College of Engineering
University of California, Berkeley
Fall 2014
Volume 6



# Berkeley ENGINEER

## FREEDOM PHONES

The future of dissent on the 50th anniversary of the Free Speech Movement

# Engineering global solutions

Extreme poverty is not a new problem. But given the widening of globalized markets and the confluence of leapfrog technologies—including access to mobile telecommunications and niche manufacturing operations—enormous opportunities now exist to eradicate the root causes of global poverty.

It is clear that traditional top-down models of international development are limited: material aid leads to dependence; well-meaning policies become mired by political instability.

In addition to market forces and access to technology, it will take human capital to build human capacity. That is why we take our responsibility to train the next generation of engineers very seriously.

Training the next generation of engineers to tackle the root causes of global poverty

Recognizing trends in the global landscape, the U.S. Agency for International Development (USAID)—the country's largest international aid agency—recently signaled a change in tactics. With a collaborative, fast-moving posture (more Silicon Valley than Inside-the-Beltway), USAID administrators have made a commitment to ending extreme forms of poverty by 2030.

With USAID's support, we opened the Development Impact Lab (DIL) on campus in 2012 to design, execute and scale poverty-alleviating systems and technologies.

The grant is managed by the Blum Center for Developing Economies and the Center for Effective Global Action in Economics, and includes many engineering faculty who have answered the call for socially responsible development engineering. As an outgrowth of the DIL mission, and in response to an outpouring of student and faculty demand, this semester we launched a development engineering designated emphasis (the graduate equivalent of a minor) for Ph.D. students. Many of the students in the program are engineers, but others come from economics, business and other quantitative disciplines. (Read more on page 2.)

While much of DIL's focus is on international solutions, in the words of advisory board member Arun Sarin, solutions often "boomerang" back to the developed world in the form of financial inclusion, arsenic-free drinking water for the Central Valley and so on.

Beyond our ethical and societal obligations, aggressively pursuing solutions to alleviate global poverty through smart infrastructure, adaptable technologies and inclusive systems will create better global adaptability and resiliency in times when the world's big problems show no signs of recognizing international borders.

As always, I welcome your thoughts and ideas.

—*S. Shankar Sastry*
DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING
DIRECTOR, BLUM CENTER FOR DEVELOPING ECONOMIES

Matt Beardsley

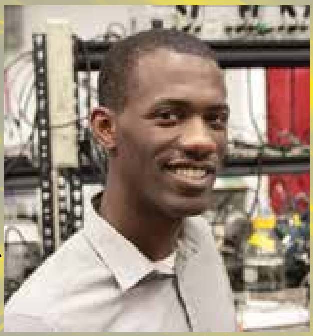
UNDER CONSTRUCTION: Dean Sastry oversees construction of Jacobs Hall. Home to the Jacobs Institute for Design Innovation, the LEED-certified building—to open in fall 2015—will serve as a hub for hands-on learning for undergraduates.

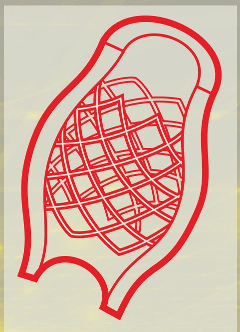
# in this issue





Daniel McGlynn





L. Brian Stauffer

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DEAN S. Shankar Sastry
ASSISTANT DEAN, COLLEGE RELATIONS Melissa Nidever
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MANAGING EDITOR Kap Stann
ASSOCIATE EDITOR Daniel McGlynn
CONTRIBUTORS Preston Davis, Julianna Fleming, Jennifer Huber, Miranda King, Kirsten Mickelwait, Thomas Walden Levy, Sarah Yang
DESIGNER Alissar Rayes

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Courtesy William Tarpeh

William Tarpeh, a Ph.D. student in environmental engineering, works on a sanitation project in Nairobi, Kenya. His goal is to develop technologies to make marketable products out of nitrogen recovered from urine. "The designated emphasis is really meaningful," Tarpeh says, "because it recognizes the interstitial space that otherwise just isn't recognized."

NEW PROGRAMS

# Launching 'dev eng'

A new Ph.D. specialty in development engineering teaches students how to build, scale and evaluate technologies designed to combat extreme poverty and other complex international development issues.

"Development engineering is a new interdisciplinary field that integrates engineering with economics and business, energy and natural resource development and social sciences," says **Alice Agogino,** Hughes Professor of mechanical engineering.

To build an academic framework for "dev eng," Berkeley faculty members with research expertise in related areas formed a development engineering graduate group last year. The group is establishing a research agenda that includes human-centered design and requires innovators to develop "multiple skills in ethnographic studies, qualitative research, hardware, analytical tools, hypothesis testing, prototyping, business model development and continuous impact analysis," says Agogino, who chairs the group.

With the support of Berkeley's Blum Center for Developing Economies, the group launched a designated emphasis in development engineering for doctoral students this fall. The specialization is open to Ph.D. candidates across campus, including students pursuing research in social sciences with quantitative components, such as public health or social welfare.

In 2012, the U.S. Agency for International Development awarded Berkeley $20 million to start the Development Impact Lab (DIL). The lab supports academic research and a community of faculty and students interested in development engineering.

"A number of faculty were engaged with the DIL lab and students doing these projects, but as one-offs in various groups without mentoring outside their discipline," Agogino says. "The creation of this multidisciplinary program was a natural fusion coming from a compelling need."

"...!"

## COMMENTS

*Friends, followers and readers: Thanks for your comments. Here is a recent sampling.*

Re: "Engineering social justice," *Berkeley Engineer,* spring 2014

I was extremely happy to learn that an "engineering in society" course was still being taught at Cal. Looking back on my career and personal evolution, it's that course I took back in 1978 that I remember the most. It shaped my thinking about what it was to be an engineer, yes, but more importantly, a just and positively contributing member of society. At the time, this topic was rarely taught in harder STEM paths across the country, and I was very proud that Cal had the foresight to offer it. Engineers gravitate toward the profession because of their love of things, but an engineer's true purpose is to translate scientific discoveries into societal benefits. For this, one must have not only a sharp intellect and a pragmatic outlook, but also open eyes, mind and especially heart. As pointed out in the piece, the "control volume" for any engineering problem must include its environment and its people.
**—Shaun Simpkins,** B.S.'79 EE, via e-mail

Re: "The last firewall," *Berkeley Engineer,* spring 2014

In the last issue, the juxtaposition of an article on mind-reading technology and one on social justice was not likely lost on readers. While EECS professor Jan Rabaey pointed to the need to develop technical solutions sooner than later, what's missing is a broader conversation about whether mind-reading technology is something we want to develop at all. We have a culture that promotes and rewards the heroic principal investigator who pushes the limits of science like Prometheus bringing the gift of fire back to the clan. Only too late do we understand and react to the unintended effects of these discoveries, such as greenhouse gases, nanoparticles, endocrine disruptors and GMOs. The university promotes a myriad of micro changes to our complex system, and we as a society are left reeling with the large systemic changes that emerge as a consequence. Indeed, when have we, in 500 years of the Enlightenment, ever decided against technical advancement?
**—Tse-Sung Wu,** B.S.'89 ME, via e-mail

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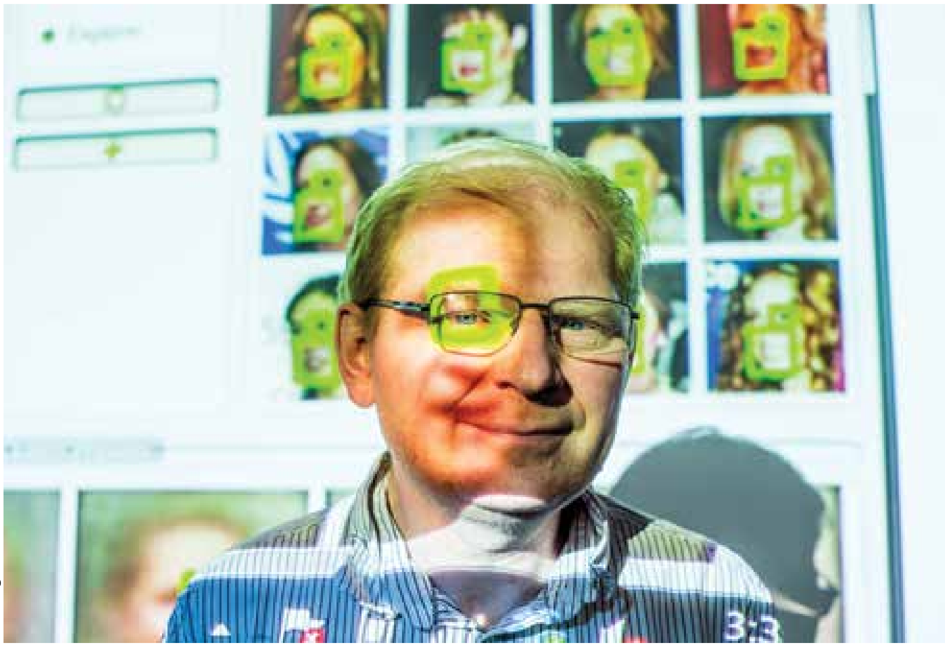
Find links to web extras through the college website at **engineering.berkeley.edu/magazine.**

# The big picture



Noah Berger

EECS professor Alexei Efros

This past fall, in the wide-open spaces across campus, students from **Alexei Efros's** computational photography class were easy to spot—they were the ones taking *camera obscura* pictures with image-capturing devices made from shoeboxes. The point, says Efros, who joined the Berkeley faculty last year as an associate professor in electrical engineering and computer sciences, was for students "to become one with the photons."

Efros is part of the Visual Computing Lab. His research combines computer graphics and computer vision to investigate larger concepts related to the visual aspects of artificial intelligence. "It's a multidisciplinary problem connecting philosophy, neuroscience and developmental psychology." Efros says. "It really goes to the heart of who we are."

The Internet is awash with visual data. Given our current ability to access and process information, most of that data is inaccessible. "I hope to make visual data a first-class citizen," says Efros. "Right now the transfer of information is tied to language. I love literature, but there is much more to the visual world. There are so many things that we just don't have the words for."

Using computation like cheesecloth, computer-vision researchers filter massive amounts of data into digestible nuggets of information. "To understand our visual world you need to have a lot of data," Efros says. "You can't understand it just with equations; you need to have the data because our world is so rich and there is so much entropy in it."

Efros balances data-heavy computer vision research with creative computer graphics work. "You get to hack, code and play with computers. What comes out on the other end are often beautiful—sometimes bizarre, sometimes intriguing—visual representations, visual narratives even," he says. "To me, that is very appealing aesthetically."

Being creative while wrestling with big research questions is a priority for Efros. He once contemplated pursuing a career as a theater director. He hopes more art students will take his computational photography class in the future.

Efros's research is also informed by his poor eyesight. "For me, this fascination for large amounts of data definitely comes from personal experience—there is this incredible power that prior experience has on what you perceive. If I have been to a place many times, then I think that I'm seeing way more than I'm actually seeing. In a familiar environment, my brain fills in the details," he says.

"I realized how having lots of data makes all of the difference, and this is true for everyone, not just for people with poor sight."

## Finding *the* Internet cat

The AverageExplorer is a tool designed to better search digital visual data. The new software, developed along with doctoral student **Jun-Yan Zhu** and former post-doctoral researcher **Yong Jae Lee,** is one of EECS professor Alexei Efros's latest projects.

"We have this enormous collection of images on the web, but much of it remains unseen by humans. People have called it the 'dark matter' of the Internet. We wanted to figure out a way to quickly visualize this data by systematically 'averaging' the images," Efros says about the project.

Unlike text-based data that can be organized and searched relatively easily, no intuitive system exists for indexing visual information. AverageExplorer addresses that problem by compiling millions of images into one average image. Users can then refine the search by adding visual constraints to the query using basic image-editing tools, such as strokes, brushes and warps.

For example, to find images of a particular species of cat from among the vast sea of Internet cat images, a user starts with a massive compilation. With AverageExplorer tools they can then narrow down the results based on specific visual characteristics, such as color or ear length, yielding a new average image.

Beyond cats, potential applications for the AverageExplorer include online shopping and further refining computer vision and computer graphics systems based on data collected from users.

Courtesy the researchers

DEVICES

# Smarter stethoscopes

As an engineer with a passion for medicine, **Connor Landgraf** (B.S.'13, M.Eng.'14 BioE) started designing digital enhancements for stethoscopes as an undergraduate. With guidance from bioengineering professor **Amy Herr,** Landgraf continued this work with fellow master of engineering students **Jiarong Fu, Zhengda Zhao** and **Robert Sibilia** (all M.Eng.'14 BioE), as the team's capstone project.

Noah Berger


Courtesy Eko Devices

**PROBLEM** According to Landgraf, up to 80 percent of new primary care physicians don't receive enough training to accurately diagnose common heart problems with standard "analog" stethoscopes. Existing audio-amplification devices for stethoscopes are pricey and unpopular with physicians, many of whom prefer classic stethoscopes.

**SOLUTION** The team took a two-pronged approach to making classic stethoscopes smarter. First, they designed a Bluetooth-enabled hardware device, which is placed between the stethoscope bell and the rubber tubing delivering sound to a clinician's ears. A slender conical attachment amplifies and digitizes heart sounds, recording an audio clip and sending it, along with a waveform image, to a secure, cloud-based server via a smartphone.

This makes findings easy to process through the second tool Landgraf's team is developing: a proprietary algorithm able to discern the difference between normal and abnormal heart sounds. This will provide what Landgraf calls "real-time decision support."

**RESULT** This hardware-software-database combo has the potential to save lives and eliminate billions of dollars a year in unnecessary spending on cardiology referrals and electrocardiograms. A study in the *British Journal of Cardiology* in 2001 found that up to 60 percent of cardiology referrals were based on erroneous diagnoses, a figure the team aims to drastically reduce.

In 2013, the smart stethoscope team joined Berkeley's SkyDeck incubator and named their venture Eko (pronounced "echo") Devices. They anticipate FDA approval this fall. Meanwhile, a local hospital is beta-testing the device.

**BE FACT**

**Berkeley ranks as the #2 university producing VC-backed entrepreneurs**

Source: Pitchfork

# Q+A with Grace O'Connell

**Grace O'Connell** joined the Berkeley Engineering faculty in August 2013 as an assistant professor in the mechanical engineering department. She earned her Ph.D. from the University of Pennsylvania and was a post-doctoral researcher at Columbia. We asked her about her background and her first year at the college.

Matt Beardsley

***When did you know you wanted to become an engineer?***

I was always fiddling with things as a kid, and then I took an engineering class at my high school in Philadelphia. Both my parents were computer programmers, so that may have also influenced me. As a girl, I was definitely in the minority in my classes, but I was so focused on my studies, I wasn't even aware of it until I was a senior in college.

***Why did you choose mechanical engineering in particular?***

As an undergraduate, I originally studied aerospace engineering. In graduate school, I switched over to have a more direct impact on people's lives. My work is biologically based. I have colleagues in bioengineering departments at other schools who do similar research to mine. It all depends on how each university structures its departments.

***Your research focuses on tissue engineering and spinal biomechanics. What are the applications of your work?***

Around 80 percent of adults will experience back pain in their lifetime. I'm studying soft-tissue degeneration so we can grow a biological repair strategy. We use cells to grow new tissues in the lab. We look at the mechanical function of native tissue to try to mimic this function in the repair tissue we create.

***What has your introduction to the Berkeley campus been like?***

I'm finding the culture here to be very open to collaboration and working across disciplines—there's a real generosity in sharing information. In the biomechanics group, for example, lab space is shared across multiple labs to encourage cross-talk and collaboration.

***As an instructor in the Girls in Engineering camp in July, what was it like to be a role model for young women?***

There's a big challenge ahead to balance the gender numbers in the engineering professions. Research indicates that girls are usually around middle school age when they become turned off to math and science. At the Girls in Engineering camp, I was excited to see how many of the campers dove right in, experimenting with tissue samples. In my own lab, I've tried to create a diverse workforce—it's currently a 60/40 male-to-female ratio. And because I'm half African, half American, I'm sensitive to racial diversity as well.

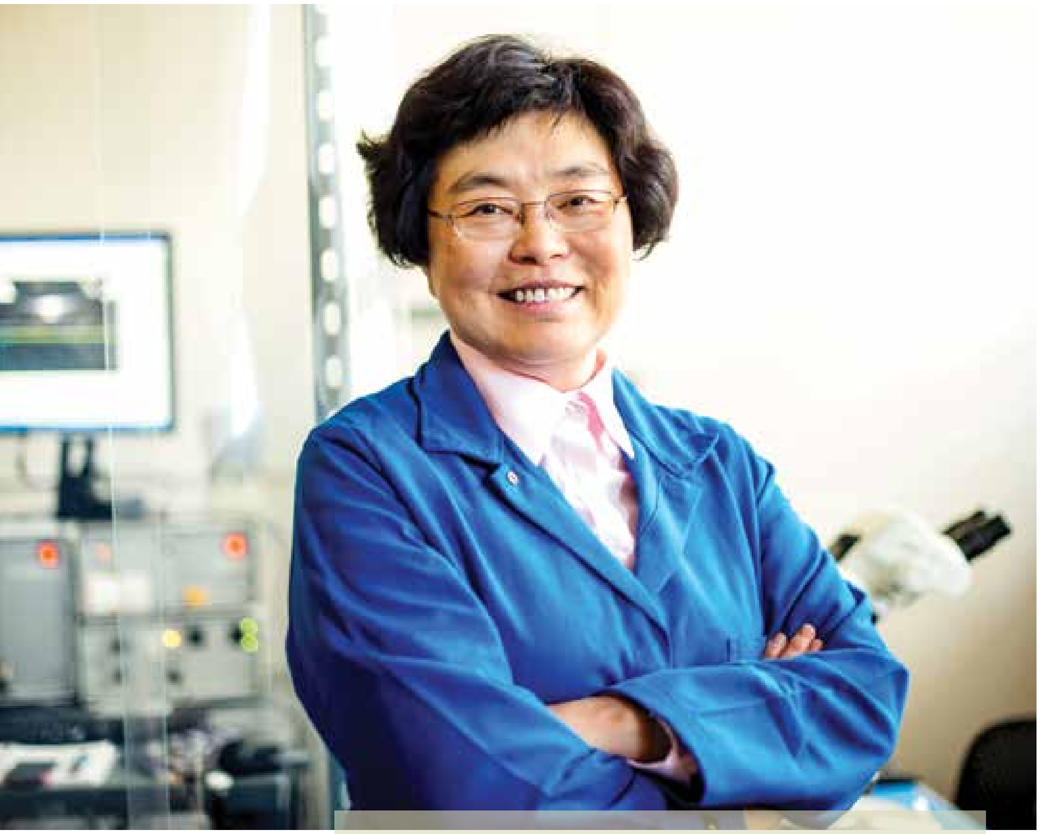
Matt Beardsley

STEM PIPELINE

## Girls in Engineering

This summer, the college launched an outreach program for middle school girls designed to bring engineering to life and inspire the girls to pursue an education in STEM fields. Led by women faculty and graduate students, the camp was also designed to instill the confidence needed to master both the hard and soft skills required of engineering leaders. Offered free to students from five East Bay schools, the summer camps were part of the college's commitment to increasing the ranks of women in technology. Research shows that by high school age, many girls have already dismissed the potential of careers in engineering.

Supported by grants from the National Science Foundation, General Electric and the Baskin Foundation, two weeklong sessions included hands-on projects in nanotechnology, robotics, optics and more, as well as field trips to nearby Pixar Animation Studios and Lawrence Hall of Science.



Noah Berger

Whinnery Distinguished Professor of electrical engineering and computer sciences Connie Chang-Hasnain was named associate dean for strategic alliances in July.

CIRCUITS

## Great optics

Harnessing light with photonic integrated circuits on silicon promises to catalyze powerful new applications in energy-efficient telecommunications, computing and more, as standard electronic circuits did in the past. This requires photonic devices to be integrated into dense, high-performing circuits, which may now be possible using semiconductor nanostructures developed in the lab of **Connie Chang-Hasnain,** Whinnery Distinguished Professor of electrical engineering and computer sciences. Her team has designed a robust toolkit of nano-optoelectronic circuit elements—including light emitters, photodetectors, a photovoltaic power supply and optical links to connect these devices into circuits—that were found to perform as well as their traditional counterparts. Chang-Hasnain and her students discovered a new method to grow light-efficient nano-resonators on a silicon substrate. Then they can use conventional nanofabrication techniques to make photonic integrated circuits, making product manufacturing easier down the line.

VISION

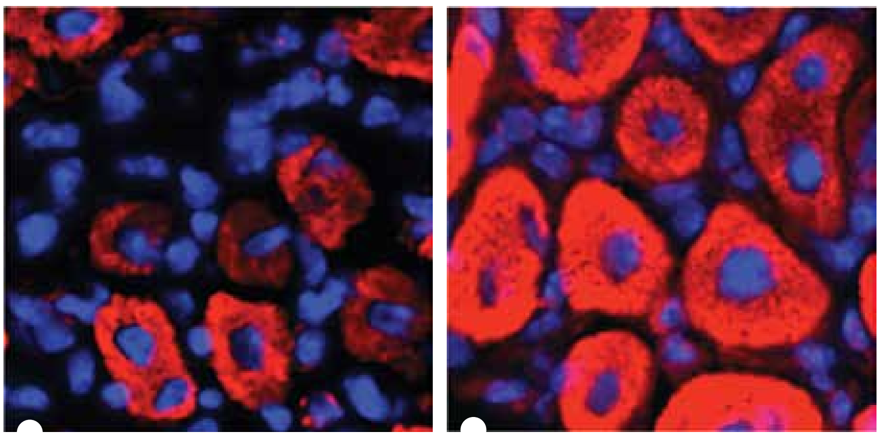
## Sight for sore eyes

What if everyone could clearly see their smartphone, tablet, computer and TV screens without having to wear eyeglasses? **Brian Barsky,** professor of computer science and vision science and affiliate professor of optometry, teamed up with colleagues at MIT to improve vision-correcting display technology. Using an iPod for their prototype, they devised algorithms to make adjustments in the display to compensate for various vision impairments. They designed ways to manipulate the intensity of light emanating from each pixel and added a perforated touchscreen "mask" to further control light and sharpen focus. Given an eyeglasses prescription, researchers can now pre-correct the display to enable that user to see the screen in sharp focus without glasses. The technology could not only help millions who wear glasses, but it could also be transformative for those with vision problems that cannot be corrected by eyeglasses. "People who are unable to view displays are at a disadvantage in the workplace as well as in other aspects of their lives," says Barsky.

HORMONES

# Rejuvenating old muscles

Your muscles grow larger and stronger from birth until your thirties, when they naturally start to lose mass, strength and mobility. Now, bioengineering researchers have discovered that oxytocin—the hormone associated with maternal nurturing, social attachments, childbirth and sex—may combat this age-related muscle wasting. Led by associate professor **Irina Conboy,** Berkeley researchers found that mice required oxytocin for healthy muscle maintenance and repair, and oxytocin levels in blood and receptors in muscle stem cells reduce with age. When they injected oxytocin into older mice, the researchers found that it improved muscle regeneration to a level comparable to young mice, with no ill effects. "This demonstrates that extra oxytocin boosts aged tissue stem cells without making muscle stem cells divide uncontrollably," explains project scientist **Wendy Cousin.** Also, by experimentally inhibiting oxytocin, researchers detected premature aging in adult mice. Cousin noted that related investigations will determine if oxytocin is a viable alternative to hormone replacement therapy to impede the effects of aging in humans.




Irina Conboy's bioengineering lab found that aging muscle cells in mice naturally degenerate (at left), but appear revitalized after oxytocin is administered (at right).

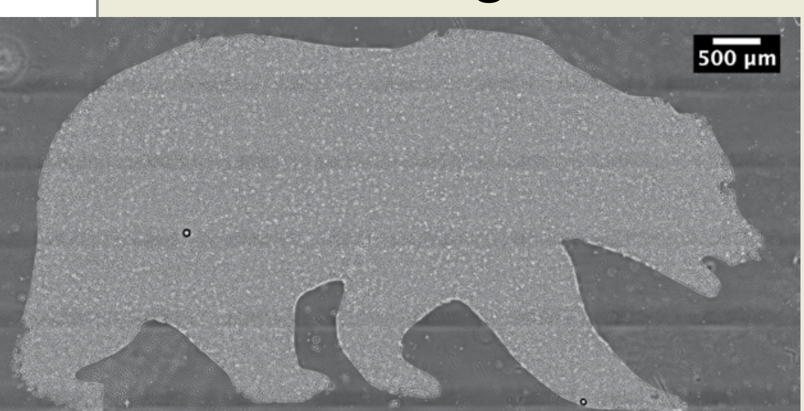
GENES

# Evolutionary algorithms

Darwin was the first to marvel at the diversity of life that natural selection has produced, given that the evolutionary forces of "survival of the fittest" and diversity appear to be in opposition. "There is a paradox in evolution," says **Umesh Vazirani,** Strauch Professor of electrical engineering and computer sciences and director of Berkeley's Quantum Information and Computation Center. "Suppose the mixing of genes through sexual recombination helps create a perfect individual. That perfection gets lost in the next generation, because the offspring inherits only half the perfect parent's genes." Vazirani and his colleagues have developed an algorithm that helps demystify this paradox, demonstrating that diversity results from the selection process as well as genetic mutations. They noticed that genes prefer a 50-50 distribution; even if there is an extremely successful genetic trait, evolution doesn't want lesser traits to become extinct. Their algorithm works to maximize the tradeoff between going all-in on a successful genetic trait and hedging bets by not committing to any one specific trait. This type of algorithm has been used in computer science, statistics and economics, but researchers have now discovered that it can be applied to nature, as well.

CURRENTS

# Herding cells with electricity




Drawing inspiration from sheep dogs that herd their flock, researchers are now able to similarly herd biological cells for tissue engineering. Led by associate professor **Michel Maharbiz** from electrical engineering and computer sciences and bioengineering graduate student **Daniel Cohen,** the researchers found that an electrical current can orchestrate the migration of groups of cells. By applying electrical current to single layers of epithelial cells (binding cells that line organs and body cavities), they were able to herd cells from side to side or to make U-turns. With stencils, they sorted cells into shapes—including the familiar shape of the Cal bear—and investigated effects on electrified cell motion. One application of this cell-herding technology could be smart bandages: with a grid of electrodes, bandages could stimulate currents into wounds to expedite healing.

HOW DO I FIND OUT MORE?
Find links to web extras through the college website at **engineering.berkeley.edu.**

# Freedom phones

## The future of dissent on the 50th anniversary of the Free Speech Movement

STORY BY PAUL PREUSS • PHOTOS BY NOAH BERGER

On January 28, 2011, the news was everywhere: just after midnight in Egypt, the Mubarak regime had cut off most Internet and cell phone service to 82 million citizens, and tens of thousands of them were already moving toward Cairo's Tahrir Square for what would become a decisive "Friday of Anger."

"Damn, this is a pretty extreme form of censorship," was Yahel Ben-David's first reaction. A Ph.D. candidate in electrical engineering and computer sciences, Ben-David is an expert in citizen access to communications. When a government that controls the infrastructure decides to shut it down, what kind of "dissent network" would it take for people to stay in touch?

Ben-David's research had turned up "many papers, but nothing practical." Much theoretical work focuses on wireless mesh networks, with multiple wifi nodes that can reroute around local failures by means of overlapping coverage. From his own experience, Ben-David knew that "mesh networks that try to maintain full Internet connectivity don't scale well—the more nodes, the less capacity in each." Even legally permissible cell phone towers or rooftop antennas could attract unwelcome attention to dissenters.

However, says Ben-David, "if a system is delay-tolerant"—if messages can wait a while before they are passed along—"some things, like smartphones, can work," by functioning as nodes on the move. "Mobility is both a challenge and an advantage."

Anonymity is essential in a dissent network, as Ben-David had also learned from experience. Not mere pseudonymity; phony IDs are easy to crack when a government controls the infrastructure and has access to what's known in cybersecurity lingo as "out-of-band" information—knowledge gained, in essence, by the government spying on its citizens.

Knowing what wouldn't work, Ben-David set out to recruit fellow students and faculty in the College of Engineering to help him create a system that could function discreetly when networks are down, reach as many people as necessary and protect the identity of its users.

### LEARNING FROM THE REAL WORLD

Yahel Ben-David is not your usual doctoral student. Now in his mid-40s, he served in the Intelligence Corps of the Israel Defense Forces (IDF), co-founded a successful Internet security and services company with headquarters in Silicon Valley and built an innovative wifi mesh network that brought the Internet to rural northern India. Before all that, he was one of Israel's most notorious hackers—although, because he was a teenager, his name wasn't made public until long after the authorities had tracked him down.

Growing up the son of schoolteachers in the village of Tiv'on in northern Israel, Ben-David says he was not a good student and was later diagnosed as dyslexic. "I was math-challenged and still am. But I found if I could teach myself, I could flourish."

Socially active, a community volunteer, a motorcycle racer from the tender age of 13 and a rock climber by 18, he was far from a stereotypical nerd, and in fact calls himself an "adrenaline junkie." Yet computers were his passion. He built his own modem, which meant sleeping on the floor: the circuitry took up the entire surface of his bed. In 1984, as a high-school junior, he gained anonymous infamy when he used his Commodore 64 (all 64k RAM) to hack into Israel's biggest newspaper and plant a front-page article lambasting an unpopular teacher, using the byline of one of the paper's leading journalists.

Like most young Israelis, Ben-David went straight from high school into the IDF, where—not least because they were aware of his hacking adventures—the Intelligence Corps already had its eye on him. He spent over four years in intelligence, in cybersecurity and on the ground in Lebanon.

**Yahel Ben-David** and **Barath Raghavan** of the De Novo Group have designed Rangzen, a smartphone app to support dissenters and protect identities.

In 1993, after active service, Ben-David joined two IDF friends to co-found the Xpert Group, a networking and security consultancy firm. They soon scored a business coup by winning the contract to establish Morocco's government-owned Internet service, the country's first. The 40-page request-for-proposal, mostly verses from the Koran, reflected a concern "to protect youth from the horrors of the Internet," Ben-David says, "but their core needs were straightforward, and our four-page proposal beat out major international players."

When the Xpert Group moved its headquarters to Silicon Valley, Ben-David kept an apartment in San Francisco but never unpacked his boxes. "I was always on a plane somewhere. Life was about making money." Then a friend called from Dharamsala, India, home of the Dalai Lama. "He said, 'We're getting hammered, and we need help.'"

Having visited Indian cities on business, Ben-David wasn't eager. "But I fell in love with rural India." He says, "I had never considered myself a philanthropist—some considered me ruthless. India wholly shaped my awareness of social issues." In 1999, he sold his holdings in the Xpert Group.

The Tibetans' security problems were formidable, and opened his eyes to issues of privacy and anonymity that had never before concerned him. He knew from his security work that existing technological solutions were inadequate. "I was supposed to teach the technology, and I did. But I also told them not to over-trust it. I had little faith in technology up against 'rubber-hose cryptography.'"

Meanwhile, he introduced the Internet to the Himalayan foothills. The company he founded, AirJaldi, has extended broadband coverage outward from Dharamsala with a series of low-power wifi nodes on short masts planted on mountain peaks and hilltops.

During his travels to and from Dharamsala, Ben-David met Yael Perez, a triathlon competitor trained in architecture, committed to using design to address the needs of underserved communities. They married and, in 2004, moved to Dharamsala.

By 2006, however, Ben-David was commuting again, now to Berkeley, where Perez was enrolled in a doctoral program in the College of Environmental Design. Ben-David joined Technology and Infrastructure for Emerging Regions (TIER), the research group founded by EECS professor Eric Brewer, whom he'd met at an AirJaldi conference. Commuting ended when Ben-David told Brewer, "I guess I'll be here a while. I'm going to be a daddy."

**BUILDING A DISSENT NETWORK**

When Egypt shut down the Internet, Ben-David went into high gear. Clandestine restoration of instantaneous Internet access was clearly impractical, but a delay-tolerant network, in which

"The basic assumption is that government agents have fewer friends."

**Giulia Fanti,** EECS doctoral student and privacy researcher for the De Novo Group

information would be exchanged on a scale of hours or days instead of seconds, might work. In this scheme, users' phones would automatically exchange stored messages directly, via an app using the smartphones' built-in wifi or Bluetooth wireless capacity, whenever they came within range of one another.

The name was easy: Rangzen is the Tibetan word for freedom, liberty or independence. What wasn't easy was protecting Rangzen's users while achieving good message propagation—a tolerably fast rate of spreading the word.

"The core problem was how to prioritize what messages should be passed on—while maintaining anonymity," Ben-David says. "I would not start work on anything else until I could solve this."

Giulia Fanti, a Ph.D. candidate studying censorship and privacy, volunteered to join the team. She provided the key, based on her familiarity with "trust graphs"—a message's trust score determines whether it is sent. "The algorithm trusts a message if the sender and receiver share many mutual friends," Fanti explains. "The basic assumption is that government agents have fewer friends."

Ben-David had meanwhile joined forces with Brewer to found the De Novo Group, a nonprofit corporation affiliated with the Center for Information Technology Research in the Interest of Society (CITRIS) through their data and democracy initiative. Ben-David describes De Novo's purpose as "making sure dissertations don't stay on the shelf but help people." Through De Novo, Rangzen is supported by a grant from the U.S. State Department's Bureau of Democracy, Human Rights and Labor.

To build a Rangzen trust graph, users must first establish authentic, "out-of-band" trust relationships, best done by meeting friends face-to-face. Thereafter all identities—including other contacts in the face-to-face friends' lists—are mathematically scrambled and can't be recovered from what Rangzen stores on a phone.

In exchanging messages, the Rangzen algorithm recognizes links, not identities. The more links shared between the contact lists of two users, the more trusted the message and the higher its priority when it is passed along. Less trusted messages are transmitted last and deleted first.

Fanti worked with Barath Raghavan, De Novo's vice president and a senior researcher in networking and security at the International Computer Science Institute at Berkeley (ICSI), to validate the algorithm's security. "Giulia's idea is a refinement of existing algorithms, but really new in the sense that it has never been used in this way," says Raghavan. "We had to validate that there existed crypto primitives to do the friendship intersection in this specific context." That is, they had to verify there were cryptographic tools to compute the number of mutual friends in a way that didn't reveal the names of either party's friends to the other. If that worked, they had to verify that Rangzen could weed out messages from the adversary.

To code Rangzen's phone app and design its interface, Fanti and Raghavan were joined by Adam Lerner, a Ph.D. student in computer science at the University of Washington and De Novo's systems security researcher, and Jesus Garcia, a Berkeley undergrad majoring in computer science.

Teachers invited Rangzen team representatives to make short presentations to a number of College of Engineering classes, during which they asked for volunteers to download the app to their phones. While they had to understand caveats such as battery drain from having their phones almost always on, the volunteers didn't need to give their names.

Says Raghavan, "We didn't care who they were by name, because the first test was to establish that the system works for communication. On top of Rangzen's normal version we built a measurement layer, reporting to a server that all users could access. It shows where you were when you encountered another user and exchanged messages."

Rangzen began preliminary testing in July 2014. Tests, simulations and analysis indicate that during an Internet blackout Rangzen can spread "honest" messages (time and place of a rally, say) to over 80 percent of the user population in less than two days, with "adversarial" messages (a false time and place, say) considerably fewer and later.

"In a nutshell," says Ben-David, "we have shown that Rangzen can work and that we can solve the remaining problems."

Some are technical. "From a commercial perspective, what we're doing is unusual," says Lerner. "Androids and iPhones require you to respond that you want to connect. Rangzen needs opportunistic, automatic connections. We can enable that, but we're trying to find simpler ways in newer smartphone systems."

A more basic obstacle, says Fanti, is that "we don't yet understand how our approach will work in practical dissent settings. We can't know ahead of time how a powerful, government-level adversary will react." In all Rangzen-like systems there may be a fundamental trade-off between how fast messages can propagate and the anonymity of their senders.

"It's like there's a big knob," Ben-David says. "You can turn it one way for blanket anonymity with slow propagation, or the other way to fast propagation but more risk. Where is it realistic to set that knob?"

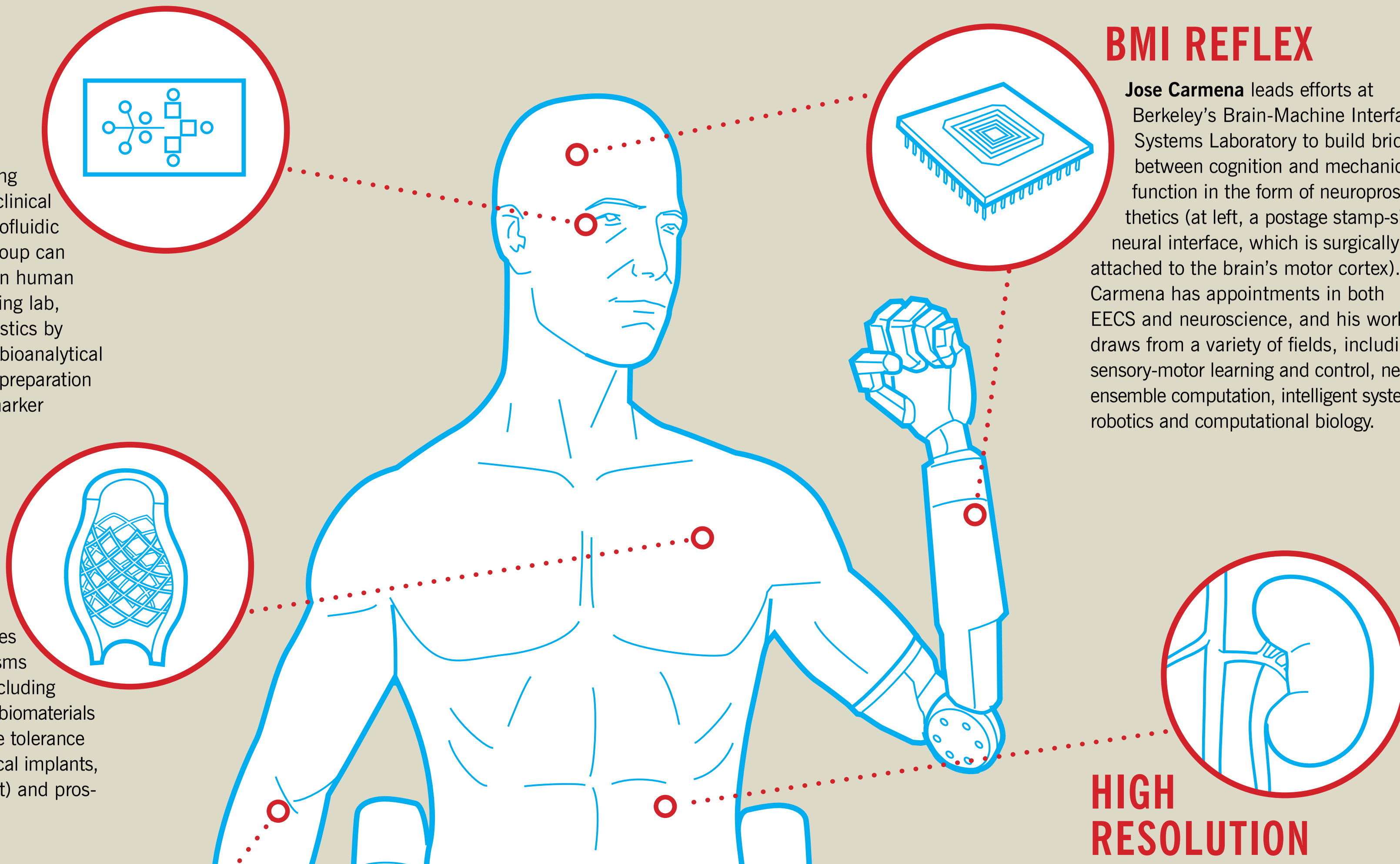
The team has already been approached by dissent groups, he says. "We're reluctant to work with them until we're comfortable that anonymity is secure. This is a dangerous business. We're not going to make claims we can't substantiate."

While adversarial gaming could help determine where to set the propagation-versus-anonymity knob, with some users playing dissenters and others playing agents trying to foil their plans, Ben-David has no illusions: "Eventually we'll have to dive into cold water and get Rangzen to the people who need it." BE

# Body mechanics

Berkeley engineers are building better bodies, one part at a time. Working across fields and disciplines, researchers are developing solutions ranging from early disease detection to brain implants and bionic-like exoskeletons. These advances hold the potential to improve quality of life for millions of people. Here is a rundown of a few of the most notable body hacks that have come out of Berkeley Engineering's labs in recent years.

ILLUSTRATION BY JASON LEE



## DEPLOYABLE DIAGNOSTICS

Professor **Amy Herr** is building better diagnostic devices for clinical applications (at right, a microfluidic device designed by Herr's group can distinguish protein markers in human tears). From her bioengineering lab, Herr aims to improve diagnostics by accelerating development of bioanalytical methods, streamline sample preparation strategies and enhance biomarker validation.

## STENT MAN

**Robert Ritchie,** a professor of mechanical engineering and materials science, studies the microstructural mechanisms of hard mineralized tissue, including bones and teeth. His work in biomaterials extends to examining damage tolerance and life prediction in biomedical implants, such as stents (pictured right) and prosthetic heart valves.

## BMI REFLEX

**Jose Carmena** leads efforts at Berkeley's Brain-Machine Interface Systems Laboratory to build bridges between cognition and mechanical function in the form of neuroprosthetics (at left, a postage stamp-sized neural interface, which is surgically attached to the brain's motor cortex). Carmena has appointments in both EECS and neuroscience, and his work draws from a variety of fields, including sensory-motor learning and control, neural ensemble computation, intelligent systems, robotics and computational biology.

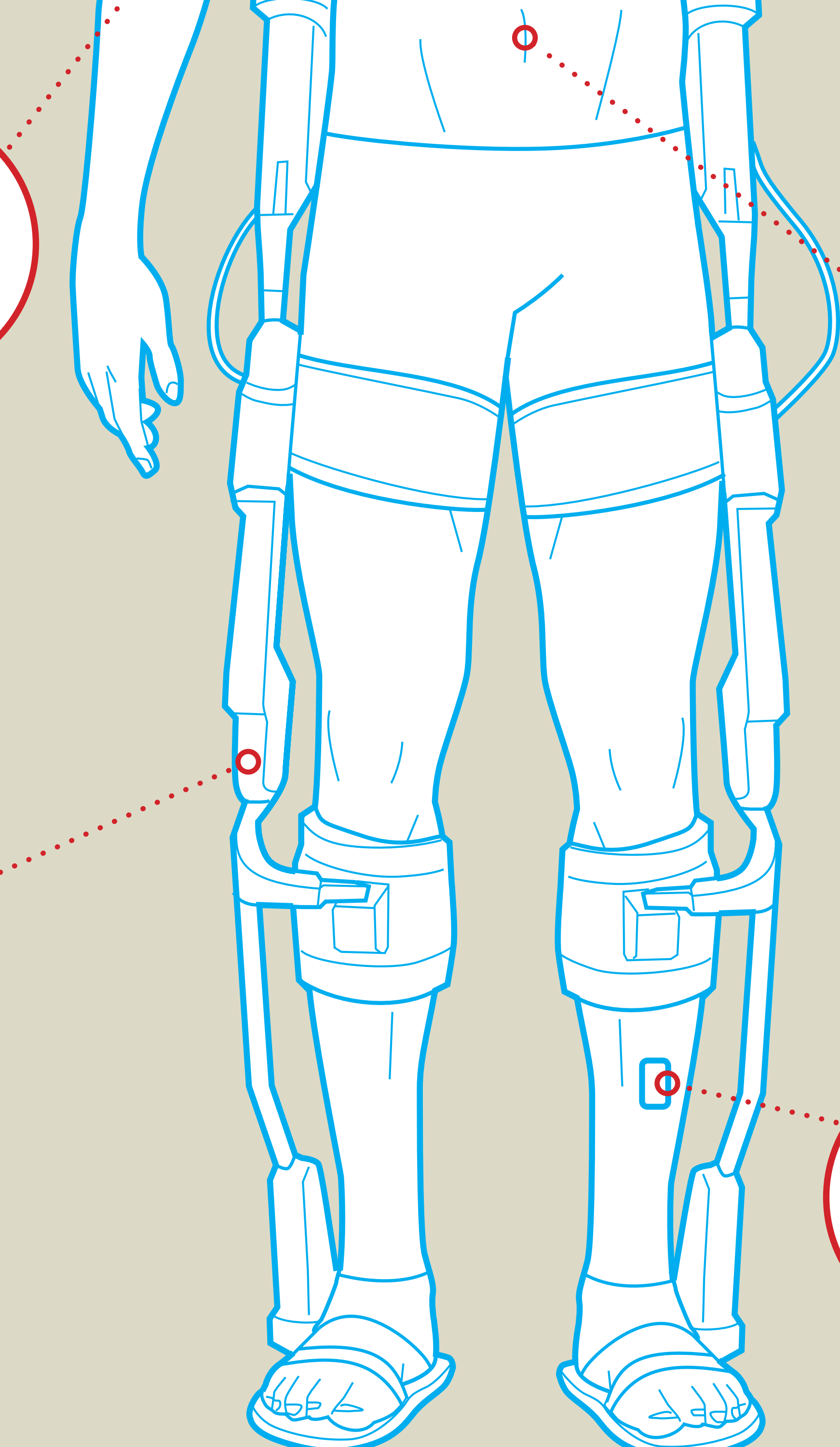
## HIGH RESOLUTION

## FINDING FAULT

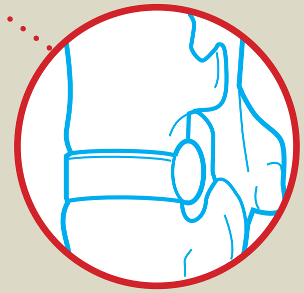
**Lisa Pruitt** runs stress tests on orthopedic implants and artificial joints. With appointments in mechanical engineering and bioengineering, Pruitt looks to improve orthopedic devices and tissues by better understanding structural relationships, biomaterials and medical polymers.

## WEARABLE ROBOTS

**Homayoon Kazerooni** designs and builds exoskeletons that enable paraplegics and people with challenged mobility to walk. A professor in mechanical engineering, Kazerooni and members of his lab also developed the Human Universal Load Carrier, the first lower extremity exoskeleton, which allows users to carry 200-pound weights over any sort of terrain for an extended period of time without extra exertion. Kazerooni is also founder of Ekso Bionics, which commercializes exoskeletons internationally.

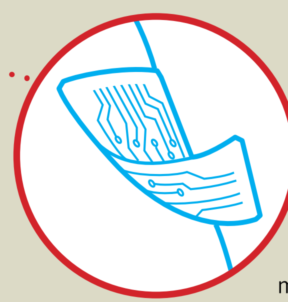


**Steve Conolly** specializes in novel medical imaging and biosensing hardware. With appointments in EECS and bioengineering, Conolly researches magnetic particle imaging and magnetic resonance imaging for enhanced diagnostics. Applications include safe angiography for kidney disease patients, in-vivo cell therapy tracking, tuberculosis imaging, functional imaging and noninvasive, early-stage cancer diagnostic imaging.



## SPINE SPACE

**Grace O'Connell,** on the mechanical engineering faculty, models soft tissues to study the biomechanics of cartilage and intervertebral discs. By understanding the mechanical function of healthy, degenerated and injured intervertebral discs and applying tissue engineering and regeneration concepts, O'Connell hopes to develop physiologically sound repair strategies.



## SECOND SKIN

**Michel Maharbiz**, a professor in the EECS department, is developing micro/nano interfaces to cells and exploring bio-derived fabrication methods. One of Maharbiz's projects is a sensor-laden smart bandage that can detect electric signals produced during healing without the need to disturb the wound.

# WHERE VISION

## XIANG ZHANG'S XLAB

STORY BY PAUL PREUSS

PHOTOS BY NOAH BERGER

Xiang Zhang greets the visitor to his airy, ground-floor office in Etcheverry Hall wearing cargo shorts, a colorful sport shirt and a broad smile. He's relaxed enough to be on vacation, a deceptive look for someone who holds the Ernest S. Kuh chair as professor in the mechanical engineering department, directs the National Science Foundation's Nanoscale Science and Engineering Center, was recently appointed director of the materials sciences division at Lawrence Berkeley National Laboratory and who in less than two decades has published more than 240 papers in such journals as *Science*, *Nature* and *Physical Review*.

Zhang is a world leader in the burgeoning field of photonic metamaterials. He makes light perform astonishing tricks by means of artificial structures that don't occur in nature: "superlenses" that capture light that ordinary lenses can't see; tiny motors called "light mills," powered by beams of light; "invisibility cloaks" to make objects vanish.

He calls his group of more than 30 Ph.D. students, postdocs and visiting scientists the XLab, "not because we're mutants, but because we're really looking for nontraditional research topics. X stands for explore, for experiment, for excellence."

As much as depth of scientific thinking, Zhang seeks creativity in recruiting XLab members, even if their test scores are not the absolute highest. "I might ask," he speculates, "'What would you like to do if you had unlimited resources?' If the answer is 'I want to go to Mars,' I'd ask, 'What would you need? How would you do it?'"

Getting an idea off the ground can mean not worrying about feasibility too quickly, a point Zhang makes by describing a kooky scheme from his early years on the UCLA faculty. "The neighborhood was expensive, and a lot of the faculty couldn't afford housing. I came up with the idea of an inflatable apartment we could pump up at night, float up in the air—great views!—and come down in the morning. We did a cost estimate; the price was actually reasonable, compared to the market." He laughs. "Housing for the future, maybe."

### INTO THE XLAB

Visionary from the start, metamaterials are a young field of research, wide open for exploration. Joining disparate components—metal versus insulator, say—

# MEETS KNOW-HOW

metamaterials owe their surprising new properties not to chemistry or crystallography but to their architecture.

"Everything we do begins in nature," says Zhang. "But we think of the natural materials as 'parents,' lending their DNA to designs with properties the parents don't have."

To make these artificial structures possible, the labyrinthine shops and workstations of the XLab wind through three campus buildings, housing an armory of tools including lasers, atomic force microscopes, ion mills, electron beam evaporators and other precision instruments.

Metamaterials embrace such macrodevices as the XLab's acoustic hyperlens, bringing high resolution to sonar and ultrasound images ranging from a school of fish to a fetus in the womb; the fan-shaped array of 20-centimeter-long brass strips can focus meter-scale sound waves to a fraction of their wavelength. The nanoscale, however, opens new vistas for metamaterials.

In the realm of acoustics, XLab Ph.D. candidate Kevin O'Brien uses lasers in Sutardja Dai Hall to create trillionth-of-a-second pulses that excite plasmons (quantized waves of electrons) in gold nanostructures shaped like Swiss crosses, having 90-nanometer short arms and 120-nanometer long arms.

"The cross-shaped nanostructures heat up and expand rapidly to generate coherent acoustic phonons," O'Brien explains. These quantized sound waves travel through solids at 10 gigaherz, a frequency many hundreds of times higher than conventional ultrasound. Detecting the in-phase or out-of-phase oscillation of the nano-arms, says O'Brien, "is a step toward potential applications, in principle including higher-resolution imaging."

Scale is a secondary concern for theorist Hamidreza Ramezani, an XLab postdoc. His whitewashed-concrete office in Hesse Hall houses only a computer; with it he is designing a unidirectional laser by applying quantum mechanical principles and symmetries of time and parity (mirror symmetry) on the scale of long-established classical physics.

Instead of a traditional laser cavity with mirrors, "we're looking for an open cavity that amplifies light in only one direction," Ramezani says. "It's an optical structure that allows photons to take many different paths, but eventually they find one way out, as a laser beam." The test version of this resonant cavity combines three distinct materials.

The metamaterial that Ph.D. student David Barth is making in a cramped corner of Etcheverry Hall combines two materials that could hardly be more ordinary: silicon and air. Using a technique called photoelectrochemical etching, "we're drilling little holes in the silicon, most about 30 nanometers big," Barth says. "We control the density and the size of the holes to change and control the refractive index of the material," manipulating the speed of light through the material to steer its path.

A medium's refractive index indicates how fast light travels through it; at index 1, the vacuum is fastest. Air's refractive index is only a few ten-thousandths greater than 1, while silicon, through which light travels slowly, has an index well over 3. A light ray traveling through pocked silicon does not respond to the air holes, which are smaller than the light's wavelength. But the light bends or accelerates according to how the density of holes changes the refractive index.

To etch the hole patterns, Barth begins with nothing fancier than a PowerPoint image projected onto the silicon wafer; the test case was a photo of Xiang Zhang himself. Depending on the size and pattern of the nanoscale holes, how light moves through the material and emerges from it can be controlled at will. Barth says, "Now that we can bend light in various interesting ways, we're making devices that concentrate light where we want it."

## A VISIONARY BOLT OF LIGHTNING

The XLab's evolving design methodologies, Zhang says, make possible "new materials based on the imagination." Most are destined to produce practical commercial advances in fields including telecommunications, biomedicine and national security. Yet some of the most startling ideas are pure speculative science.

In 2012 two independent groups, Zhang's at Berkeley and that of Nobel Prize-winning theorist Frank Wilczek at MIT, were musing on special relativity and the possibility of broken-time symmetry—which suggested the possibility of a "space-time crystal," a clock to keep perfect time for eternity.

Zhang and postdoc Tongcang Li proposed a unique system of trapped ions, rotating perpetually at their lowest quantum energy level in a static magnetic field. "By leading to a breaking of time-translational symmetry, this makes time—for the first time!—discrete, not continuous as we experience it," Zhang says. "This exotic four-dimensional crystal is not only periodic in space, but also in time."

Explorations of space-time only a little less far out are made possible by "continuous-index photon traps," described in 2009 by Zhang, visitor Dentcho Genov and then-postdoc Shuang Zhang. In these metamaterial devices, light behaves like massive bodies, allowing investigations of celestial mechanics, including black holes and other manifestations of general relativity, right on the lab benchtop.

Zhang's fascination with physics began as an undergraduate at Nanjing University. He then spent a year's research at Fermilab, hoping to pursue particle physics when the Superconducting Super Collider started operations; its defunding in 1993 caused an abrupt career switch. Zhang was soon pursuing a master's degree in environmental engineering at the University of Minnesota.

"I designed a few monitoring devices for air pollution, and I learned hard lessons about instrumentation," he says. The most fundamental lesson: "Creativity must be combined with practical skills."

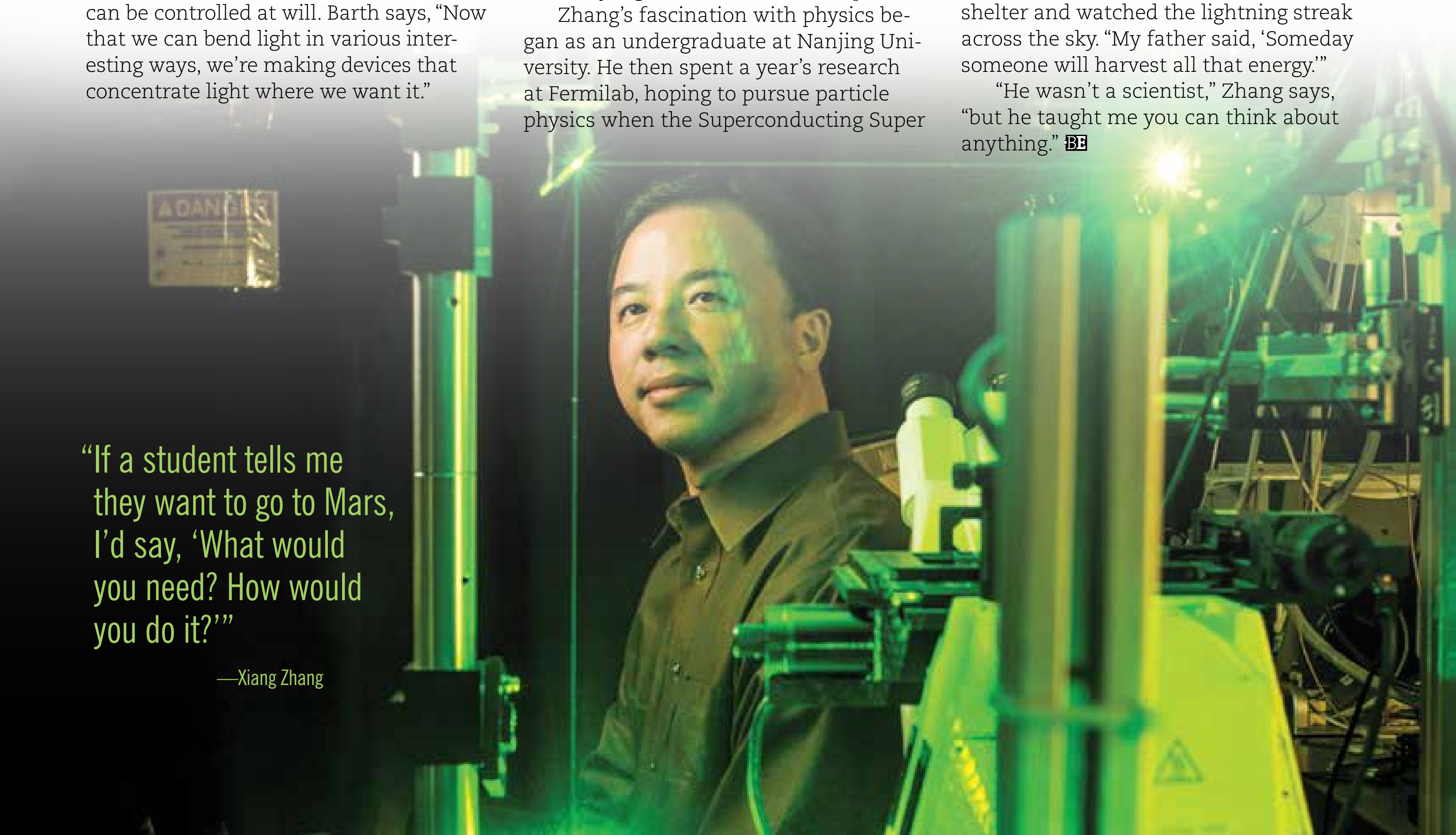
Working toward his 1996 Ph.D. at Berkeley, Zhang learned from mechanical engineering professor Costas Grigoropoulos "how to use laser light to pattern devices." It unleashed his imagination. A few short years later, Zhang was a full professor at UCLA, where he founded the first large metamaterials program in the U.S.

He returned to join Berkeley's ME faculty in 2004 and today views himself as an applied scientist, but one who "sees things the other way around: I'm interested in how technology enables new science."

That's only part of the picture. Ask him where his all-embracing vision, from the mundane to the cosmic, could have originated, and his answer is quick: "I went to school during the Cultural Revolution. Crazy people were running the schools. Education was done with."

There was an upside, he says: no homework and total freedom for the mind to grow. To guide that growth he depended on his father, a middle-school history teacher. Zhang remembers when he was six or seven, and the two of them were bicycling into a thunderstorm; they took shelter and watched the lightning streak across the sky. "My father said, 'Someday someone will harvest all that energy.'"

"He wasn't a scientist," Zhang says, "but he taught me you can think about anything."



"If a student tells me they want to go to Mars, I'd say, 'What would you need? How would you do it?'"

—Xiang Zhang

**Grace Kang** (B.S.'81, M.Eng.'87 CEE), started her new position as director of communications at the Pacific Earthquake Engineering Research Center (PEER), just in time. Two weeks later, the Bay Area was hit with its largest earthquake since Loma Prieta, and a deluge of media inquiries, press releases and site observations descended on the center. A registered structural engineer, Kang worked in engineering consulting for over 25 years. She is a director on the board of the Structural Engineers Association of California, was president of the Structural Engineers Association of Northern California and served on the steering committee for "Loma Prieta 25: Still on Shaky Ground," a public policy symposium marking the 25th anniversary of the 1989 quake.

PHOTO NOAH BERGER

## 2010+

**Eleni Christofa** (M.S.'08, Ph.D.'12 CEE) and **Eric Gonzales** (M.S.'07, Ph.D.'11 CEE) were married on June 22, 2014 in Christofa's hometown of Mytilini, Greece. Both are assistant professors of civil and environmental engineering at the University of Massachusetts, Amherst. Christofa researches intelligent transportation systems, while Gonzales focuses on the operation, management and design of urban transportation systems.

**Amy Kim** (M.S.'02, Ph.D.'11 CEE) was an associate transportation engineer at Dowling Associates, Inc. and a traffic engineer at Declan Corporation before joining the faculty of the University of Alberta as an assistant professor of civil and environmental engineering in 2011.

**Adam Mendelsohn** (Ph.D.'11 BioE), **Kayte Fischer** (Ph.D.'10 BioE) and **Lily Peng** (Ph.D.'10 BioE) competed in the Berkeley Business Plan Competition; several competitions later, the classmates co-founded Nano Precision Medical, a start-up company developing implantable drug-delivery systems. The company has raised $3 million in financing and has eight employees.

**Volker Sorger** (Ph.D.'11 ME), assistant professor at George Washington University in Washington D.C., won a young investigator research program grant from the Air Force Office of Scientific Research to conduct research on nanophotonics devices with capabilities beyond classical photonics limits.

**Daniel Tischler** (M.S.'11 CEE), a transportation planner at San Francisco's county transportation authority, has been awarded an Air-Sage-funded PASS scholarship, one of only three in the country.

**Yoonjin Yoon** (Ph.D.'10 CEE) joined the faculty of the Korea Advanced Institute of Science and Technology as an assistant professor in the department of civil and environmental engineering in 2011. Previously, Yoon was a researcher at the National Center for Excellence for Aviation Operations Research.

**Bo Zou** (Ph.D.'12 IEOR) joined the faculty at the University of Illinois, Chicago as an assistant professor in the department of civil and materials engineering in 2012.

## 2000+

**Soyoung (Sue) Ahn** (M.S.'01, Ph.D.'05 CEE) is an associate professor of civil and environmental engineering at the University of Wisconsin, Madison, with research interests in traffic flow theory and operations, intelligent transportation systems applications and traffic operation impacts on environment and safety.

**Mikhail Chester** (M.S.'05, Ph.D.'08 CEE) received the 2013 departmental teaching award from Arizona State University, where he has served as an assistant professor of civil, environmental and sustainable engineering since 2011.

**Christian Claudel** (M.S.'09, Ph.D.'10 EECS) has been an assistant professor of electrical and mechanical engineering at King Abdullah University of Science and Technology in Saudi Arabia since 2010.

**Nikolaos Geroliminis** (M.S.'04, Ph.D.'09 CEE) joined the faculty of École Polytechnique Fédérale de Lausanne as an assistant professor of civil and environmental engineering in 2009. Previously, Geroliminis was an assistant professor at the University of Minnesota.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SEND YOUR CLASS NOTES to **berkeleyengineer@berkeley.edu,** or mail to:
*Berkeley Engineer*, UC Berkeley College of Engineering, McLaughlin Hall #1704, Berkeley, CA 94720-1704.

**Anne Goodchild** (M.S.'02, Ph.D.'05 CEE) joined the University of Washington faculty as an associate professor of civil and environmental engineering in 2005. She directs UW's Freight Mobility Lab and is associate director of the freight operations research program.

**Arjun Gupta** (B.S.'08 CEE) was named one of 37 Young Leaders of 2014 by *The Economic Times,* one of India's largest newspapers and the host of the competition, from a field of more than 20,000 applicants.

**Yanfeng Ouyang** (M.S.'05 IEOR, Ph.D.'05 CEE) has been on the civil and environmental engineering faculty at the University of Illinois, Urbana-Champaign since 2005. In 2010, Ouyang received the Xerox award for faculty research. Ouyang develops strategic, tactical and operational models and solutions for problems that arise in multidisciplinary areas of transportation systems, network optimization and logistics systems planning.

**Megan Ryerson** (M.S.'06, Ph.D.'10 CEE) joined the faculty of the University of Pennsylvania as an assistant professor of city and regional planning and electrical systems in 2013. Previously, she was an assistant professor at the University of Tennessee, Knoxville. She researches fuel consumption and the impact of high fuel prices on the transportation system.

**Athulan Vijayaraghavan** (M.S.'05, Ph.D.'09 ME) is chief technology officer at Berkeley-based System Insights, a global supplier of manufacturing software.

**Daniel B. Work** (M.S.'07, Ph.D.'10 CEE) joined the faculty of the University of Illinois at Urbana-Champaign as an assistant professor in the department of civil and environmental engineering in 2010.

## 1990+

**Orla Feely** (M.S.'90, Ph.D.'92 EECS) has been appointed vice president for research, innovation and impact at University College, Dublin. Feely joined the UCD faculty in 1992 and now heads up electronic engineering.

**J.D. Margulici** (M.S.'99 CEE) established his consultancy, Novavia Solutions, in 2010 and recently embarked on a new venture by co-founding Vehicle Data Science, where he serves as chief technology officer. He reports that "life at home isn't particularly quiet either," with sons Anthony and Mateo, both under five years of age.

# Smart spoons

**Anupam Pathak's** (B.S.'04 ME) idea to build a device to assist people with Parkinson's disease evolved from helping soldiers survive combat. Pathak started his doctoral research at the University of Michigan in 2004, at the height of U.S. troop deployments to Iraq and Afghanistan. Field reports revealed large numbers of troops facing stress-induced tremors during combat. A soldier with shaky hands is dangerous; tremors were actually affecting casualty rates.

Pathak researched the actuator, the part of a weapon-stabilizing device that counters the tremor. By the time he graduated in 2009, he was thinking about other applications for stabilization technology and learned that more than 10 million people in the U.S. are facing tremor-related challenges. "It turns out that a solution does not exist for a lot of people," Pathak says.

After more than a year of R&D, Pathak founded Lift Labs in 2012. Their first product, Liftware, consists of a mechanized handle with different attachments. The sensor in the handle interacts with the actuator to counter the tremor in a user's hand.

While designing, building and getting feedback about Liftware, Pathak says he thinks back to an engineering ethics class he took as an undergraduate at Berkeley. "We were taught to think about who you are affecting by your work. I think that is so important in how we develop this product."

In September, Lift Labs was acquired by Google and will be part of Google's life sciences division.

STORY AND PHOTO BY DANIEL MCGLYNN

# Measuring DNA health

STORY BY JENNIFER HUBER • PHOTO COURTESY EXOGEN BIOTECHNOLOGY

Sometime soon, **Sylvain Costes** (Ph.D.'99 NE, right) and **Jonathan Tang** (Ph.D.'10 BioE) hope that annual medical checkups will include a simple blood test to determine levels of DNA damage.

The list of things assaultive to the body's basic building blocks is long—radiation, ultraviolet light and toxins, to name a few—and errors occur even during normal cell division. The body continually repairs this damaged DNA, but sometimes the routine repair process fails. DNA damage and genetic mutations can lead to serious health problems, like cancer, immunological disorders, neurological disorders and premature aging.

To map DNA damage in tissue or blood samples, the Berkeley Lab scientists developed a new technology that automates measurements with a high-throughput microscope and proprietary image analysis software to spot DNA breaks. The result is a more accurate count, in a fraction of the time compared to conventional methods.

The pair founded Exogen Biotechnology to translate their technology into an affordable product the public can use to monitor personal DNA health. Exogen technology can measure DNA damage levels from blood samples easily collected with an in-home kit.

"To me, this will become the cholesterol test of cancer," says Costes. "Your genetics place you in a certain range, but your lifestyle can change where you are within that range. In contrast to genetic testing, we feel like this test can bring hope—because you have a way to act."

**Jason Mikami** (B.A.'92 East Asian Languages, B.S.'98 EECS) is the owner of Mikami Vineyards, a small family operation in Lodi that was recognized in the July 2014 *Wine Enthusiast* as a "trail-blazing" artisan winery.

**Jorge Prozzi** (M.S.'98, Ph.D.'01 CEE) is an assistant professor in the department of civil, architectural and environmental engineering at the University of Texas at Austin, where he chairs the international activities committee of the transportation research board. Prozzi joined the faculty in 2002, after working as a technical specialist at the Council for Scientific and Industrial Research for more than a decade.

**Karen Smilowitz** (M.S.'98, Ph.D.'01 CEE) is an associate professor of industrial engineering and management sciences at Northwestern University. In 2012, she was a visiting professor at the University of Newcastle, Australia in the school of mathematical and physical sciences.

## 1980+

**Scott Jordan** (B.S.'84, M.S.'87, Ph.D.'90 EECS) was named the chief technology officer of the Federal Communications Commission. As a computer science professor at UC Irvine, Jordan was well-known for his research on net neutrality and Internet pricing. He has previously served as a congressional fellow on Internet and telecommunications policy in the U.S. Senate and also on the FCC Open Internet Advisory Committee.

## 1970+

**Howard Pines** (M.S.'77 ME) worked for more than 30 years in research and technology, earning five patents in wireless voice technology before becoming a novelist. *The Whale Song Translation* is a scientific thriller "about an engineer, by an engineer and for engineers," says Pines. The story follows an engineering professor as he contacts another earthly species of intelligence. In the 1960s, Pines was captivated by the race to the moon, spurring his career in alternative energy technology at Lawrence Berkeley National Laboratory.

**Mark Schanfein** (M.S.'74 MSE) is principal advisor of nonproliferation, arms control and international safeguards at Pacific Northwest National Laboratory. He provides technical leadership in development operations and implementation across multiple

Environmental engineer **Tami Bond** (M.S.'95 ME), professor of civil and environmental engineering at the University of Illinois at Urbana-Champaign, was named a 2014 MacArthur Fellow. She was recognized for research that measures the global impacts of black carbon emission and atmospheric pollution on human and environmental health.

Bond's goal is to refine the integration of black carbon into climate models to create a more comprehensive global framework for how black carbon inventories and impacts are quantified and classified. The first step is to develop standardization for black carbon emission observations.

The annual "genius" grant is given to professionals across a variety of disciplines as recognition for original thinking. "My first reaction was not to have a reaction," Bond told the *Daily Cal.* "I was so surprised. You don't have any skills for a moment like that. The very first reaction was blank shock."

PHOTO COURTESY OF THE JOHN D. & CATHERINE T. MACARTHUR FOUNDATION governmental agencies, including the Department of Energy and the Department of Defense.

**George Tyris** (B.S.'78 ME) has published *Tau Centi: A Ship from Earth,* the first in a series of novels chronicling the growth of a colony on a planet in the Tau Centi system. The story follows the colony from a quiet backwater to an independent world defending itself against the manipulation of interstellar politics.

## 1960+

**Jesse Ante** (B.S.'68, M.S.'70 ME) retired this past July after 40 years in the U.S. Air Force, PG&E and the California Public Utilities Commission. A loyal alumni volunteer, Ante has mentored over 100 students throughout his lifetime and has established several Cal Alumni Association Scholarships. He is now a "manny" for his "Class of 2034" grandson.

**Steven Dodge** (B.S.'67 Eng. Phys.) received an M.S. in systems science at UCLA while working at a naval laboratory in 1970. He had worked for three aerospace companies in sonar and new business acquisition before retiring in 2001. He remains active with hiking, traveling and his model railroad hobby.

## 1950+

**Tommy Woo** (B.S.'58 EE) worked in high-tech jobs for over 10 years before changing careers. For the past 30 years, he has been designing restaurants.

## 1940+

**Edwin Fong** (B.S.'49 EE) worked for CalTrans from 1950–78 and the California Public Utilities Commission from 1978–82. A father of three (including two Berkeley graduates), Fong is now living at Saint Paul Towers overlooking Lake Merritt in Oakland.

# Farewell

*This year, the college lost four professors emeriti, with more than a century of service to the college.*

**Arthur Bergen,** professor emeritus of electrical engineering and computer sciences, died in July 2014 at the age of 91. As an officer in the U.S. Army, Bergen served in World War II; after the war ended, he served with the Signal Corps in the Army of Occupation in Germany. He received his doctorate in electrical engineering from Columbia University in New York. As a field engineer for Westinghouse, his first foreign assignment was in Brazil, where he worked on the installation of a generator on a river in the rainforest. Subsequent jobs took him to other remote locations in the U.S. and abroad. He joined the Berkeley faculty in 1958 and retired in 1991, serving as associate dean for 10 years in the interim.

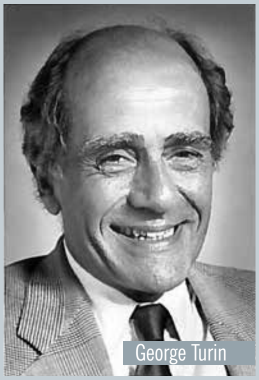
**Chieh Hsu,** professor emeritus of mechanical engineering, died in July at age 92. Born in Beijing, Hsu lived through the Japanese invasion of China in 1937, when he was forced to evacuate. After serving in the army, Hsu was one of 60 students chosen in a nationwide competition for a scholarship to study abroad, in what he would later call the "lucky break which changed my whole life." Hsu received his Ph.D. from Stanford in 1951 and went to work at IBM in New York. Returning to academia, his first appointment was at the University of Toledo in Ohio. He joined the Berkeley faculty in 1958, where he remained until he retired in 1991. He was the editor of the *Journal of Applied Mechanics,* invented the technique of cell-to-cell mapping for the analysis of dynamical systems and was honored with many awards, including election to the National Academy of Engineering in 1988.

**Gareth Thomas,** professor emeritus of materials science and engineering, died in February at age 81. Thomas grew up in Wales, obtained a doctorate in metallurgy at Cambridge University in 1955 and brought his skills as an electron microscopist to the Berkeley faculty in 1960. Thomas proposed and oversaw construction of the National Center for Electron Microscopy at Lawrence Berkeley National Laboratory and served as its first director from 1983 to 1991. According to Uli Dahmen, director of the NCEM and a former student of Professor Thomas, "He put Berkeley on the map and made it a worldwide center for electron microscopy that attracted scientists from all over the world." Thomas also achieved the rare honor of being elected into both the National Academy of Sciences and the National Academy of Engineering.

**George Turin,** professor emeritus of electrical engineering and computer sciences, died in March 2014 at the age of 84. Born in New York City in 1930, Turin received his S.B. in 1951, S.M. in 1952 and his Sc.D. in 1956 from the Massachusetts Institute of Technology. Turin joined the Berkeley faculty in 1960 and later served as EECS chair. In 1983, he became dean of the school of engineering and applied science at UCLA before returning to Berkeley. He helped found Teknekron, a Bay Area firm designed to strengthen ties between high-technology firms and university research. His career also included work at MIT's Lincoln Laboratory in Lexington, MA and the Hughes Research Laboratories in Culver City and Malibu, CA.


Arthur Bergen


Chieh Hsu


George Turin


Gareth Thomas

Archive photos

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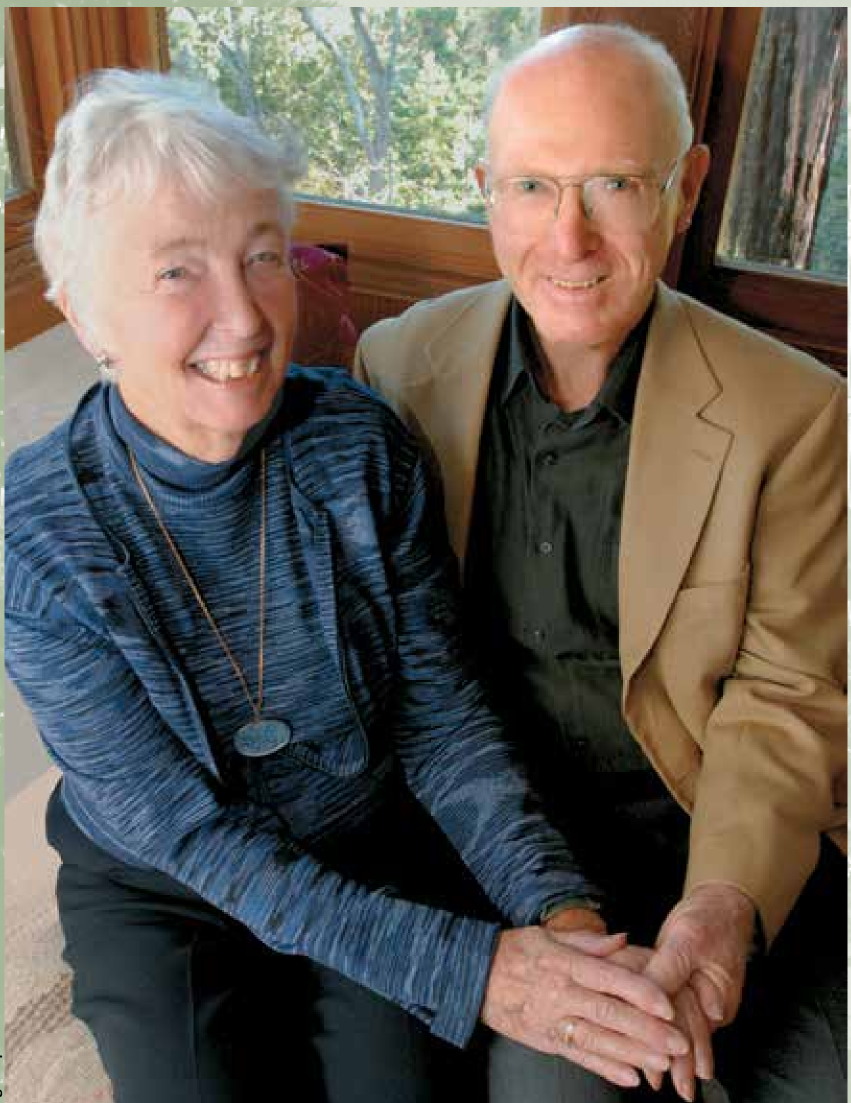

Peg Skorpinski

**Candy Penther and Howard Friesen** met at Berkeley in 1948 and married three years later. Devoted to helping Berkeley's students, the Friesens have funded nearly 300 undergraduate scholarships. They're thinking ahead, too—their estate plans include provisions for endowed faculty chairs.

Thanks to smart financial planning and expert advice from Berkeley's gift planning specialists, they found they could start funding three chairs now. Berkeley Engineering professors David Culler and Scott Shenker hold two of them. Thanks to the Friesens' generosity and foresight, these distinguished faculty members are able to pursue groundbreaking research and mentor promising students.

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—HOWARD (B.S.'50 EE) AND CANDY (B.A.'50 HUMANITIES) FRIESEN

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