's self-paced courses could just be moved over and plopped down somewhere



Artistic rendering of the library colonnade at the future UC Merced campus.

else," says Michael Clancy, senior lecturer in computer science at Berkeley, "without the infrastructure of graduate students as teaching assistants, experienced instructors, and a program tailored to suit students."

This changed with the state's funding of CITRIS, which will enable Berkeley and Merced to team up and research the best practices in online teaching and course creation.

Rather than outright transfer of courses from one campus to another, the group has decided to create new technology that makes it easier to design the right course for UC Merced out of Berkeley's core content. In addition to the computer science content, UC Merced will receive a "course environment" with all the necessary rationale for course design, as well as working alternatives to the Berkeley approach.

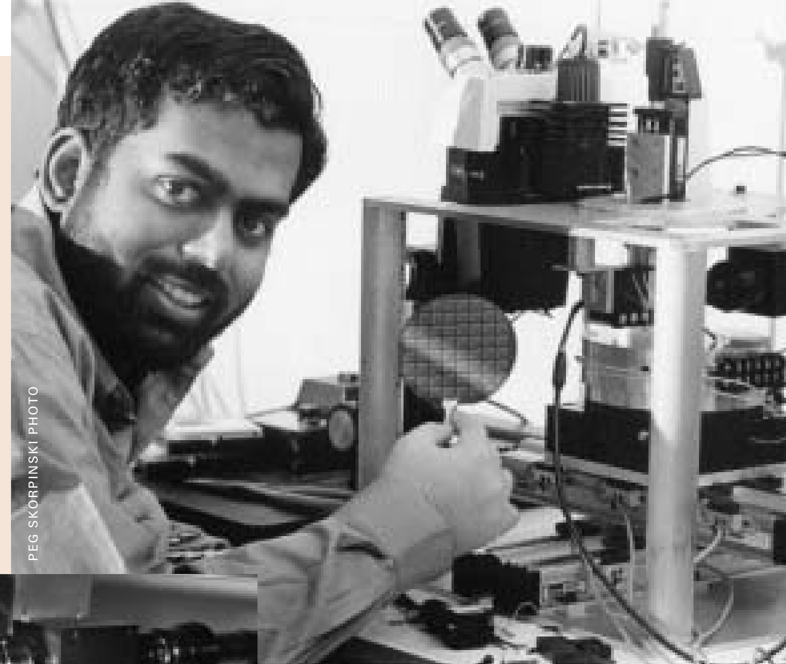
"The courses we're providing are just a tip of the iceberg," Clancy says. "What we're really bringing to bear are years and years of Berkeley's experience teaching computer science. The value added is the rationale behind how the courses are constructed."

While the future of online learning is much debated, most in the field agree great potential exists, says Berkeley education professor Marcia Linn, a partner on the project. "Online courses can offer value added with effective use of visualizations, explanations on demand, and interactive problem solving," she says.

"Our goal is a true integration of proven classroom experiences with proven and emerging technical innovation," says Jeff Wright, dean of engineering for UC Merced, "resulting in an overall educational framework that provides students more thorough, more lasting, yet personalized experiences." F

BY KATHY SCALISE

Will printed circuits replace barcodes on tomorrow's soup cans?



PEG SKORPINSKI PHOTO

Wafers such as the one Subramanian is holding are used to fabricate printed circuits. Liquid gold synthesized in Subramanian's lab is printed in computer-generated patterns onto the wafer by the inkjet printer to form transistor contacts, wires, inductors, and other components used in RFID circuits.

The future of the ubiquitous bar code is looking grim. In development at Berkeley are circuit-laden smart tags printed directly on product packaging that could revolutionize commerce beginning with your weekly trip to the supermarket.

Imagine filling your shopping cart and walking right out of the store past a sensor that automatically identifies what you're buying and instantly charges your credit card. Of course, the store itself would always be fully stocked because the electronically-enabled shelves would take their own inventory and automatically reorder supplies as necessary. Your refrigerator might even generate its own shopping list, sensing when your milk is sour or your egg carton empty.

"We're focused on disposable electronics," says Professor Vivek Subramanian of the Department of Electrical Engineering and Computer Sciences. "The question is – can we print a circuit on a package so that when you ping it with a radio signal it'll reply 'hey, I'm a can of soup.' Just as importantly, can we do it very inexpensively?"

For these printable radio frequency identification (RFID) tags to catch on, they need to be dirt cheap – adding less than one-half a cent to the price of existing product packages, Subramanian says. To meet that price point, Subramanian and his research group have embarked on a multi-disciplinary project spanning chemical, electrical, and mechanical engineering. The result is an extraordinary inkjet printer and a family of electronic inks that enable circuits to be patterned onto paper, plastic, or cloth without damaging the material.

An RFID tag consists of passive components – the inductors, capacitors and wires that handle the communication, interconnection, and power coupling; and active components – the transistors and diodes that handle signal modulation and switching.

"In the long term, you'd like to have a bit of programmability," Subramanian says. "For example, every can of soup could have the same identification number, but each batch could be programmed with a different expiration date." To introduce this capability, the group is also working on adding memory to the tags.

At the April meeting of the Materials Research Society, Subramanian's group presented their success in developing a printed conductor system that could be used to fabricate the RFID tags' power scavenging and communication circuitry. The key is "liquid gold." Synthesized in Subramanian's laboratory, liquid gold consists of gold nanocrystals that are only 10 atoms across and melt at 100 degrees Celsius, 10 times lower than conventional gold films. The size of the gold nanocrystals is engineered to reduce the gold's stability at elevated temperatures, to reduce the melting point.

The gold nanocrystals are encapsulated in an organic shell of an alkanethiol (an organic molecule containing carbon, hydrogen, and sulfur) and dissolved in ink. Then, an inkjet printer – either the group's cannibalized commercial model or one they have built from scratch – deposits the material on the plastic, paper, or fabric in the desired circuit pattern. The liquid gold is also suitable for screenprinting, commonly employed to print product packaging. As the circuit is printed, the organic encapsulant is burned off, leaving the gold as a high-quality conductor.

"Gold is already used in semiconductors, and given the amount you need in our system, the raw material cost is not very high," Subramanian says.

The next stage of the research is to develop high-quality printable transistors, probably a year or two away, Subramanian says. One challenge, he explains, is protecting the printed transistors from corrosive oxygen and moisture. In collaboration with the College of Chemistry, the researchers are exploring the use of the same polysiobutylene rubber-type material used in automobile tires as a screen printable packaging for the printed transistors. In the meantime, the researchers are working with their existing organic transistors, as well as with models of what they postulate their future transistors will look like.

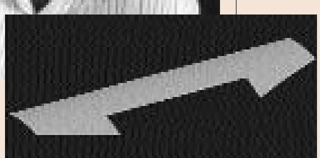
"We want to know just how good the transistors need to be for the system to work," he says. "After all, this project is truly at the intersection of economics and engineering."

BY DAVID PESCOVITZ

Wing design reduces wake turbulence

Adding triangular flaps to the design of aircraft wings dramatically reduces the turbulence generated in a plane's wake, according to Berkeley mechanical engineer Ömer Savas, whose recent research may lead to improvements in both flight safety and airport capacity.

BRUCE COOK PHOTO



Top: Savas conducts wind-tunnel and water-tank experiments to gather data on wake vortices. Right: In tests, Savas' wing design significantly cut wake turbulence compared with traditional wing designs.

Wake turbulence, or wake vortices, may have played a role in the American Airlines Flight 587 crash that killed 265 people last November 12, according to crash investigators. The tail fin of the Airbus A300 jet sheared off after the pilots struggled against the wake turbulence left by a Boeing 747 that had taken off less than two minutes earlier.

Savas and former graduate students Jason Ortega and Robert Bristol have been experimenting with wing designs that would quickly render wake turbulence harmless after takeoffs and landings. "The wing we designed could make substantial differences in flight safety and airport capacity," says Savas. In their bat-like design, triangular extensions jut out behind each wing, dissipating wake vortices two to three times faster than traditional wing designs.

Berkeley recently filed a provisional patent application for the design using results from Savas' experiments.

Federal regulations require flights to be spaced far enough apart during take-off and landing to avoid the potential hazards caused by wake turbulence. While wake turbulence alone probably couldn't have caused the crash of Flight 587 in New York, "turbulence in combination with a possible structural problem in the tail fin could be devastating," says Savas.

A wake vortex results from the mismatch in speed, direction, and pressure of air moving above and below a plane's wing. These differences govern the lift generated during flight. Planes that are large, heavy, and moving slowly create stronger wake vortices.

Depending upon weather conditions and a plane's speed and size, the wake vortices can stretch a distance of hundreds of wingspans, or three to five miles for a commercial aircraft, says Savas.

"In addition to improving safety, cutting the distance that the wake vortex remains coherent would allow planes to take off and land closer in time together without compromising safety," says Savas. "That leads to more efficient use of runway capacity, a major problem at congested airports around the country."

Savas is currently working on a pilot program with scientists at NASA Ames Research Center to incorporate the triangular-flapped wings in aircraft designs. He notes that commercial jets have not gone through a significant design change since the Boeing 707 began rolling down the runways in the 1950s. "Maybe it's time for something new," he says. F

BY SARAH YANG

Revisiting shaken-baby syndrome

The 1998 Massachusetts v. Woodward case, or the "Nanny Murder Trial" as it was known in the tabloids, horrified many people. A British au pair, Louise Woodward, was accused of intentionally shaking to death the eight-month-old infant in her care. Although the charge was reduced to involuntary manslaughter, the case's publicity brought shaken-baby syndrome to the top of infant abuse allegations.

BONNIE POWELL PHOTO

Werner Goldsmith displays the models he's used over the years to study adult head injuries.

But Berkeley mechanical engineer Werner Goldsmith is trying to stop pediatricians – and prosecutors – from jumping to the wrong conclusion. "The pediatricians' mantra is that subdural hematoma plus retinal hemorrhage (bleeding in the brain and behind the eye) equals child abuse. But that is not necessarily the case," argues Goldsmith, a much-honored professor in the graduate school who has been researching head injuries since 1966.

"If someone intentionally abuses an infant, the law should throw the book at them," he is quick to clarify. "I simply want to differentiate between intentional abuse and accidental trauma, so that people who experience the latter aren't unjustly convicted."

The problem is a total lack of biomechanical data on infant neck and head trauma. Goldsmith intends to correct that by building a lifelike dummy of a baby, complete with a skull, dura (the membrane that envelopes the brain), and brain. Unlike the crash test dummies we see in TV ads, Goldsmith's model will have full range of motion in the head, allowing him to measure the motion, deformation, and force of both linear and angular motion. Working with UC San Francisco neurosurgeon Geoffrey Manley, Goldsmith hopes to obtain actual cerebral arteries and veins that will allow him to model the vasculature of an infant's brain exactly, perhaps even simulating blood flow. F

BY BONNIE POWELL

Testing, testing: new dorms' seismic foundation system passes muster

A series of seismic tests on drilled piers, conducted in a campus parking lot, could help existing Berkeley structures ride out quakes more effectively while cutting costs for constructing earthquake-safe buildings in the future.

The Berkeley Seismic Review Committee (SRC) launched the project last fall as part of its continuing effort to lower the cost and improve the effectiveness of seismic design on the Berkeley campus.

Funded by Berkeley's Capital Projects, the office that oversees campus construction, with participation by the Pacific Earthquake Engineering Center (PEER), the tests assessed the performance of drilled cast-in-place piers, not in a lab, but at an actual campus construction site.

"While drilled cast-in-place piers are a long-established part of constructing earthquake-safe building foundations," says Michael Ordonia, project manager with Capital Projects, "the twist here is that rather than relying on scientific guesses as to the capacity of the piers, these piers were actually tested *in situ* to measure their ultimate capacity."

Supervised by structural engineering firm Rutherford and Chekene, the tests took place at the Underhill Parking Lot on Bowditch and College, adjacent to dormitory Units 1 and 2. The team used the parking lot, nestled between the highrise dorms where over the next four years additional construction will take place, to test new technology that could be put to use quickly, and right next door.

Site engineers divided the parking lot into two test areas, drilling three holes into the ground at each test area, then pouring in concrete, which cured for two weeks. Then they ran a series of static and dynamic tests on the piers.

The static tests measured the steady force the piers could withstand by pulling them out of the ground over a few hours; the dynamic tests were performed using a relatively new dynamic test device, a Fundex Pile Load Test (PLT), recently introduced in California by American Piledriving Inc. This device mimics axial seismic loading by dropping a heavy weight onto a pier for a duration of about 0.1 seconds. Test results came as a pleasant surprise, according to PEER director Jack Moehle. "The piers were three times stronger than was previously thought," he says.

Foundation piers transfer the force of an earthquake from a building to the soil, and do this at significant depths. But determining the size and quantity of piers necessary to safely accomplish this transfer depends on the unique properties of the soil on which a building is constructed.

Unlike pre-made piers, whose strength can be evaluated each time they are driven into the ground, direct tests of cast-in-place piers are rare because of the way they are constructed. "That means," says Moehle, "that you don't have any direct measure of the strength or capacity of the cast-in-place piers." To compensate for this, traditional design formulas are conservative, which often results in using more and larger diameter piers than are necessary.

"The dynamic nature of the PLT tests will allow us to use better values for seismic design of foundation elements on the Berkeley campus and, hopefully, we can also influence future design to take better advantage of the good dynamic response of foundation elements," says civil engineering professor Nick Sitar, outgoing SRC chair. "Also, the PLT test is relatively simple and quick, which means we should be able to use it on a more routine basis on future projects."

The project will create significant savings for the University, Ordonia says. Capital Projects staff estimate that after spending roughly $100,000 to conduct the tests, the campus will garner a net savings of up to $400,000 in reduced construction costs. Test results have already been incorporated into the residential hall building project adjacent to the test site. And because the soils under the campus are fairly uniform, the research could be used for upcoming construction projects as well, says Ordonia.

Test data will also help retrofit existing buildings. "If there's some structural element that has to be rebuilt as part of the building, now we have an additional tool with which to analyze the structural system," says Ordonia. "What's more, the project offered a unique opportunity for architects, structural engineers, geotechnical engineers, earthquake engineers, and University administrators to work together using performance-based engineering techniques." F

BY JESSICA M. SCULLY

NICK SITAR PHOTO

Berkeley architects, engineers, and administrators teamed up last fall to test the seismic strength of foundation piers at a campus construction site. Using an innovative dynamic testing device, above, engineers collected and analyzed data that will lead to more effective retrofitting and lower construction costs.

Nanotransistors could hold Moore's Law at bay for decades

Berkeley breathes new life into silicon

PEG SKORPINSKI PHOTO

Wafers such as these that Tsu-Jae King, left, and doctoral student Yang-Kyu Choi are inspecting, have just come out of the "stepper," (out of view) the lab's new state-of-the-art lithography equipment used to print fine features on the surface of the wafer. Once imprinted, the wafers are inspected and loaded up for etching. "Yang-Kyu has made some of the world's smallest transistors," King points out. "Now we want to prove they can work in the circuit. What we want is circuit performance."

The future of computing is headed toward a brick wall. Eventually, the silicon industry's rule of thumb known as Moore's Law – which predicts that the number of transistors that can be packed on a silicon integrated circuit doubles every 18 months – will be vetoed by the laws of physics and economics.

First proposed in 1965 by Gordon Moore, a Berkeley chemistry alum who went on to co-found Intel, Moore's Law has proven itself with a steady increase in computing power at proportionate decreases in cost. At a certain scale though, today's transistors – the tiny on/off switches that make up integrated circuits – will become too unreliable and, perhaps even sooner, too expensive to be practical. The private sector expects that day to come within a decade or so. But a trio of Berkeley researchers designing the world's smallest next-generation transistors aren't quite ready to put Moore's Law to rest.

"We think we can keep shrinking the transistor for another 20 years," says Chenming Hu of the Department of Electrical Engineering and Computer Sciences who, with faculty colleagues Jeff Bokor and Tsu-Jae King and a team of graduate students, created new devices that enhance performance while also enabling chips to keep shrinking. "Even if the brick wall faced by Moore's Law can't be toppled, it certainly could be pushed further out," says Hu.

To extend the life of Moore's Law in the long-term, and improve computing power in the short-term, the Berkeley researchers are proposing two new paradigms in silicon transistor design: FinFET (Fin Field Effect Transistor) and UTB (Ultra-Thin Body). Ten times smaller than today's transistors, the FinFET and UTB devices measure less than 100 atoms across. Their Lilliputian scale means that a trillion transistors could be packed on a chip that today holds a mere one billion. That increase in processing power could lead to ultra-fast and hyper-realistic medical simulations, handheld foreign language translators that work in real time, and computers that respond to natural spoken language.

While these applications are at least a dozen years away, the FinFET and UTB research is already bearing fruit. Most recently, the Berkeley researchers presented their progress in performance and manufacturing processes at the 2001 International Electron Devices Meeting (IEDM) in December. But Hu, Bokor, and King's crew were not the only ones trumpeting advances in transistor technology born, or at least furthered, at Cal. For starters, an IBM research group, led by a former student of Bokor's, presented their own positive FinFET findings.

"IBM was already working on this technology when they got one of our Berkeley experts to go there," Bokor says of his former student. "He sort of supercharged their project, and we're all very proud of that."

Also at IEDM, Intel Corporation touted

their newly announced TeraHertz transistor, essentially a structural double of Berkeley's UTB transistor. The company expects to add elements of the TeraHertz technology into its product line as early as 2005.

"These various companies have our former students, so they have the benefit of knowing the issues with laying out and designing these circuits," King says. "I would think they have a good chance at being very successful."

The FinFET and UTB project was born in 1996 out of a Defense Advanced Research Projects Agency (DARPA) call for researchers to fabricate a transistor that was 25 nanometers in length. (A nanometer is one-billionth of a meter.) At the time, the smallest transistors were 250 nanometers in length. A cloud of uncertainty hovered over the silicon industry as researchers expressed concern that the future of silicon transistors, especially past the 50-nanometer size, was grim.

"The expectation then was that DARPA's size requirement could only be met by exotic approaches like quantum devices that are not compatible with circuits for real applications," Hu says. "But we submitted a proposal to do it with silicon, which is Berkeley's specialty. We believed in the future of silicon when most people were doubting it."

In 1999, the Berkeley team dropped their 18-nanometer transistor design in DARPA's lap, christened as FinFET. In 2000, DARPA honored the group's success with the prestigious Award for Technical Achievement. Currently, the project is funded under Microelectronics Advanced Research Corporation and Semiconductor Research Corporation grants.

To understand how Berkeley broke the world record in silicon scaling, a bit of transistor terminology is necessary. Complementary metal-oxide semiconductor (CMOS) is the technology commonly used to fabricate transistors. Semiconductors are exactly what the name implies. The crystalline materials, including silicon and germanium, aren't as good as, say, copper wire in allowing electrons to flow through. But they're not that bad at it either. Also, impurities such as boron can be added to the semiconductor to selectively enhance its conductivity. This process, called "doping," results in a semiconductor with either an abundance of mobile positive charge (a "p-type" material) or an abundance of mobile negative charge (an "n-type" material).

The transistor itself contains three terminals: the source, the gate, and the drain. In the most common transistor type, the source and the drain, doped n-type, reside in a p-type body. The conductivity of the p-type region between the source and drain is controlled by the gate, which is located

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Hu, Bokor, and King (pictured counter-clockwise from top) inspect wafers, which are fabricated in the MicroLab, then measured here, in the Device Characterization Lab in Cory Hall.

"We think we can keep shrinking the transistor for another 20 years."

PEG SKORPINSKI PHOTO

MicroLab researchers such as Bokor and King (the lab's director) suit up from head to toe in "clean suits" (they call them bunny suits) to prevent even the smallest amount of contamination from entering the lab or its extremely sensitive equipment. The lab has more than 300 active users, including researchers from nine departments on campus and users in private industry.

directly above the channel with a thin interposing oxide layer. This layer is needed to prevent electrical current from flowing between the gate and the channel. The size of a transistor actually refers to the length of the gate, which corresponds to the spacing between the source and the drain. Applying a positive voltage to the gate attracts the negatively charged electrons from the source into a surface channel, creating a continuous n-type layer for current to flow between the source and drain. At this point, the transistor is "on." If the voltage at the gate is removed, the n-type channel layer cannot be maintained, switching the transistor "off."

The problem is that as the gate length is shrunk and the source and drain are pushed so close together (less than 100 atoms apart), more electrons can sneak through during the "off" state.

"There's no such thing as zero in engineering, but the goal is to make the current as minimal as possible" when the transistor is off, Bokor says. "When chips have hundreds of millions of transistors, even a tiny amount of leakage per transistor adds up."

In the FinFET design, a thin vertical silicon "fin" is built between the source and drain. Then the gate electrode material is deposited on both sides of the fin resulting in a double gate structure, one on each side of the channel.

"It's like trying to stop a bleeding vein," Hu says. "You could press down on the vein, but it would be much more effective if you could get another finger behind the vein and pinch it closed."

At IEDM 1999, the group presented a groundbreaking paper demonstrating that the FinFET design successfully blocked current in the "off state," even on such a small scale. Last year's encore showed that the FinFET conducts enough current in the "on" state to deliver on its promised high performance.

"In industry, they have large fabrication facilities and lots of engineers to work on optimizing devices," Bokor says. "It's obviously harder for us. So it took a while, but we did it."

Hu, Bokor, and King's second transistor design, the Ultra-Thin Body device, employs a very different engineering innovation to shorten gate lengths while preventing leakage. In today's transistors, most of the leakage occurs deep in the body of the transistor below the gate. The UTB approach is to eliminate that material except for the top-most portion of the channel that is well-controlled by the gate.

"To continue the bleeding analogy, the UTB approach is like closing off a vein by pushing it against a hard surface like a bone," Hu says. "It's an improvement, but pinching it like the FinFET does is still the best way."

Once the FinFET and UTB structures were designed, King and Bokor, along with electrical engineering colleague Vivek Subramanian, faced another set of challenges inside the clean room where the transistors are manufactured.

"No one else had really tried to thin down silicon this much in a controllable manner and make transistors," says King, the faculty director of Berkeley's Microfabrication Laboratory. "We had to find ways to even define the features so we could make these transistors."

For example, in the case of the UTB approach it's desirable to make the silicon

"We believed in the future of silicon when most people were doubting it."

body below the gate as thin as possible to help control leakage. But this isn't the case on either side of the gate. There, the material should be as conductive as possible to prevent a bottleneck in the flow of electricity. Their novel solution, King explains, was to selectively thicken the areas around the gate by depositing materials only in those regions.

While King oversees the integration of the entire manufacturing process, Bokor focuses on one critical element: lithography. Layers of material in today's chips are patterned using a process where light shining through a mask (essentially a stencil of a chip's features) projects the circuit pattern onto a silicon wafer coated with photoresist, an organic film that hardens when exposed to light. The shorter the wavelength of light projecting through the mask, the smaller the features on the chip. In order to make transistors with features as small as the FinFET and UTB devices, Bokor employed an electron beam, exposing the mask pattern on the silicon wafer. Fortunately, the best electron beam facility in the world for this type of work is adjacent to the Berkeley campus at Lawrence Berkeley National Laboratory (LBNL). Since 1996, Bokor has collaborated with Erik Anderson, director of LBNL's Center for X-ray Optics, and director of LBNL's "Nanowriter" facility.

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Probe stations, such as this one in the Device Characterization Lab, measure devices as small as a single transistor.

"This is a laboratory technique though, and not suited for mass production," Bokor says. "A whole other issue in this project is how to mass produce transistors on this size-scale."

One part of the answer may lie in Bokor's pioneering research into extreme ultraviolet lithography (EUV), the industry's leading candidate for next-generation lithography. It is expected that EUV will enable the fabrication of chips with 20-nanometer transistors and smaller, breaking down some of the mass manufacturing barriers threatening Moore's Law.

"The brick wall is now at 10 nanometers and we're reaching out to touch it," Bokor says.

With the end of silicon in sight, the Berkeley research into FinFET and UTB structures is cranking along with an emphasis on honing the production process for mass manufacture. Indeed, King says, it's a detail-oriented job.

"On this scale if you have one less atom in a channel, that can affect the performance," she says. "And we want to see how these transistor structures perform at the ultimate size limits."

While computers can simulate the operation of transistors, King believes that the only way to truly test novel devices is to make them. Then the simulation models can be updated with real-world data, and circuits using the FinFET and UTB transistors can be accurately designed.

Once the advantages are on the table and the manufacturing kinks ironed out, it's up to the private sector to take the ball and run with it.

"The brick wall facing today's transistors is still a ways off," Hu says. "The industry can continue for a while. But at what point would a company become more competitive to convert to our new structure? Our challenge is to make that switch more compelling." F

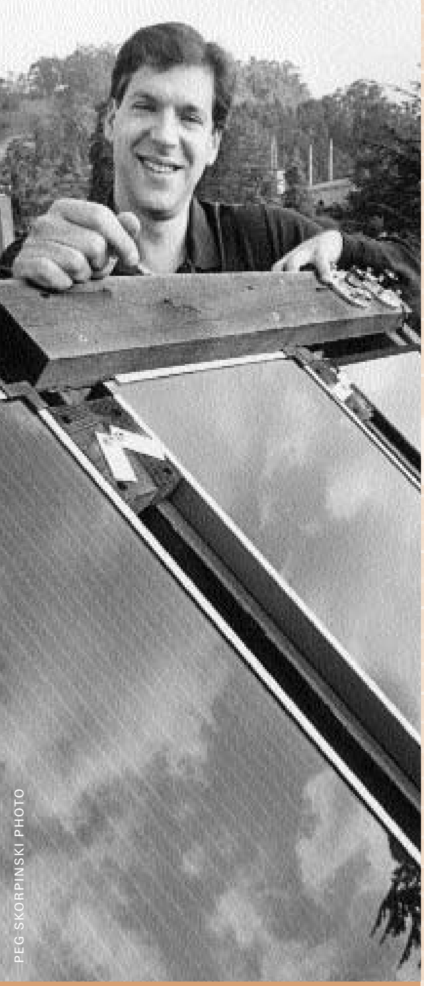
Written by David Pescovitz, a contributing writer to *Wired* and creator of *Lab Notes* (www.coe.berkeley.edu/labnotes), the College's online research digest. His work has appeared in *Scientific American, New Scientist,* the *New York Times*, and *Salon*.

A trillion transistors could be packed on a chip that today holds a mere one billion.

Hydrogen-powered vehicles do more than run on clean energy, they generate electricity

The fuel cell vehicle's day may be dawning

For years, advocates of alternative energy have decried using oil to fuel our power plants and vehicles. Drilling for oil creates environmental havoc, critics charge. Burning oil produces noxious air emissions and contributes to global warming, they continue. Besides, our oil-guzzling ways make us dangerously dependent on foreign oil and the foreign powers that control it.



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High-efficiency solar panels, such as these, could be used to produce hydrogen to power a fuel cell vehicle.

But solutions to America's thirst for speed, power, and electrical gadgetry have been elusive. Electric cars are often a big draw at auto shows, but such vehicles are still extremely scarce on the roadways. Electricity produced by wind and solar energy has, until recently, been more expensive than that produced by fossil fuel-powered plants. And while conservation has reduced our oil use significantly – especially in California – there are limits to how much Americans can keep the lights low, the appliances off, and their cars at home.

For many, this has looked like an unsolvable mess. But for Daniel Kammen, Berkeley professor of nuclear engineering, energy and resources, and public policy, the solution is simple: develop cars that not only run on "clean energy," but also generate "clean electricity." "And," says Kammen, "develop and promote them now."

Kammen, who directs the Renewable and Appropriate Energy Laboratory (RAEL), has been analyzing the benefits of such cars for years – one aspect of his ongoing work on the environmental, health, and economic impacts of energy use in industrialized nations and third world countries.

He and several colleagues released a paper last year showing that fuel cell vehicles (FCVs) – cars that generate electricity from fuel cells – can serve a dual role: powering your car as well as supplying electricity at competitive rates, especially in office buildings. "We surprised ourselves by the results," says Kammen with a grin. "We didn't realize the potential would be so great."

The idea of using fuel cells, which convert the energy in a fuel like hydrogen and oxygen into electricity, is not new. Back in 1839, Sir William Grove, an English scientist, discovered that by combining hydrogen and oxygen, he could produce water and electricity. Years later, in the 1950s, Francis Bacon used Grove's earlier discovery to develop a hydrogen-powered fuel cell that could power a vehicle. Then during the 1960s, Pratt & Whitney went a step further, and developed fuel cells to create electricity for the Apollo space missions.

"After that, some power companies expressed interest in using stacks of fuel cells to generate electricity," Kammen says, "but it was too costly. Now we're finding the real cost-effectiveness lies in having people generate their own electricity with their own fuel cells."

Fuel cells could provide a transition from fossil fuels to renewable sources of energy, according to Kammen, who has explored the intersection of energy use and society since his graduate school days. Fuel cells use an electrochemical reaction to produce electricity, rather than moving parts, so the cells are quiet. And since there is no combustion, they generate no air pollution or greenhouse gases. And because fuel cells are so thin – as thin as a piece of paper – they can be stacked together to produce a lot of electricity within a small space. That stackability – or "scaleability" – means fuel-cell vehicles will have the get up and go that electric cars currently lack.

You can also produce extra electricity from them. Rather than thinking of fuel cells in the traditional model of energy production – in which a utility generates electricity from a centralized location, then transmits it to millions of consumers – Kammen envisions consumers using their FCVs to generate electricity for local neighborhoods and businesses right from their own garages.

Here's how it works. At the end of the day, you drive your FCV home from the office. The fuel cell you'd be using would, most likely, run on hydrogen, derived, at least initially, from natural gas supplied by filling stations. Once inside the garage, you plug your car into an electrical outlet – no ordinary electrical outlet, but one that sends electricity *into* the grid, rather than pulling it *out* of the grid. Then the fuel cells begin generating electricity.

Using FCVs to generate electricity for just one home is not all that efficient, Kammen concedes. But an FCV could easily generate enough electricity to light up several homes, even an office building. To do that, drivers would motor to work in their FCV, park in a fuel cell plug-in station, and pump electricity into the company's building.

It appears to be a clean, efficient solution. And, says Kammen, it's a solution that could put money back into consumers' pockets, if FCV consumers are reimbursed for their electricity, either by their utility company or their employer. In one back-of-the-envelope calculation, he predicted consumers could earn between $200 and $1,000 a year, rather than paying $500 to $1,200 in annual utility fees.

Equally important, such "distributed generation" (rather than centralized power production from a power plant) could "radically transform the way we see and use electricity," Kammen says. "If production is closer to where the electricity is used, we'll waste less electricity during transmission. What's more, we can avoid building new power plants and vastly increase the security and reliability of our electricity system."

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Kammen wires up a solar panel, adjusting the device that measures how much sunlight the panel absorbs; all this in the treetops of his Barrows Hall roof lab.

Consumers' fuel cell vehicles could generate electricity for local businesses right from their own garages.

Kammen knows that moving toward a world where energy production relies neither on internal combustion engines nor centralized power production is a Herculean undertaking – one that involves moving mountains in the form of car companies and government agencies, not to mention consumers. California, Kammen notes, may be the ideal place to start. The Zero Emissions Requirement of 1994 has made the need for clean-running cars mandatory; and the state-wide energy crisis of 2001 raised consumer awareness to new levels.

"Instead of revamping an inefficient, antiquated grid that relies on 1940s technologies, we should replace it with distributed generation," Kammen says. "And it doesn't have to be done overnight. We can update the system neighborhood by neighborhood, but only if the utilities or other startup companies are afforded the market opportunity."

Just how soon FCVs could be on the market is unclear. Several car companies say they will release FCVs in the next few years. And earlier this year the Bush administration announced it would back the development of "clean" vehicles powered by fuel cells. It could be, says Kammen, that we will see FCVs on the road by the end of next year. F

Written by Susan Davis, whose father helped design the Apollo fuel cells. A Bay Area writer and editor, Davis has written on environmental issues for Intel Corporation, Lawrence Berkeley National Laboratory, and The Nature Conservancy. She co-authored *The Sporting Life*, a book on the physics of sports, as well as several books on playing with children, and has contributed to *Sports Illustrated*, *Parenting*, and *Ladies Home Journal*.

Berkeley engineers test how water temperature affects geothermal energy

How much stress can a poor rock stand?

PEG SKORPINSKI PHOTO

It takes about three hours to heat up Glaser's pressure chamber. Gauges control the temperature and pressure for the water injection system used to put the rock samples through their thermal paces.

In the heart of Sonoma County's lush wine country, just 34 miles northeast of San Francisco, engineers have tunneled under the Russian River to carry treated wastewater from the city of Santa Rosa to the Geysers geothermal fields — the largest producer of geothermal energy in the world.

Steam-driven turbines at the Geysers produce enough electricity to meet the daily needs of some one million people throughout the state of California. But, for the past 15 years, the amount of steam available to fuel the geothermal plants has been decreasing, as the reservoir beneath the Geysers dries up, a victim of overpumping. As a result, energy production has slipped and is in danger of grinding to a halt.

In search of solutions, plant operators at the Geysers, in partnership with the Lake County Sanitation District, came up with an innovative plan to restore and maintain adequate levels of underground water to ensure continued energy production. They decided to inject tertiary-treated wastewater, which is completely safe to drink, from the Lake County communities surrounding Clear Lake into the ground at the Geysers – 30 miles to the south – to replenish the underground reservoirs.

For the past four years, some 7.8 million gallons of water each day have been injected at the Geysers. With the addition of the Santa Rosa wastewater project, expected to be completed this year, an additional 11 million gallons of water will be added each day. But while all the operational details to replenish the water reserves seemed in place, according to Steven Glaser, Berkeley professor of civil and environmental engineering, one crucial element had been overlooked.

"I was shocked when a colleague told me that nobody really knew what happened when cooler water, like the injected wastewater, hit very hot rocks," says Glaser. "Will the fracturing of the hot rock that inevitably results from the cold water injection disrupt or block the movement of steam or increase it?" he wondered. "Despite years of water injection in geothermal fields like the Geysers, no one knows. Certainly, you don't want to damage your reservoir."

So, Glaser assembled a research team, secured funding from the U.S. Department of Energy and Shell International Exploration and Production Co. (they are interested in drilling under high temperatures), designed new lab equipment, and began a series of controlled laboratory experiments testing rocks similar to those found in the Geysers.

Working with graduate student Jeff Moore, Glaser assembled a unique testing device now located along one wall of his rock mechanics lab. Inside the testing device, flat bladders filled with pressurized oil squeeze a rock sample up to 1,500 pounds per square inch (psi), matching pressures found deep underground. Glaser and Moore saturate the pressurized, heated sample with steam, up to 300 psi, pumping the temperatures up to more than 200 degrees

Celsius – almost 400 degrees Fahrenheit. Finally, they inject water at room temperature to a well-point drilled into the rock. Then they wait, and watch.

Glaser and his colleague Frank Morrison, professor of civil and environmental engineering, monitor the movement of the cooler water through the hot rock, recording any fracturing. Sensitive acoustic sensors arrayed around the rock sample inside the heater detect the telltale sounds that indicate fracture has occurred. "Every time rock cracks," says Glaser, "it generates sound waves, little snaps, crackles, and pops."

"The sensors, as they stand right now," Glaser adds, "are not going to like 200 degrees Celsius. We have to find different materials, with higher heat resistance, out of which to make them." Using a technique that triangulates signals from multiple sensors, the engineers should be able to create a three-dimensional map of the inside of the rock, showing the placement and size of new fractures.

But it's not enough to know where new fractures occur. Glaser and Morrison want to know how the cold water flows through and interacts with the hot steam already in the rock. To that end, the team will measure changes in the rock sample's ability to transmit electrical currents, or its resistivity, as the cold water moves through the heated rock sample. "Minerals in rock act like insulators," Morrison explains. "Current in rock flows through any water inside it." Resistivity increases when rock is cold, and decreases when it is hot, since cold water is less likely to conduct a current. Thus changes in resistivity should indicate where areas of cool water and hot steam are as they flow through the rock. "I've measured resistivity on blocks of rocks before," Morrison adds, "but not under conditions of such high temperatures and pressures, or with injected water."

These conditions, which match those occurring deep underneath the Geysers, as well as the substantial size of the rock samples used (10.25 inches on a side) distinguish Glaser's experiment from other rock tests. "Usually test rock samples are about the size of your thumb," he says. "At Stanford, for example, they do tests on thumb-sized rock samples that they can heat to 105 degrees Celsius. Our experiment will run more than twice as hot.

"Once the experiment is up and running this spring, it will help heat the notoriously chilly lab in the Davis Hall annex," jokes Glaser, adding that he is concerned future testing could be jeopardized because of the pending annex demolition.

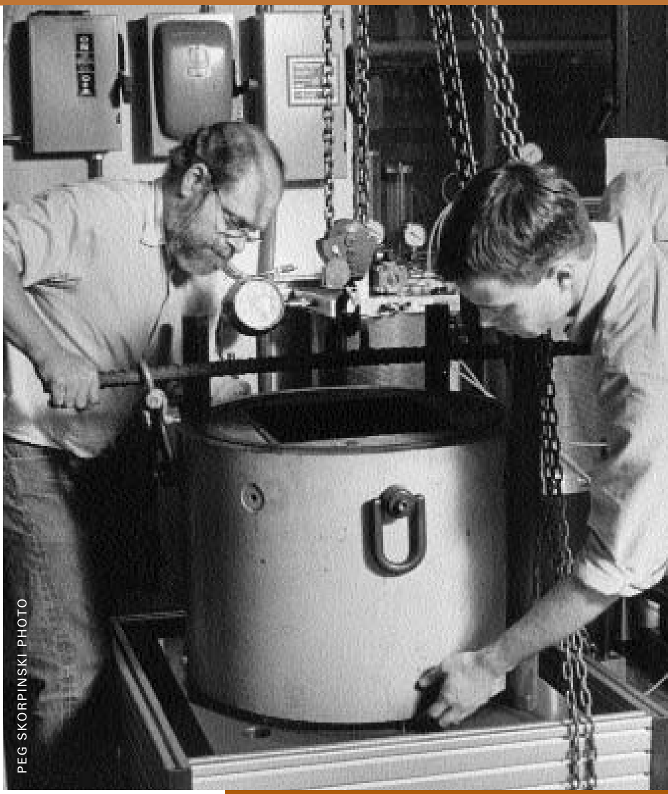
Preliminary tests will be done on a sample of Berea sandstone, a well-understood rock often used in petroleum testing. Then, as the real testing begins, the team will collect rock samples at the Geysers. "You consult a geologic map, drill some cores, and find out where on the surface there are outcroppings of rock similar to what's in the steam-producing zone underground," says Moore.

"Nobody really knows what happens when cooler water, like the injected wastewater, hits very hot rocks."

Glaser's one-of-a-kind testing device will also study fracturing in hot dry rocks as well as those filled with steam. Engineers in Japan and Europe regularly inject water into the hot dry rocks deep in geothermal areas there, hoping to generate steam to produce electricity. But, as with the Geysers, more testing must be done under realistic conditions. Glaser's device also mimics conditions encountered during petroleum drilling, and tests what happens when engineers inject steam to clean up polluted underground sites.

The results of Glaser's and Morrison's tests will become even more important once Santa Rosa's wastewater begins flowing. Knowing what's really happening underground as the chilly water hits hot rocks filled with steam will enable geothermal plant operators around the world to continue to generate desperately needed electricity for years to come. F

Written by Sally Stephens, a freelance astronomy writer based in San Francisco. Formerly a staff scientist and editor of *Mercury*, she co-authored *The Sporting Life*, a book on the physics of sports.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Before firing up their 4,000-pound pressure chamber, Steve Glaser, left, and Jeff Moore prepare to hoist the device some five feet into the air, where it will dangle as it is carefully wrapped in an insulating blanket, allowing researchers in the rock mechanics lab to work around it safely.

The first in a series exploring women's issues at the College and beyond

Women in engineering:
a faculty roundtable discussion

In an era when women are comfortably positioned on the Supreme Court, hold seats in the Senate, and take leadership roles in corporate board rooms, it may come as a surprise that women comprise just nine percent of Berkeley's august engineering faculty. Undergraduate women's presence in engineering is, not unexpectedly, somewhat higher at 23.5 percent, a number that has not changed significantly for the past five years.

Tallies tracking women in engineering began in 1876, when Elizabeth Bragg became the first woman to earn an engineering degree. It took just shy of 100 years from Bragg's graduation, however, for a woman to be invited into the College's faculty ranks. Computer science professor Susan Graham bears that distinction. Of 54 academic appointments in the College, from 1995 to 2000, four were women. But since July 2001, four of the nine faculty hired in the College have been women.

For the most part, Berkeley's statistics mirror the national numbers. In 1998, women made up about 20 percent of all undergraduate engineers across the nation, up from 12 percent in 1979, according to the Society of Women Engineers.

While the numbers of women engineers on both sides of the academic chalkboard are slowly rising at Berkeley and elsewhere, women remain a relatively small, and sometimes isolated, entity with the College.

The numbers tell a story all their own, but the full picture is best revealed by the women faculty themselves. Fiona Doyle, Jasmina Vujic, and Jennifer Mankoff shared their experiences in a lively roundtable discussion last January at the Women's Faculty Club. Excerpts from their discussion follow.

Professor Fiona Doyle, the Donald H. McLaughlin Professor of Mineral Engineering, an expert on solution processing of materials and metallic contaminants in water and soils, joined the materials science and engineering department in 1983. She teaches courses in the surface properties and aqueous processing of materials. "I always thought science and math were so easy and so interesting that I couldn't understand why anybody would want to do anything else," says British native Doyle, 45, who has two young children with whom she is forever doing chemical experiments in her kitchen, as she puts it.

Nuclear engineering associate professor Jasmina Vujic, 48, was the first woman to join the nuclear engineering faculty in 1992. "I decided to pursue nuclear engineering because people said it was the most difficult field," says Vujic, whose daughter, Nevena, is a senior in Berkeley's civil and environmental engineering department. A Yugoslav native, Vujic came to America to pursue her doctoral studies and decided to stay when her native country began disintegrating. Her research includes the development of increasingly advanced computational tools to design and analyze nuclear reactors, and other radiological devices to detect and treat aggressive tumors.

Assistant professor Jennifer Mankoff, one of the College's new hires, joined the computer sciences faculty last fall. Now 28, Mankoff began her college career at Oberlin as a double degree student in liberal arts and viola performance, before focusing solely on computer science. While a student at Georgia Tech, she played viola with the Emory-Atlanta symphony, and now plays viola in Berkeley's University Orchestra. Also an accomplished painter, Mankoff is recovering from a severe case of repetitive strain injury, a disability that in part drives her current research in special-needs computing and assistive technology.


Jennifer Mankoff (in background) and Fiona Doyle

Q: Let's talk about some of the challenges you faced, first as young girls with an interest in math and science, and later as professional engineers.

DOYLE: I went to a high school where we were taught needlework, not metal work or engineering drawings. But I was lucky in that as an undergraduate in the sciences, I attended a women's college at Cambridge University where there was a lot of support. I went to graduate school at the University of London's Imperial College, where I was the first woman they'd ever had in the extractive metallurgy program, and they regarded me as something of a curiosity, but were quite gentlemanly about it. Here, I've been the only woman on the faculty in my department for the past 18 years and I've definitely felt some marginalization.

VUJIC: In Yugoslavia, where I grew up, young girls were encouraged to study and pursue hard fields like engineering and they weren't afraid of math or physics. Although there were only a few women in the department of electrical engineering, we had a lot of respect from our colleagues because we were excellent students. The problems arose when I came to do my doctorate at the University of Michigan. I had a young child, so I was stretched among many different obligations and daycare was nonexistent. In my country the government runs our daycare centers. But here, it was very difficult, and


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Jasmina Vujic

"We have to change the perspective at the elementary and high school levels and encourage girls to take math and physics."

"Although women are choosing to have careers, they still have different career paths than men."

sometimes you are treated as if you don't have family obligations, and you are stretched, particularly during your pre-tenure years.

DOYLE: It's something that's problematic for young men too. The perception among some senior faculty is that if one is taking care of one's family, one is not serious about one's job.

MANKOFF: Everywhere I interviewed, I asked whether anyone had had a child before tenure. What kind of support was there within the department for people having kids? Was there a parents' room? There are young men in the department with young children, but I'm the only woman who is pre-tenure right now, so we'll see what happens. But going back to the original question, I've spent a lot of time being the only woman interested in math or the only woman in the computer sciences department. But so far, people have supported me on women's issues. I think things are a little different for my generation.

PEG SKORPINSKI PHOTOS

Jennifer Mankoff

Q: How has the career landscape evolved for women engineers in academia over the years?

DOYLE: When I first came here – back in the dawn of history – there were only three women professors in the College of Engineering. Women seemed to be regarded as a curiosity, and there was a lot of skepticism as to whether or not women could really do engineering. Now I have such amazingly good female colleagues that there is no question at all about the excellence of women in engineering. In my mind, there are enough data points, that it is generally acknowledged that the women work harder than the men.

VUJIC: I agree, because in order to become a faculty member, particularly for women in engineering, you have to really do a good job.

MANKOFF: One thing to remember is that although women are choosing to continue having careers, they still have different career paths than men. In general, they will stop to have a family sometimes, or even if they don't stop, their family has an impact. A lot of women will go into industry first, then maybe come back to academia. So even if you increase the numbers through graduate school, there's such a diversity of ways that women move professionally at that stage, that it has a big impact on what happens to the numbers.

Q: So, it would seem that there's more to be done. What are your thoughts about remedying the gender gap in engineering?

DOYLE: Last year the College looked at the issue of women on the faculty and one of the committee members interviewed women who either didn't get the faculty positions for which they interviewed, or chose not to come. Quite a few commented that they felt that Berkeley was less supportive of its women faculty than some of our competing institutions. So you know, we do have data that we don't seem to be keeping up with some of our competitors.

VUJIC: There are several organizations helping with outreach, but the University should do much more. We have to change the perspective at the elementary and high school levels and encourage girls to take math and physics. Girls are still led to believe that these subjects are scary and that they can't do as well as boys.

MANKOFF: I think that mentoring is extremely important. It's been a constant in my life by other students and faculty, as well as an important part of what I've done for others. But, I had someone ask me recently: if we're trying to make changes, when do we stop trying? If it's 30 percent female faculty, have we gone far enough? What about 50 percent? Or 70 percent?

DOYLE: When we stop asking the questions, we're there. I suspect that if one can get to a state where all the biases have been removed, we would end up with a situation where there are fewer than 50 percent women in engineering. From my statistically unrepresentative observation of boys and girls, I see different behaviors and interests. I suspect there wouldn't be enough women interested in engineering to equate the genders exactly.

Q: Well, that leads me to ask whether you see inherent differences between how boys and girls think and solve problems. If so, how does this affect the gender equation ultimately?

DOYLE: I tend to see a lot more creativity in women students. It's always difficult to generalize, because there are some enormously creative men as well as many women who aren't creative. But I suspect that there would be more "out of the box" thinking about problems that could lead to some fairly revolutionary changes in the way things are done. But despite everything I just said about creativity, engineering has to be quantitative. Not only does one have to come up with bright ideas, they have to be rigorous, practical ideas that can work. And I suspect that fewer girls are interested in that very quantitative way of viewing the world than boys.

VUJIC: I don't think there are inborn differences. I think it's simply how you start to learn from an early age, how your family passes on the values.

MANKOFF: I agree. It's interesting to think back on the fact that centuries ago music and math were the same field. And you would think of one as creative, and the other as analytical, right?

VUJIC: And they go together.

Q: How would the field of engineering be different if the ratio of women to men were reversed?

DOYLE: The first thing that crosses my mind is that society would have a much lower opinion of engineering as a profession and the salaries would be significantly lower. My sister is a physician in Britain, and when she went to medical school, medicine was a male-dominated profession and very prestigious, with high salary levels. Now, close to 30 years later, the gender difference is reversed, and she tells me that the salary levels are going way down because society does not value physicians the way it used to.

MANKOFF: That's a good point, because when a career becomes popular you see these switches. It's called "feminization of a field," and it's happened multiple times in different careers.

Fiona Doyle

VUJIC: Also, because women are less aggressive, if they were dominating the field there would be less research to create anything destructive. There would undoubtedly be more emphasis on innovations to help ease our lives.

DOYLE: Women tend to question some of the assumptions that are part of everyday problem solving. We tend to step back and ask if there's another way to do this. Generally, great inventions result from people thinking unconventionally.

Marguerite Rigoglioso moderated the roundtable discussion and helped edit the transcript of comments. A former associate editor of the Harvard Business School's alumni magazine, she is a Bay Area freelancer who writes on women's issues, the environment, and technology.

"Women tend to question some of the assumptions that are part of everyday problem solving ... and think 'out of the box.'"

Allison Ryan (in clear glasses) marches with the band.

Engineers fill Cal Band's brassy ranks

The College of Engineering is hardly the only place where Cal's engineers make their mark. They contribute, in spades, to one of Berkeley's most cherished institutions – the raucous and always stellar marching band. While engineering students make up just 13 percent of Berkeley's total undergraduate population, they populate the band in far higher percentages. Currently, 46 percent of the 200 high-steppers in the band are engineering students.

"Music is a fairly mathematical thing," says third-year mechanical engineering student Allison Ryan, clarinetist. "It's counting beats and dividing things up. You definitely have to do some math in order to look at a measure and come up with the rhythm."

Engineering students bring more than sheer numbers and musical talent to the band. Ten years ago, an electrical engineering and computer sciences major designed the unique computer program called CalChart that allows students to map out and design the band's complex, fluid choreography. Coming up with those patterns this year lies with fourth-year civil engineering student Jonathan Stan, a trombone player and the band's drum major. "We noticed that the engineers were some of the show's best charters," says Stan, who also dabbles in filmmaking. Before they had the luxury of a computerized choreography program, band members sharpened their pencils and sketched out on paper each member's playing field stepping pattern. "It took a disgusting amount of time," says Stan.

For engineering students – who juggle some of the most demanding schedules on campus – time is a valued commodity to be carefully parceled out, as band members search for creative ways to manage 10-20 hours per week for rehearsals. Ryan, who is a member of a mechanical engineering honors society, works at Lawrence Berkeley National Laboratory as an intern, and recently joined the American Society of Mechanical Engineers, is up to the challenge. "My idea of what I can fit into a semester might be a little different from someone who's not in the band," she says.

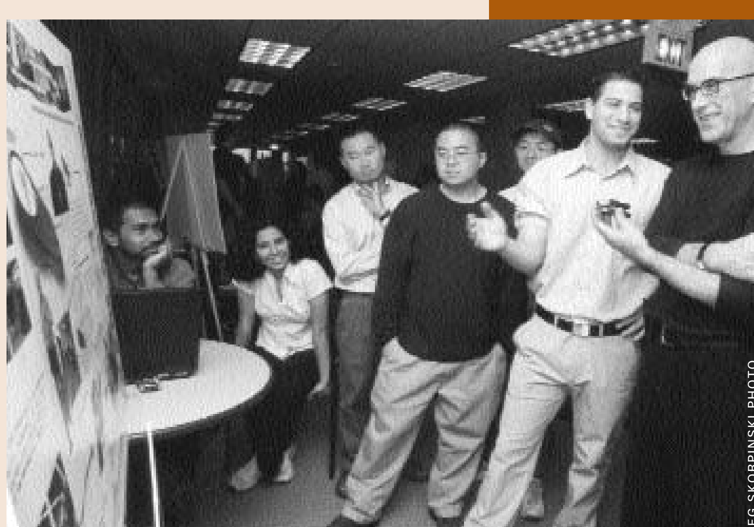
"You have to commit to finding the time and making sure you have the time to do both things," adds third-year electrical engineering and computer sciences student Titia Wong, who plays the mellophone, an instrument similar to a French horn. "Otherwise you cut a little here and a little there and hope it works out."

Being part of the Cal Band, which since its inception in 1925 has been almost entirely student run, appears to be worth the frenzied scheduling and occasional sleep deprivation. While the group has lost some of its autonomy since coming under the umbrella of the University's student musical activities department a few years ago, the degree of student control is still remarkable. Band members raise funds to maintain the $400,000 annual band budget, plan and rehearse performances, set up road trips, book hotel rooms, and make sure everyone is well fed on the road.

Beyond their unique independence, band members point to the camaraderie, the incredible sound, and of course, the indomitable sporting spirit that make the band such a draw. "It's just a good, big group of friends that's always there," says David Wagner, fourth-year manufacturing engineering student, alto saxophone player, and former senior manager of the band. "The 'Go Bears' spirit stays with band members long after they graduate. It puts a smile on my face when I play my instrument and see people smiling in the stands who were in the class of '50 or '60 and played in the band. And they can say to the grandchild on their shoulders, 'Hey, that's the Cal Band. You should be clapping.'" F

BY JESSICA M. SCULLY

STUDENT TRADESHOW: Mechanical engineering professor Paul Wright, far right, admires the work of students Anargyros Panayotopoulos and Warren Chow, team members on the prototype Airport PAL, a flight tracking and notification system. This was one of many prototypes on display at last November's ME tradeshow, sponsored by Intel and Ford Motor Company. Provided with high-tech sensors as their baseline technology, graduate students were challenged to design an inconspicuous wearable product as their class assignment for Wright's *High-Tech Product Design and Rapid Manufacturing* class. Other projects included a tracking device to help parents find a lost child in a crowded mall; wearable sensors that relay athletes' vital signs back to the coach and warn of heat exhaustion; and a motorcycle helmet equipped with a wireless communication system.



Students create user interface solutions for disabled women

An allergy sensor that detects potentially harmful ingredients, such as peanuts or dairy. A jacket with self-adjusting temperature control. A sports-utility wheelchair (SUW), that could drive over sandy beaches or rough mountain terrain. Personal flying machines.

For their first assignment of the new semester, students in *User Interface Design, Prototyping, and Evaluation,* a computer science course taught by faculty member James Landay, spent a rainy Saturday afternoon in January with a dozen or more women with disabilities, letting their imaginations run wild.

The "innovation workshop" at Soda Hall brought together students, faculty, staff, and members of the disabled community. Their goal: to generate ideas for the Institute for Women in Technology's Virtual Development Center, an industry-supported partnership of universities and communities aimed at increasing women's participation in the design and development of technology.

Berkeley became a center site this past fall and Landay's class, Computer Science 160, is the campus's first course collaboration with the center. Student projects focus on designing appropriate computer technology for women with disabilities.

The first half of the workshop aimed to open up lines of communication among participants. The second consisted of breakout sessions, in groups of six, designed to generate and refine ideas for student projects, based on the input of women with disabilities.

More than one student said the all-day workshop was an opportunity to discuss technology outside a small circle

PEG SKORPINSKI PHOTOS

Above: Faculty member Jennifer Mankoff, who teaches a course in assistive technology, joined the workshop to meet with students and community members with disabilities.

Left: James Landay takes notes at the January workshop, which was held to generate ideas for the Virtual Development Center, an industry-supported partnership of universities and communities aimed at increasing women's participation in technology.

of "techno geeks." For the women, it was a chance to be heard.

"A lot of people don't take the time to understand or listen. People don't see us as individuals," Priscilla Moyers, a deaf specialist in sign language communication, said through an interpreter. "I came here. My ideas were heard, and I appreciate that very much."

Other ideas – some more realistic than others – came up at the session: PDAs, such as Palm Pilots, with voice recognition; cookware with a "food-doneness" indicator; hands-free ATM machines; a one-handed jar opener; a hand-held device that would translate audio to text for the hearing-impaired; and a machine that makes the bed.

In fact, technology developed for the disabled can help everyone, says Landay. "Engineering is all about how to solve design problems, given constraints."

The women participants had a variety of disabilities, says Maureen Fitzgerald, director of the local nonprofit group Computer Technologies Program, who recruited the community participants. "There are women here who are blind, deaf, have mobility impairment, and cognitive disabilities," she says. "These women have helped students have an expanded sense of what it's like to have disabilities. I think it's blowing their minds."

Landay's 48 students were required to write, by the following Monday, a two-page essay on one of the project ideas. Says class member Jenny Nguyen, "I see my normal routine in a whole new perspective. It's really changed the way I think about things." F

BY FERNANDO QUINTERO

PEG SKORPINSKI PHOTO

SMART INVENTIONS: Mechanical engineering seniors Janine Pierce, top right, and Genevieve Gaspar, bottom, demonstrate their "decappitator," a test tube decapper for use in medical labs, at the Inventors' Open House last December, as mechanical engineering professor Liwei Lin, looks on, left. (Not pictured are team members Mike Miklos and Ed Chan.) The event showcased student projects from Lin's *Mechanical Engineering Design* course. Student teams created "smart" mechanical engineering products using computer-aided design (CAD) software and embedded microprocessors, in the process becoming familiar with product development, going from paper-and-pencil sketches to final products in one semester. Other inventions included a portable biochemical sensor and vaccine injector, robotic fish for underwater exploration, an autonomous golf trolley, and a mapping robot.


PEG SKORPINSKI PHOTOS

In their new ethics and technology course, William Kastenberg and Gloria Hauser-Kastenberg are creating a unique educational experience for their undergraduate students.

Timely ethical issues inspire a new teaching model

A walk in the woods can inspire introspection, a chance perhaps to ponder solutions to personal or global problems. While hiking in Tilden Regional Park a couple of years ago, Berkeley professor William Kastenberg and his wife, Gloria Hauser-Kastenberg, an attorney, ruminated about how they could integrate their professional and personal lives and learn more about each other's ways of thinking.

About the same time, Kastenberg read a newspaper editorial by then-Secretary of Agriculture Dan Glickman about the controversies surrounding the use of genetically modified crops and foods, which reminded the nuclear engineer of intense debates decades earlier surrounding nuclear technology. As the College of Engineering had instituted a new requirement for students to take a course in ethics, the Kastenbergs decided to create and co-teach a course on the role of ethics in the development and use of technology.

Rather than restrict the course to engineering students, the Kastenbergs took the rare step of approaching the College of Letters and Science, which each semester funds four undergraduate courses not sponsored by a particular department. The College administration welcomed the collaboration between an engineer and an attorney, and *Ethics and the Impact of Technology on Society* made its debut this spring.

The Kastenbergs' course examines complex ethical issues, with broad legal and social ramifications that have emerged with current technology, exploring how various philosophies, religions, and societies have dealt with ethical problems throughout history. "We shape our society through the technology developed here (at the University of California)," says Kastenberg, an expert on nuclear reactor safety and environmental risk analysis. "And it seems to me that it's our obligation to talk to our students about the implications."

One need only look at the latest news headlines to know that students will face no shortage of pertinent, pressing ethical issues to explore: cloning, stem cell research, nuclear waste disposal, biological warfare, genetically modified organisms, and Internet security and privacy. The timeliness of the subject matter attracted a diverse and large group of students; advance interest prompted the Kastenbergs to increase enrollment to 120 students, and by the second week of the term there was still a waiting list.

"I had never taken an ethics course before, and because this one dealt with technology, I thought that it would be a good way to check the field out," says computer sciences major John Gibson. Oscar Lang, a senior in cognitive science interested in Internet privacy issues, is surprised by the democratic nature of the class, where everyone participates and determines the course of discussions. "I've never had a class organized this way," he says.

With her expertise as a mediator in alternative dispute resolution and an outsider's perspective, Hauser-Kastenberg encourages a dialogue throughout the course and extracts common themes that could help students form their own set of ethics. Students will also work in teams of five each on a project attempting to resolve an ethical issue tied to a modern technology, by applying various theories as well as individual ethics. Gibson's team, for example, will try to tackle global warming.

In developing the course, the Kastenbergs strove to include a broad range of cultural viewpoints. Kastenberg took a sabbatical from 2000 to 2001 that provided the couple with time to read, travel, and become immersed in the subject. "We decided to use ourselves and our relationship as an experiment," says Hauser-Kastenberg.

They rented out their Berkeley hills home and spent months with new surroundings, new people, and new ideas. The journey took them to the rainforests of Ecuador, where they lived with members of the indigenous Ashuar Nation. They traveled to India to study with Ramash Balseker, an octogenarian former banker turned "nondualistic" philosopher, and to learn about that country's experience with the Green Revolution in agriculture. Closer to home, they spent three days in a seminar with the Dalai Lama, which led them to a concept of "compassionate technology" as a guiding principle for their course.

Most modern technology stems from the linear, Cartesian paradigm that has dominated Western scientific thought for three centuries, says Kastenberg. Descartes' legacy includes a separation of science from spirit, of human from nature, and faith in reductionism and empirical observation as the best ways to understand a system's behavior.

But many cultures have adopted a sophisticated yet nonlinear code of ethics, and Hauser-Kastenberg believes that increasing globalization obligates us to consider other ways of knowing. How might our society change if we applied nontraditional approaches to the creation of technology? If sustainability rather than efficiency served as a primary goal, would we behave differently?

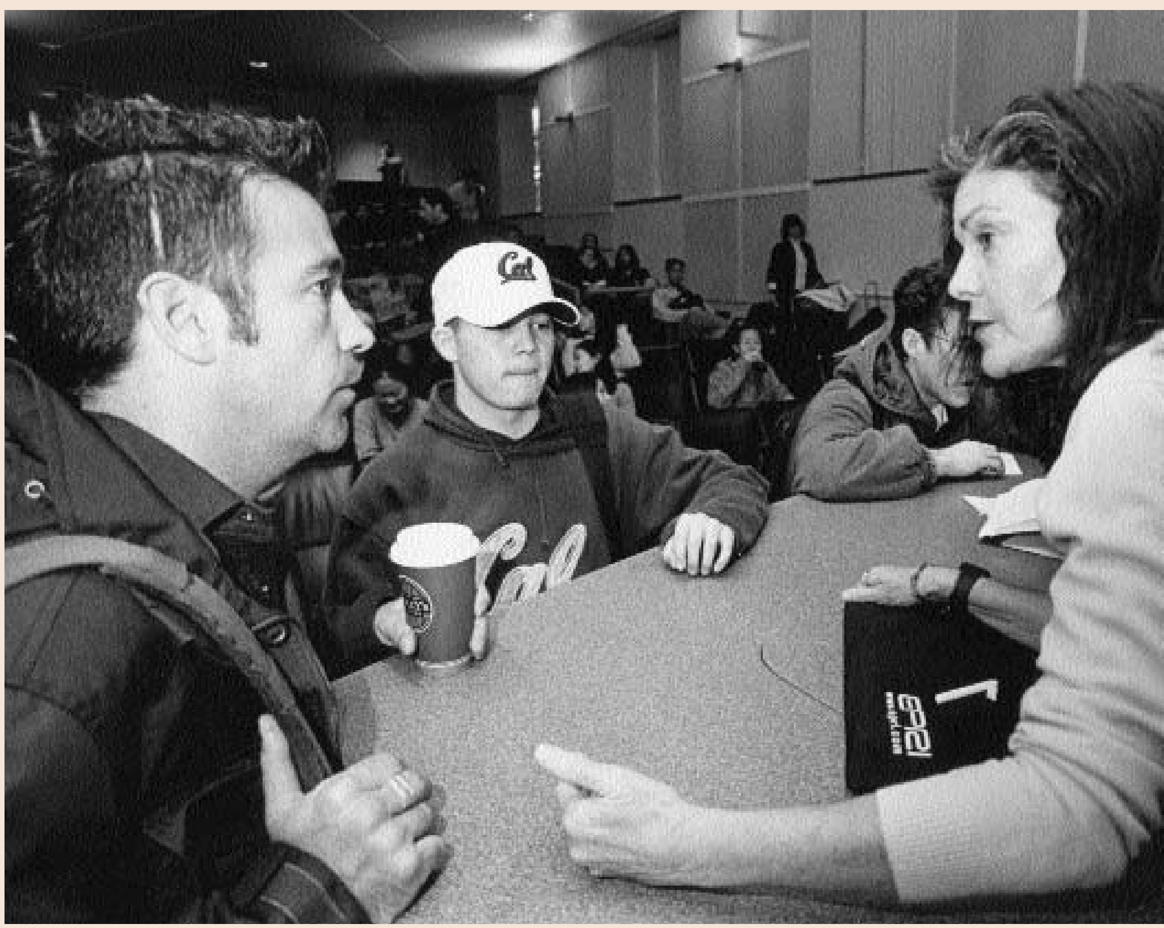
The Cartesian paradigm may fall short of supporting a sufficient technological ethic. Take the example of MTBE, a gasoline additive intended to control air pollution but now implicated as a source of groundwater pollution. Says Kastenberg, "There's a failure to understand how complex our environment is. By trying to solve one problem, we created a problem that's more difficult to solve."

Increasingly, the sorts of ethical dilemmas that engineers and scientists face have potentially global ramifications. They can also be imperceptible in time – as rapid as an Internet stock trade or as gradual as large-scale climate shifts. Methods of quantifying risks, the Kastenbergs agree, need to catch up with the greater degrees of uncertainty that accompany the latest technology.

"We're not proposing that we have an answer," Hauser-Kastenberg hastens to add. "If students get a sense of the breadth and depth of the issues, I'd be happy."

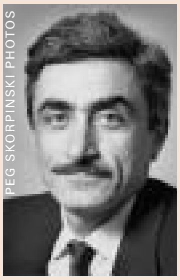
The Kastenbergs' interest in the subject won't wane with the last lecture. They foresee similar courses in biology or computer science. Plans are underway for a campus symposium on ethics and technology. And Kastenberg expects his research to continue shifting toward new ways of assessing and managing the risks of complex technological systems. "When you understand the risks and are finding ways to manage those risks, you are dealing with ethical issues," he says. You never know where a trail through the woods may take you. F

Written by Blake Edgar, science acquisitions editor at University of California Press, and former senior editor of *California Wild*. He has co-authored three books on paleoanthropology, including *The Dawn of Human Culture*, just published by John Wiley, and *From Lucy to Language*. His work appears in Bay Area and national magazines.



Two professors, two alumni elected to National Academy of Engineering for 2002

Two Berkeley professors – leaders in transportation systems and algorithm complexity – have been elected to the National Academy of Engineering (NAE), the highest professional honor for an American engineer.



PEG SKORPINSKI PHOTOS

Adib Kanafani

New members from the College of Engineering faculty are civil and environmental engineering professor and chair Adib K. Kanafani and computer science professor Christos H. Papadimitriou. They are among 74 new members and seven foreign associates elected this year.

Their election brings the total Berkeley faculty membership in this prestigious society to 86. Among academic institutions, Berkeley maintains one of the highest representations in the academy.

Kanafani joined Berkeley's civil engineering faculty in 1970, after earning his Ph.D. at Berkeley in 1969. He currently chairs his department and holds the Edward G. and John R. Cahill Chair for Civil Engineering. He also co-directs the National Center of Excellence for Aviation Operations Research, a university-industry consortium funded by the Federal Aviation Administration.

Kanafani's research interests center on transportation planning and systems analysis. He was recognized by the NAE for "contributions to national and international air transportation, the development of U.S. research on intelligent transportation, and the education of transportation professionals."

Papadimitriou received his undergraduate degree in electrical engineering at Athens Polytechnic and his Ph.D. in computer science at Princeton University in 1976. He taught at Harvard, MIT, Athens Polytechnic, Stanford, and UC San Diego before joining Berkeley's computer science faculty in 1995, where he focuses on theories of algorithms and complexity and their applications to databases, artificial intelligence, and game theory. The associate chair for Berkeley's computer science division, he also holds the C. Lester Hogan Chair in Electrical Engineering and Computer Sciences.

Christos Papadimitriou

The NAE cited Papadimitriou for "contributions to complexity theory, database theory, and combinatorial optimization."

In addition to Kanafani, two other College of Engineering alumni were elected this year. Michael J. Carey, CS '83, a technical director at BEA Systems in San Jose, was cited for "contributions to the design, implementation, and evaluation of database systems." Apple Computer Inc. co-founder Stephen Wozniak, EECS '86, now chief executive officer of Unuson Corp., was cited for "the invention and development of the first mass-produced personal computer."

New academy members will be inducted in October at a ceremony in Washington, D.C. F

Faculty awards and honors

CEE professor **Robert G. Bea** was awarded the Ralph Peck Medal by the American Society of Civil Engineers, citing his "pioneering contributions to the design of pile foundations for offshore platforms and application of reliability methods to the design of deep foundations." Bea also received the Blakely Smith Medal from the Society of Naval Architects and Marine Engineers (SNAME) for his "vital contributions to the safety and integrity of a broad range of offshore and marine systems."

Elwyn Berlekamp, Professor of EECS and Mathematics, and **Alan Smith,** Professor of EECS, were named 2002 Fellows by the American Association for the Advancement of Science. Smith was honored for his performance analysis of computer systems, "particularly the design of memory hierarchies and cache memory design."

CEE professor **Anil K. Chopra** has been awarded the George W. Housner Medal. The highest honor of the Earthquake Engineering Research Institute, the Housner medal is bestowed on one individual per year for extraordinary and lasting contributions to public earthquake safety through the development and application of earthquake hazard reduction practices and policies. Chopra also received the 2001 Norman Medal from the American Society of Civil Engineers (ASCE), given for the best paper among all journals published by ASCE.

Chenming Hu, Taiwan Semiconductor Manufacturing Company Distinguished Professor of Microelectronics, shared the 2002 Solid-State Circuits Award from the Institute of Electrical and Electronics Engineers with former EECS professor Ping-Keung Ko. The award recognized their distinguished contributions to Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) physics and development of the Berkeley Short-Channel IGFET Model (BSIM) for circuit simulation using complementary metal oxide semiconductors (CMOS).

Douglas W. Fuerstenau, Professor in the Graduate School, MSE, was elected a Foreign Fellow of the Australian Academy of Technological Sciences and Engineering. He was one of only two people elected as Foreign Fellows by the Australian Academy in 2001.

IEOR professor **Shmuel S. Oren** has been elected an Institute of Electrical and Electronics Engineers Fellow in recognition of his research and development in power-system economics.

Alberto Sangiovanni-Vincentelli, Professor of EECS, was named the 2001 recipient of the Electronics Design Automation Consortium's prestigious Phil Kaufman Award. The Kaufman Award honors individuals "who have made a substantial sustainable contribution to the success and advancement of the electronic design industry." Sangiovanni-Vincentelli's involvement with the design industry dates to the mid-1970s. F

Engineering@cal launched in April

By visiting http://engineeralum.berkeley.edu online, Berkeley engineering alumni now have access to a rich electronic resource, one that can help them stay in touch with friends and colleagues, or get more involved with their alma mater.

The Berkeley campus and the College of Engineering launched the new Web-based community in April, when postcards were mailed to alumni announcing the program.

"We're hoping that the newly launched Engineering@cal program will strengthen lifelong relationships between alumni, the College of Engineering, and the University community," says Gina Rieger, alumni affairs director for the College. "Alumni now have a free, accessible means to get in touch with one another as well as stay in touch with the College. We're excited about the possibilities."

Using the personal identification number (PIN) printed on the postcards (and included above the address on the back of this magazine), engineering alumni can visit engineeralum.berkeley.edu and register to take full advantage of the resource, or opt out of the service altogether. Participants can use the online directory, share career information, network with other Cal professionals, serve as a resource for students, obtain a Berkeley e-mail forwarding address, or join e-mail discussion lists.

Friends of the College of Engineering who are not alumni may join a separate but related online community.

To register or learn more, visit http://engineeralum.berkeley.edu. If you have comments, send e-mail to engineeralum@coe.berkeley.edu. F

BERKELEY'S STARS SHINE: The Distinguished Engineering Alumnus Awards dinner, postponed from its original September 13 date, took place February 23 at the Claremont Resort Hotel. The 2001 honorees were, clockwise from left, Clayton D. Mote, Jr., ME '59 '60 '63, former vice chancellor of university relations at Berkeley, now president of the University of Maryland, and a pioneer in the field of biomechanics; Loring A. Wyllie, Jr., CE '60 '62, senior principal and chair of the board of Degenkolb Engineers and an international leader in seismic-resistant structural design; and Werner Goldsmith, ME '49, Berkeley mechanical engineering professor in the graduate school and an expert on the engineering mysteries behind impact and wave propagation. The awards honor alumni for their achievements and service to the engineering profession, the University, and the community.

Engineering Short Courses

For a full list of courses offered by UC Berkeley Extension, visit www.unex.berkeley.edu. Courses below are part of the Berkeley Summer Institute, held on the Berkeley campus.

JUNE

3-7	UNIX Kernel Internals: Implementation, Networking, and Tuning
6-7	Project Risk Management for Major Engineering and Construction Projects
10-11	Engineering Practical Microsystems for Biomedical Analysis
10-12	Modern Telecommunications
11-14	Fundamentals of MEMS
13-14	BioMEMS
17	Parametric Design of MEMS
17-18	Low-Cost High-Density Interconnect Technologies
17-18	Optical MEMS in Communication and Sensing
24-26	Plasma Etching and Reactive Ion Etching
26-28	Advanced Digital Integrated Circuits
27-29	Computer Security Crisis Intervention
28-29	Seismic Isolation Design

JULY

8-9	Developing Field Programmable Gate Array (FPGA) Digital Signal Processing Systems
8-12	Analog Integrated Circuit Design in a Mixed-Signal Environment
12-13	Energy Dissipation Systems for Seismic Design of Buildings
15-17	Inventing the Future: User Interface Design, Prototyping, and Evaluation
18-19	Low-Power Circuits and Systems for Digital Wireless Communications
25-27	Exploring Critical Internet Technologies of Tomorrow
30-31	SDH/ATM Networks

AUGUST

1-2	IP/MPLS Networks

ALUMNI PROFILES

Berkeley launched Floyd Kvamme's chip career

In spring of 2001, President George W. Bush appointed Floyd Kvamme, EE '59, to co-chair the President's Committee of Advisors on Science and Technology (PCAST). It's the capper to a long, illustrious Silicon Valley career in semiconductors and venture capital that began at Berkeley's College of Engineering.


BART NAGEL PHOTO

Floyd Kvamme

The first member of his Norwegian immigrant family to go to university, Kvamme chose Berkeley on the advice of his high school English teacher. "I loved mathematics, and he told me that engineering is really applied math," he recalls. Initially he considered majoring in civil instead of electrical engineering, since it was more familiar: Kvamme spent every available moment after school working on construction sites with his father, a carpenter, to help pay his tuition.

Kvamme's pursuit of the nascent semiconductor field originated not in his undergraduate coursework, but from dropping in on afternoon colloquia. "Berkeley's openness was terrific – being able to wander in and hear a seminar," he says. "They were mostly for graduate students, so I only understood 10 percent of the material. That was enough to pique my interest."

Electrical engineering at Berkeley in the late '50s was very close to a physics major, according to Kvamme. "John Whinnery, the EE chair then, wanted to make sure that students got a very technical education," he says. "And I just loved that. When I graduated, I had a technical background that was – as I learned from engineers from other schools – much stronger in the underlying physics and theory of my profession."

After getting his master's in semiconductor-focused EE from Syracuse University, Kvamme went to work for the seminal chip companies Fairchild Semiconductor and National Semiconductor, which he helped transform from a small East Coast transistor company to a leading microelectronics supplier. Running National's Advanced Systems subsidiary gave him the experience he needed to head Apple Computer's sales operations.

Then, in 1984, the premier venture capital firm Kleiner Perkins Caufield & Byers made him an "offer too good to refuse," to invest and nurture cutting-edge chip startups. In March 2001 Kvamme moved his venture capital work to a back burner in order to head up PCAST, counseling President Bush on technology issues ranging from homeland defense to federal research-and-development spending.

Asked if there was anything he'd change about how this career began, Kvamme says, "Taking part in collegiate athletics would have been a lot of fun, had my circumstances been different. But c'est la vie. I got a solid education and had a great time at Berkeley." F

BY BONNIE POWELL

ALUMNI PROFILES

Julia Gee deftly juggles working and volunteering

Julia Gee, ME '82, isn't just a workaholic, she's a volunteer-aholic.

Looking at the professional activities page of her résumé, you'd think the soft-spoken Gee was an entire army. A few highlights: president of the Berkeley Engineering Alumni Society (2000); coordinator of the National Society of Professional Engineers' Golden Gate MATHCOUNTS program for 15 of the 19 years it's been around; president of the Golden Gate chapter of the California Society of Professional Engineers for almost 10 years; chair of the San Francisco section of the American Society of Mechanical Engineers (1987, plus numerous other positions). And the list goes on.


BONNIE POWELL PHOTO

Julia Gee

And that's in addition to her travel-intensive, full-time job with Bechtel. Gee started working for the engineering construction corporation on a six-month, co-operative internship her junior year of college. She returned full time after graduation.

"What drives me is the opportunity to learn new things and Bechtel has given me that," she says. Since 1982 she has rotated through Bechtel's construction, project control, 3-D simulation, and (currently) subcontract divisions, working on mammoth undertakings ranging from waste management facilities to a space vehicle processing and fueling annex in Kazakhstan.

Gee says that although few of her Bechtel projects have drawn specifically on her ME course work, the method of learning itself has proven useful. "Every company has its own way of solving problems, and yet they use the same basic engineering methodology," she explains. "It isn't about memorizing equations, but about knowing which equations to pick under what circumstances."

As part of her plan to ease back on volunteer activities – and in exchange, take a few more hiking and kayaking vacations – Gee is currently focusing on MATHCOUNTS. On a recent Saturday she rose at 5 a.m. to coordinate a competition for 110 sixth-, seventh-, and eighth-graders and 30 volunteers. "I really believe it's helping to interest more kids in math. I know it's helped energize the math teachers, the 'champions' of the program," she says. "I've gotten a lot from these organizations, and I like to give back." F

BY BONNIE POWELL

Bequest of $3.5 million to benefit graduate students

Margaret Lucas never took her Cal degree for granted. She earned it while she was in her 40s, after two decades of secretarial work. And while the sight of a re-entry student is a common one today, Lucas' pursuit of a diploma, undertaken right after World War II, makes her a pioneer.

Lucas died in 1998 at the age of 92, leaving the bulk of her estate to the University. "She lived practically her whole life in Berkeley and always felt close to the campus," explains Jim Ferguson, a longtime friend and executor of Lucas' estate.

Her bequest of nearly $3.5 million will aid students in the College of Engineering, and serves as an apt tribute to Margaret Lucas and her late husband, Frank, who graduated from Cal in 1930 with a degree in civil engineering.

The couple lived for many years in a home on Dwight Way, across from the Clark Kerr Campus. Frank Lucas took part in designing and building the Bay Bridge and then spent the rest of his career with Caltrans. Margaret Lucas worked as a secretary for the California Board of Health and later with the California Department of Health Services, where one of her co-workers was Ferguson.

"The student aid fund was her idea," says Ferguson. "She talked about it a lot. She had the money and wanted to make sure it went to the students."

Lucas' bequest comes at an opportune time. Students arriving at Berkeley for graduate work find the cost of living to be one of the highest in the nation. Available fellowship aid falls far short of the true need. While Stanford and even Michigan – a public university like Berkeley – are able to provide full, multi-year fellowships to a majority of their graduate students, most students at Berkeley must cobble together a patchwork of loans, instructorships, and year-to-year fellowship aid.

"Berkeley is the best place in the nation for graduate study," says Berkeley engineering dean A. Richard Newton. "We want to stay that way so we can provide leadership to tackle economic growth and social problems. Fellowships like the Lucas fund are essential if we are to attract and keep the most promising students."

Newton and other campus leaders estimate that the University's fellowship endowment must grow by several hundred million dollars if the campus is to compete effectively for first-rank graduate students. A campuswide initiative is being launched to close the gap over the next five to 10 years. F

BY KAREN RHODES

Clock is ticking for challenge match – lend your support by June 30

BERKELEY ENGINEERING ALUMNI VOLUNTEERS are just itching to give their money away. Last fall, they personally pledged to match first-time and increased gifts to the College of Engineering – up to $125,500, right out of their own pockets.

But the College will miss out on any portion of that pledge that remains untapped by June 30. So far, alumni have matched a little more than half the potential dollars. "I guess this is the odd circumstance where I'd really like to lose some money!" says Bob Sanderson, IEOR, '66 '70, vice chair of the alumni volunteers and a key alumnus fueling the pledge. "We're hoping to encourage all engineering alumni to use up the entire matching fund – our alumni giving rate needs a real boost."

New and increased alumni gifts will qualify for this much-needed support if received by June 30. For details, contact the Berkeley Engineering Fund, 510/643-6291.

BRUCE COOK PHOTO

PEDERSON HONORED: Family, friends, and colleagues of Professor Emeritus Donald O. Pederson gathered on November 16 for a special celebration — the ceremonial unveiling of the Donald O. Pederson Center for Electronic Systems Design, located on the fifth floor of Cory Hall. More than 40 individuals contributed towards a distinguished professorship and the new center, both named to honor Pederson for his pioneering work in integrated circuit and computer-aided design. Roughly 75 graduate students will conduct research in the Cory Hall center, which was renovated to make more efficient use of space, outfitted with new equipment, and set up for video conferencing. Pictured from left are Gary Baldwin, director of the new center and executive director of the Gigascale Silicon Research Center; Donald Pederson; and electrical engineering professor Robert Brayton. Electrical engineering professor Jan Rabaey has been named the first holder of the distinguished professorship.

Engineering gifts

Private funds are vital to Cal's excellence in engineering. Here the College recognizes new pledges and gifts received between August 8, 2001, and March 4, 2002. Gifts and pledges from individuals ranged from $20,000 to $2.8 million. Corporate gifts of $200,000 or more are also listed.

We are grateful to our donors for their support of Berkeley engineering.

NEW MAJOR GIFTS AND PLEDGES

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The Estate of Margaret Lucas
Lucas Scholarship Fund

Barbara P. Newell
The Gordon F. Newell Fellowship

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Robert D. & Shirley A. Sanderson, '66 '70
Engineering Annual Fund and support of IEOR

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New lab wired for 21st-century education

When researchers officially unveiled the new National Semiconductor Mixed-Signal Systems Laboratory on February 20, it was more like an organ transplant than a mere facelift for Cory Hall.

National Semiconductor's $1.35 million gift enabled four rooms to be completely gutted and rebuilt into a state-of-the-art classroom. The 200 to 250 students per semester enrolled in *Design Techniques and Components for Digital Systems*, one of the core requirements for a degree in electrical engineering and computer sciences, had previously bumped elbows at workstations built out of World War II-era Army surplus benches. The new lab increases the overall area from 1,800 to 3,400 square feet, replacing 26 full and 30 partial workstations with 65 roomy, ergonomically correct full stations, a multimedia-equipped command center for the instructor, and a meeting area.

While the interior design is impressive, it is the cables snaking along floors and beams that provide the lifeblood for a 21st-century style of teaching. In addition to a pulse generator, mixed-signal oscilloscope, and other diagnostic equipment at every station, each Dell desktop has a video camera, microphone, and speakers hooked into a multimedia local area network.

All workstations are wired to the teaching assistant's desk for sound and video, so the assistant can hear and see students when they ask questions. The class can watch a multichannel demonstration of the answer on pull-down screens around the room – or on their own computers, by way of a whiteboard camera, an instrument camera, and a link to the teaching assistant's own high-resolution screen. Two wall-mounted plasma displays flash course updates and announcements.

Before the lab's unveiling, EECS professors Ron Fearing, John Wawrzynek, Robert Meyer, and chair Shankar Sastry presented their plans for the lab to 20 National Semiconductor attendees, including CEO Brian Halla, who had nurtured the project. Executive Vice Chancellor and Provost Paul R. Gray initiated the lab idea when he was dean of engineering. Halla later presented an EECS joint colloquium, "The Sight and Sound of Information – Defining the Future Beyond the PC," to students and faculty in Soda Hall's Hewlett-Packard Auditorium.

National Semiconductor, which has helped fund the construction of Soda Hall and other projects, also established a distinguished professorship to accompany the new lab. Chip legend Meyer – whose book *Analysis and Design of Analog Integrated Circuits* is now in its fourth edition – has been named the first holder of the professorship. F

BY BONNIE POWELL

Left: National Semiconductor's Brian Halla, right, with Dean A. Richard Newton at the February unveiling of Cory Hall's spacious new mixed-signal systems lab.

Right: Brian Halla, left, and Professor William Oldham admire the new workstations that students and teaching assistants will use to interact electronically in the renovated lab space.

PEG SKORPINSKI PHOTOS

Coming Events in Berkeley Engineering

Presidential Library Tours

Saturday, May 11
Saturday, May 18

The Southern California Engineering Alumni Society will sponsor tours of two presidential libraries. On May 11, visit The Richard Nixon Library and Birthplace in Yorba Linda. On May 18, tour the Ronald W. Reagan Presidential Library and Museum in Simi Valley.

Day in the Wine Country

Saturday, May 18

The Northern California Engineering Alumni Society is sponsoring a tour of the UC Davis Department of Viticulture & Enology research station in Oakville, followed by lunch and a tour of two Napa Valley wineries. Space is limited.

College of Engineering Commencement

Saturday, May 25

Hearst Greek Theatre, Berkeley Campus, 9 a.m.

Family, graduates, alumni, faculty, and friends will gather for a morning filled with processions, pomp and circumstance, and photographs. 510/643-7992.

Hearst Memorial Mining Building Renovation Tours

Friday, May 31
Friday, June 28

Berkeley Campus, 3:30 p.m.

Join alumni and friends for a first-hand look at the renovation and seismic retrofit of the Hearst Memorial Mining Building in these last tours before the fall semester opening. There is no charge for the tour, and light refreshments will be served at the construction site. RSVP to EAS, 510/643-7100 or eas@coe.berkeley.edu.

Berkeley in Silicon Valley Symposium

Saturday, June 1

Hayes Mansion Conference Center,
San Jose
8:30 a.m. - 2:15 p.m.

Sponsored by the Engineering Alumni Society and the Colleges of Engineering and Chemistry, this second annual event features nine outstanding faculty members of the two colleges who will speak about their evolving research in nanotechnology and biotechnology.

Southern California Alumni Meeting

Thursday, June 6

Southern California Engineering Alumni Society Annual Meeting in Los Angeles, featuring keynote speaker CEE Professor Abolhassan Astaneh-Asl, speaking on "The Collapse of the World Trade Center, Lessons Learned."

Nominate Distinguished Engineering Alumni

Friday, June 21

Nominate candidates for the 2002 Distinguished Engineering Alumni Awards by Friday, June 21. Visit www.coe.berkeley.edu/alumni/deaa_cover.html for details.

Symposium to Honor Chang-Lin Tien

Saturday, June 22

The Department of Mechanical Engineering celebrates the legacy of former Chancellor and University Professor Emeritus Chang-Lin Tien with a day-long symposium highlighting his contributions to research, higher education, and public policy.

Hearst Memorial Mining Building Reopening

Visit www.coe.berkeley.edu/events for details on the official reopening event being planned.

www.coe.berkeley.edu/events

For details on these and other engineering events, visit **www.coe.berkeley.edu/events**

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