College of Engineering
University of California, Berkeley
Fall 2015
Volume 8

CellScope in Cameroon
Safe treatment for river blindness

Fortifying breast milk
Global delivery device

BerkeleyENGINEER

SOPHIE'S SUPER HAND

Fabricating custom prosthetics

Disrupting health care by design

When we talk about seismic shifts and unsustainable infrastructure here at the college, we're usually describing earthquake engineering. But these days, those terms are heard just as readily in discussions about the future of health care, particularly as a "silver tsunami" of aging Americans brings challenges to today's costly health care system.

In college labs, we are seeing explosive growth in compact, low-cost mobile sensing and imaging technologies to advance diagnostics, therapeutics and wellness monitoring. Our data scientists are creating a wealth of analytics for personalized medicine. Digital fabrication and 3-D printing in maker spaces like the new Jacobs Hall are generating customized prostheses and biomedical devices.

At last count, about 40 percent of the College of Engineering faculty is engaged in health-related research.

One new initiative, Health@Home, promises to limit trips to the hospital with new tools for monitoring, screening and care to be used at home (or work, or school) — with greater comfort, lower risk and dramatically lower cost. Our industrial engineers are working alongside campus colleagues from economics, business, public health and policy to build a sustainable model of health care infrastructure.

Our clinical partners are key to these ventures, and Berkeley Engineering has benefitted tremendously from a close relationship with UC San Francisco, most notably in joint programs in bioengineering and translational medicine. A new partnership with UCSF Benioff Children's Hospital Oakland is already bearing fruit — an early collaboration with electrical engineering professor Ana Claudia Arias has resulted in clinical trials for a swaddling MRI vest to improve pediatric imaging.

Our vision to improve health care through engineering includes pioneering new translational tools, such as the organ-on-a-chip technologies from bioengineering professors Luke Lee and Kevin Healy, and providing access to care in low-resource settings, such as the CellScope from bioengineering chair Dan Fletcher. This fall, the CellScope will see its largest deployment yet, when 20 devices will be used to screen 30,000 people for safe treatment for river blindness in Cameroon.

Ultimately, our goal is to use all the extraordinary tools and talent we have here at the college to improve health and reduce suffering — for young and old, in homes and communities here and around the world.

As always, I welcome your thoughts and ideas.

Low-cost mobile sensing and imaging, digital fabrication and 3-D printing are changing the way we deliver health care.

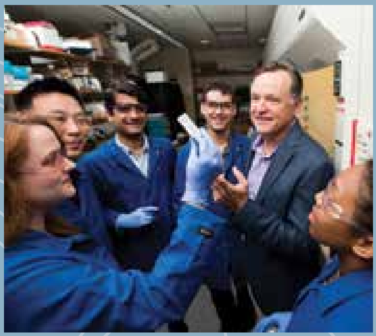
—*S. Shankar Sastry*
DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING
DIRECTOR, BLUM CENTER FOR DEVELOPING ECONOMIES

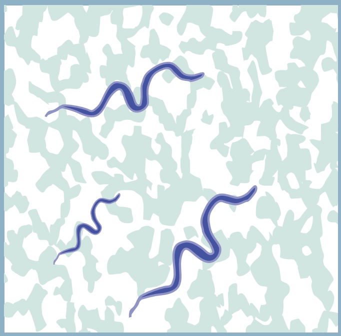
Berkeley Engineering leadership, benefactors and more than 700 members of the college community celebrated the opening of Jacobs Hall on August 20. The new building houses the Jacobs Institute for Design Innovation.

Noah Berger

in this issue

BerkeleyENGINEER FALL 2015





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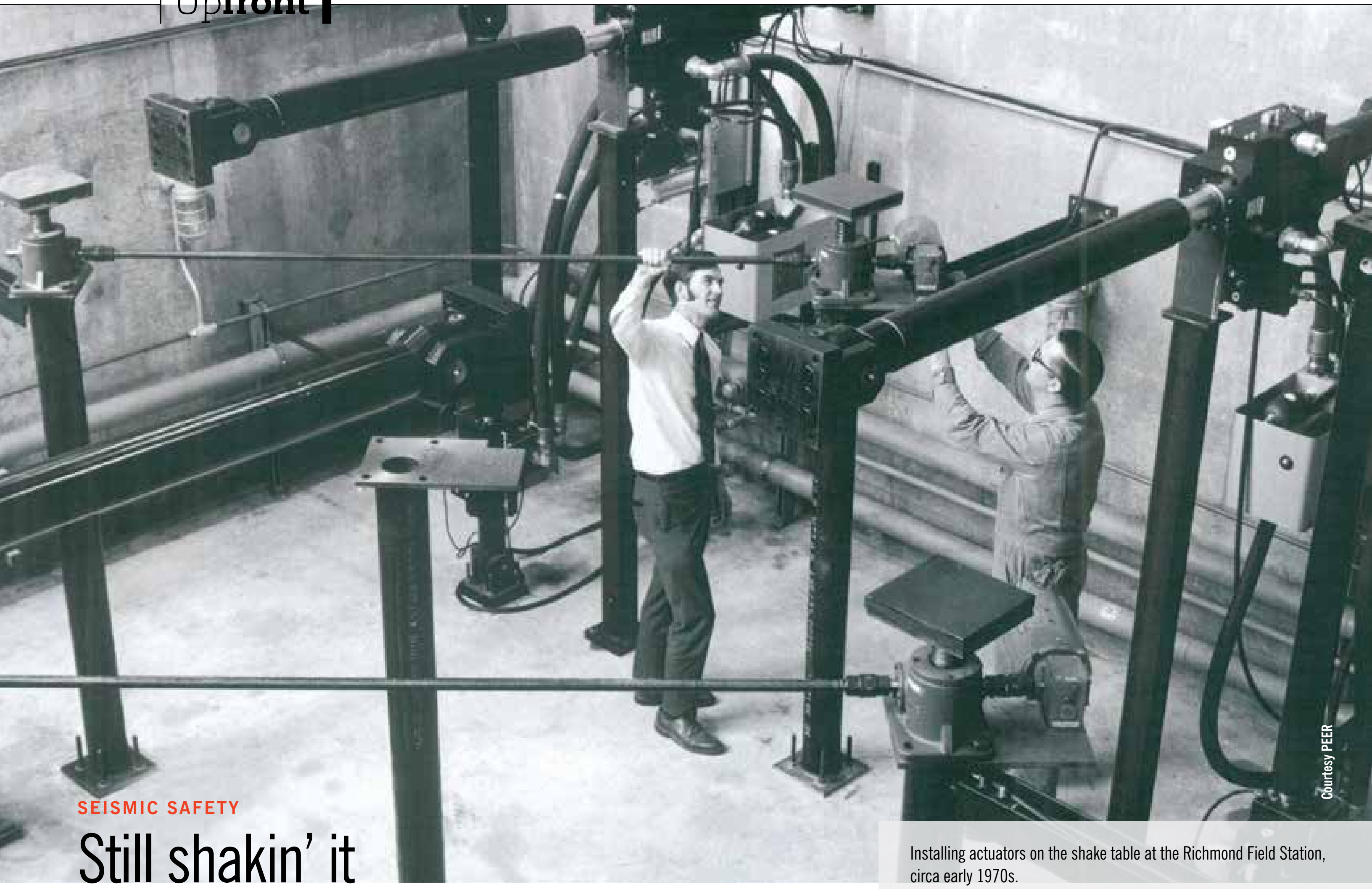


SEISMIC SAFETY

Still shakin' it

Installing actuators on the shake table at the Richmond Field Station, circa early 1970s.

Mobile phones and laptops that are old news within a year, cars with plastic fenders — it feels like the pace of designed obsolescence is quickening. So it is truly impressive when something built decades ago continues to be adaptable to modern needs.

Such is the case with the Pacific Earthquake Engineering Research Center (PEER) shake table, located at the Richmond Field Station. The world's first modern shake table, the 20'x20' reinforced concrete table was unveiled in 1972, soon after the 1971 Sylmar earthquake.

Initially, the table shook vertically and horizontally; upgrades now enable it to move in six degrees of freedom: three translational degrees (vertical, lateral and longitudinal) and three rotational degrees (pitch, roll and yaw) — making it the largest six-degrees-of-freedom table in the country. Over the years, specimens weighing up to 150,000 pounds have been hoisted by a 10-ton bridge crane to be tested on the table.

The table was pivotal in proof-of-concept tests for energy dissipation devices such as rubber-bearing isolators and friction dampers; the testing was essential in demonstrating those devices could be beneficial to the seismic performance of a structure. Subsequent tests of building systems and anchoring and bracing systems have led to the adoption of new industrial standards and technology.

Computational features controlling the shake table continue to be enhanced. PEER researchers use open-source modeling and simulation software to analyze how distinct parts, or subassemblies, of a structure perform during seismic events. An emerging method, called hybrid testing, allows researchers to model how, for example, the top of a skyscraper will behave in an earthquake, then dial in the shake table to replicate that behavior, and then test specimens that would be located at the top of the skyscraper — essentially performing accurate piecemeal testing.

And now, with a new 19'x27' rolling skylight, the sky is truly the limit for future tests.

OPEN LETTER

"Artificial Intelligence (AI) technology has reached a point where the deployment of such systems is — practically, if not legally — feasible within years, not decades, and the stakes are high: autonomous weapons have been described as the third revolution in warfare, after gunpowder and nuclear arms."

— STUART RUSSELL | EECS PROFESSOR | May 27 | Author and first signatory of an open letter from the scientific community urging the ban of lethal autonomous weapon systems that operate beyond meaningful human control.

WEB EXTRA > See **engineering.berkeley.edu/magazine.**

DESIGN

Opening Jacobs Hall

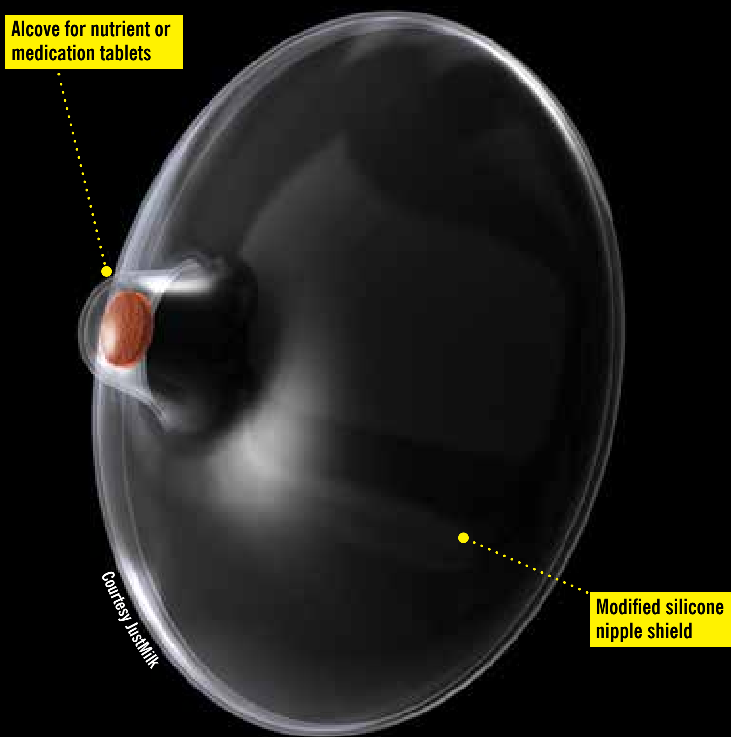
Days before the start of the fall semester, the Berkeley Engineering community held a public celebration to mark the opening of Jacobs Hall, headquarters of the Jacobs Institute for Design Innovation.

This semester, more than 1,300 students are taking classes or participating in other activities in Jacobs Hall. The capabilities of the new building offer faculty the opportunity to develop new courses. This fall, 22 courses are being taught in Jacobs Hall, including a freshman seminar called "How It's Made" and a competition course called "The Challenge Lab," in which students create innovative products serving a social cause.

OPENING DAY: Jacobs Hall offers 24,000 square feet of studios and maker spaces for classes and projects in digital design, prototyping, fabrication and manufacturing. The $25 million building was funded entirely by philanthropy.

"Educating leaders, creating knowledge, serving society — that's Berkeley, that's engineering, that's Jacobs Hall and the Jacobs Institute — and it's going to be fantastic," said David Dornfield, the newly appointed faculty director of the Jacobs Institute.

Noah Berger



SPECIAL DELIVERY: Berkeley engineers are helping develop low-cost manufacturing techniques for JustMilk delivery devices.

GLOBAL HEALTH

Fortifying breast milk

Death by diarrhea is avoidable. Nonetheless, this year, approximately 800,000 children under the age of five will succumb to diarrhea-related complications, primarily in the developing world. One effective treatment is the right combination of zinc, clean water, sugar and salt. JustMilk, an international nonprofit organization, has developed a new technology to simplify that intervention.

"We are focusing on zinc delivery," says Aspen Flynn, a Berkeley molecular biology alumna and one of JustMilk's co-founders. Other co-founders, based at UC Irvine and University of Cambridge, are working toward making the device available in health clinics worldwide.

The technology springs from a 2008 International Development Design Summit project to prevent HIV transmission during breastfeeding. A nipple shield — a thin protective barrier frequently used by breastfeeding mothers with cracked or sore nipples — was reconceived as a device capable of delivering HIV-inhibiting medication. Then the eureka moment: it could also deliver other crucial drugs.

"It's a platform technology," Flynn says, "and zinc is classified as a nutrient instead of a medication, so there are fewer obstacles to testing. Proving the effectiveness of the method will open the door for medication delivery."

Last year, Flynn teamed up with mechanical engineering professor **Alice Agogino** to work on deploying and scaling the JustMilk device. "The next challenge is to prototype and test different materials, geometries and manufacturing methods," says Agogino.

TRANSIT TRENDS

CARMAKERS CHASE SHARING ECONOMY: The auto industry is not known for its speed in responding to the market. But in the case of the emerging sharing economy — or collaborative consumption — which is affecting everything from employment to housing, automakers are experimenting with new tactics to capture the attention of car-sharing consumers. And they have to. According to **Susan Shaheen,** an adjunct professor of civil and environmental engineering, 23 car-sharing companies are renting roughly 20,000 vehicles to 1.3 million American drivers. The data only includes companies that actually rent vehicles; other systems of peer-to-peer renting through social media are also taking off. All together, car sharing is growing by 35 percent a year. Ford, BMW, Rolls Royce and others are experimenting with mobile apps and business development strategies to capture some of that newly oriented consumer demand.

MERGE RIGHT: You know it when you see it: the jerk merge — when a motorist tries to save themselves by zooming rapidly into an open lane of traffic and then pulling, last minute, in front of a line of waiting cars. It happens frequently at freeway exit ramps and on busy city streets with dedicated turn lanes. If you loathe the practice, then know this: science is on your side. "Of all the maneuvers, it's probably the most disruptive to traffic," civil engineering professor **Michael Cassidy** told the *San Francisco Chronicle.* "If the police were to say, 'We're going to crack down on one type of maneuver,' that would be the one. It would likely have the most significant effect on traffic."

Q+A with BRETT

Born into the PR2 family of personal robots made by the Willow Garage robotics research lab, BRETT joined EECS professor **Pieter Abbeel**'s artificial intelligence program in 2010, arriving fully grown but with infantile cognition. We asked BRETT (whose formal name is Berkeley Robot for the Elimination of Tedious Tasks) about its educational progress as we watched it learn to assemble a toy airplane. While BRETT has no organs of speech, nearby computer screens displayed its thought processes. Abbeel acted as our translator.

The last time we met, you were spending a lot of time folding towels. You'd gotten it down to 20 minutes. How are things going?

I still fold towels from time to time, and I'm a lot faster now — 90 seconds! But these days I'm concentrating on improving my basic learning ability.

How are you doing that?

My coach, Pieter Abbeel, decided that instead of my spending many, many hours on a specific task in a specific environment, it makes more sense to figure out how to learn a variety of tasks, either by trial and error or by watching humans do them. And to learn in a general way, so that what I learn doing one task can help me with the next. To do this, an approach called deep learning has been key.

How is deep learning working for you?

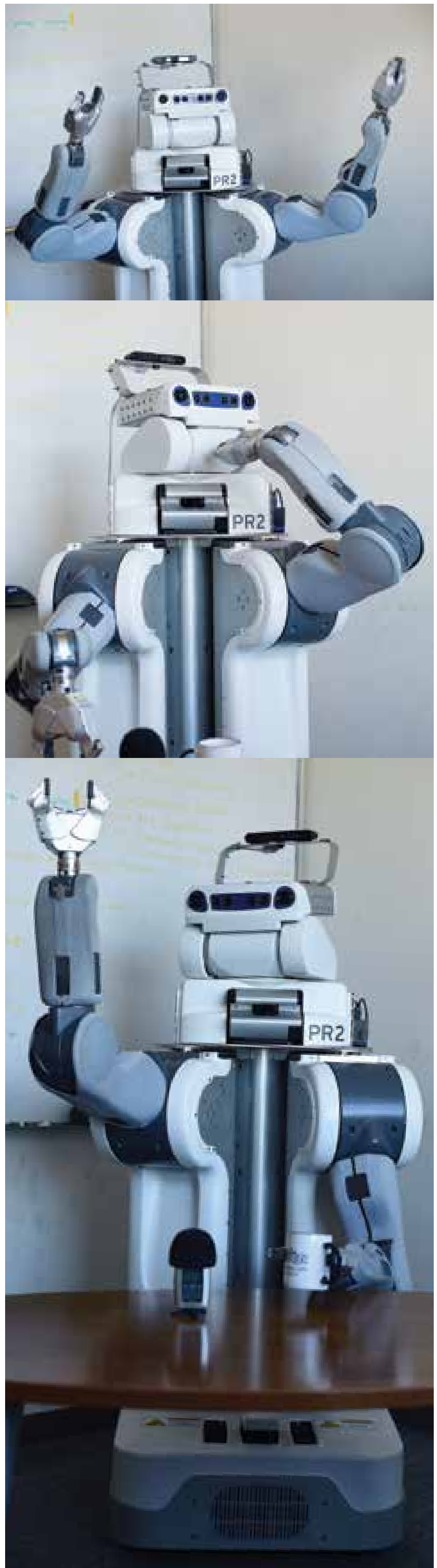
I had to adopt new ways of thinking, but so far so good. In many robots, part of their programming is devoted to figuring out what they're looking at, while separate programs control their motor system. I integrate and learn these, using my multilayer artificial neural network.

Your what?

A network inspired by the neurons in your brain, except mine aren't squishy, they're digital. My brain is in that desktop PC you're looking at over there; it communicates with my sensors and motors via Wi-Fi. The monitor shows a map of my neural activity, starting with gauging what I'm looking at, then proceeding through the various motor actions needed to complete a task. Like putting this... darn toy airplane together.

Where does the learning come in?

Each artificial neuron is connected to many others, and those connections are "weighted." Numbers, really. When I make a good move toward accomplishing the task, coordinating the right neurons, the weights of the active connections increase. They decrease when I make a wrong move. Currently my network incorporates 92,000 weighted neural connections.



That sounds like a lot.

You humans have 100 trillion neural connections. Don't brag about how fast you can fold a towel.

What's next for you?

Deep learning has already put me on par with traditional programming-heavy approaches, which need a new program written for each task. With further advances in learning, I hope to achieve a much broader ability to generalize. One of these days I want to roll into a house I've never seen before and cook, set the table, clean up after dinner, make the beds, take out the garbage — all with no special programming.

And...?

Okay, that too — fold the laundry.

FIRST PERSON

"ONE OF THE MAIN THINGS WE'VE BEEN LOOKING AT IS: HOW CAN WE GET A ROBOT TO THINK ABOUT SITUATIONS IT'S NEVER SEEN BEFORE? YOU CAN'T JUST EXECUTE BLINDLY THE SAME SET OF MOTIONS AND EXPECT SUCCESS."

— PIETER ABBEEL | EECS PROFESSOR | May 8 | *PBS News Hour,* on the future of artificial intelligence.

Noah Berger

ARCTIC CROSSING: The region around the confluence of the Silverthrone and Klinaklini glaciers in Southwest British Columbia provides a glimpse into how the terrain traveled by Native Americans in Pleistocene times may have appeared.

FORENSICS

Origin science

The first Americans traveled east from Siberia via a land bridge into modern-day Alaska and Canada no more than 23,000 years ago, at the height of the last Ice Age. After a pause of perhaps thousands of years, some groups left for South America while others stayed to roam the continent, diversifying into two branches.

These findings, revealed by a new genomic analysis of the most comprehensive genetic data set from Native Americans to date, both support and dispel some earlier ideas. While they confirm the most popular theory of the settling of the Americas, they refute the notion that an earlier wave of people came from East Asia. The new evidence also undercuts theories that multiple independent waves of migration produced the major subgroups of Native Americans we see today and that Polynesians or Europeans contributed to the gene pool of the first Americans.

Researchers used different statistical models — one created by the lab of associate professor of electrical engineering and computer sciences **Yun Song** and another by integrative biology professor Rasmus Nielsen — to analyze the sequenced genomes of multiple individuals, including Native Americans, Siberians and Oceanians.

HEALTH

GMOs on lockdown

Berkeley engineers may have found a way to keep genetically modified organisms safely under lock and key. The trick involves tweaking essential genes so that they require the addition of the molecule benzothiazole to function. Working with a strain of E. coli commonly used in research labs, bioengineering professor **J. Christopher Anderson** and researcher **Gabriel Lopez** engineered five genes essential to bacteria's survival. They mutated the genes, rendering them inactive (i.e., locked) unless the molecule benzothiazole (the key) was added.

By unlocking a single gene with a single chemical molecule, they improved the organism's viability 100 millionfold. Combining several gene locks improved viability 10 billionfold. This cheap and easy method of preventing the accidental spread of genetically modified organisms has a range of potential applications, such as in organisms engineered to treat diseases within the human body, which should be activated only when needed.

DIAGNOSTICS

Light-speed genetics

Researchers led by bioengineering professor **Luke Lee** have found a more efficient way to perform a fundamental polymerase chain reaction (PCR) genetics test. PCR tests make thousands, sometimes millions, of copies of a DNA sequence for use in diagnostic tests or research.

Traditional PCR tests have revolutionized biological science, but because the test requires repeated temperature changes to amplify the genetic sequence, they take hours and lots of energy to perform.

Lee and his team found that by heating electrons at the interface of thin films of gold and a DNA solution with LED lights, they can greatly decrease the amount of time and cost associated with running PCR tests — without losing resolution.

The team is calling the system a photonic PCR, and they are looking to integrate it with other diagnostic equipment they have developed, such as the ultrafast genomic diagnostic chip (a microfluidic lab on a chip), making the technology ready for field deployments.

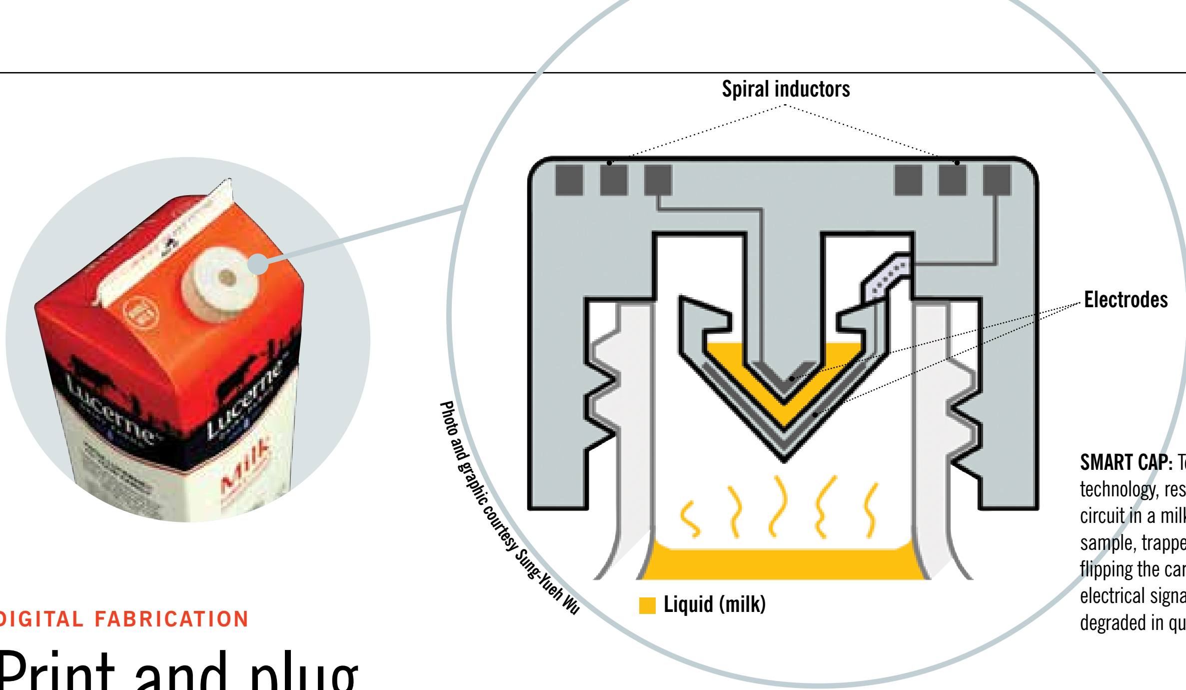


Photo and graphic courtesy Sung-Yueh Wu

SMART CAP: To test the application of this technology, researchers made a resonant circuit in a milk carton cap. A test milk sample, trapped in the cap by quickly flipping the carton over, showed changing electrical signals as the unrefrigerated milk degraded in quality over 36 hours.

DIGITAL FABRICATION

Print and plug

Makers and tinkerers may soon have a new source of electronic components: their personal 3-D printer. Mechanical engineering professor **Liwei Lin** led a team to demonstrate the potential of 3-D printers to produce not only standard components like resistors, inductors and capacitors, but also custom devices for specific applications — in this test case, a novel wireless sensor integrated into a milk-carton cap to detect spoilage.

Granted, 3-D printers can't do all the work themselves. While plastic polymers offer flexibility and precision as building blocks of miniature and one-off objects, they don't conduct electricity. The researchers solved this problem by building solid shapes of plastic and wax, removing the wax, and injecting silver into the voids left behind. The form of the metal determined the components' final function — thin wires as resistors, flat plates as capacitors, spiral coils as inductors — all on a scale small enough to hide inside a milk cap.

NUCLEAR ENGINEERING

Radioactive wrecks?

Courtesy the researchers

Jimmy Lee (B.S.'15 NE, at left) and nuclear engineering student **Chris Figueroa** tested the submersible for evidence of contamination after its descent to find the *U.S.S. Independence,* sunken off the Farallon Islands.

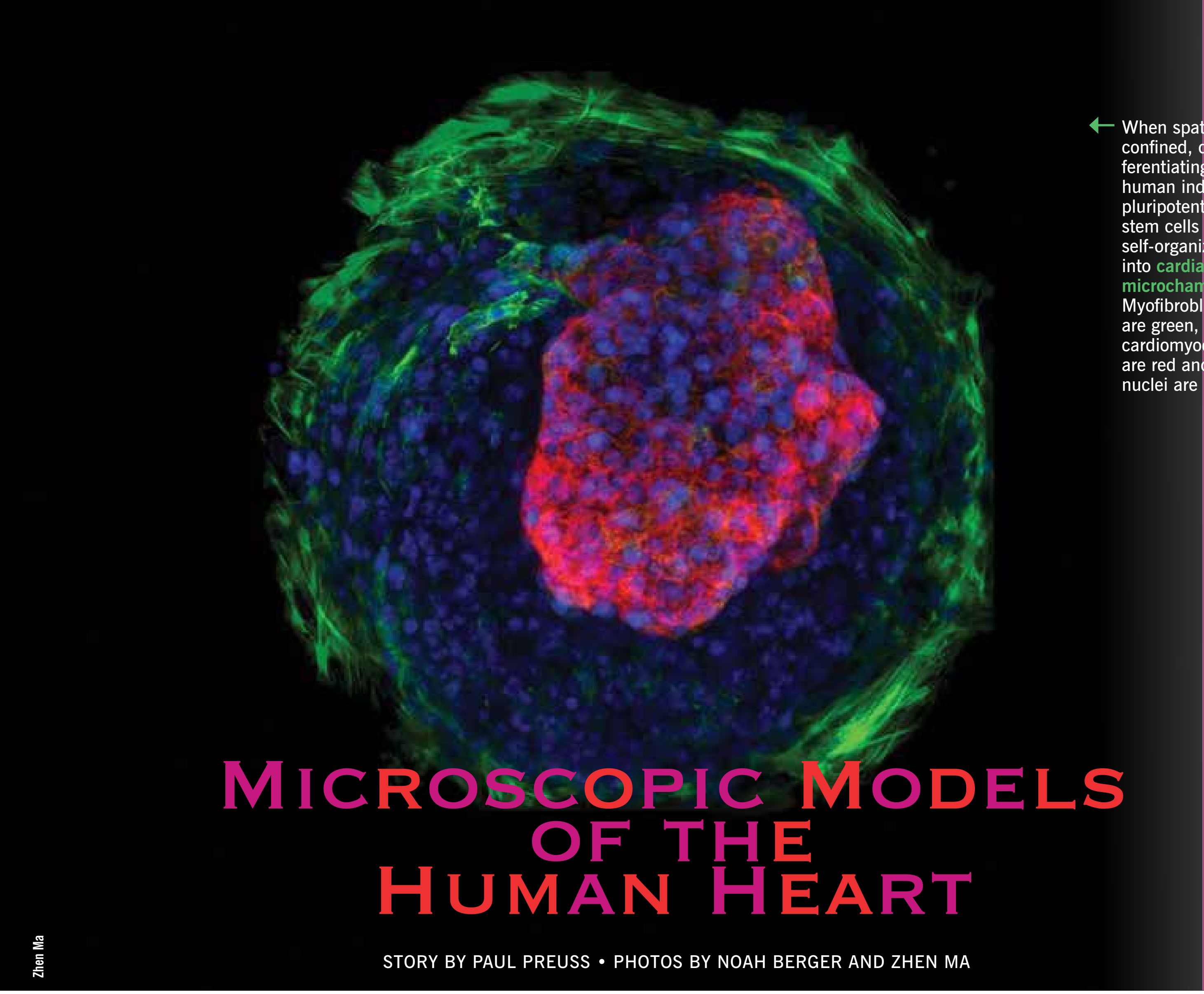
Marine archaeologists have a lot of things to think about while probing the deep for lost wrecks, but radiation exposure is normally not one of them. But exploring the *U.S.S. Independence,* which was scuttled in 1951 just south of the Farallon Islands, 40 miles off the coast of San Francisco, was a different story. The aircraft carrier has a radioactive history. First, the military used it as a target for atomic bomb tests at Bikini Atoll. Then it was loaded with 55-gallon drums of low-level radioactive waste and sent to the bottom of the Pacific, presumably for safekeeping.

Sixty-four years later, marine archaeologists with the National Oceanic and Atmospheric Administration (NOAA) located the wreckage, using an autonomous underwater vehicle to pinpoint its final resting place.

Concerned about contaminating their submersible, NOAA researchers turned to nuclear engineering professor **Kai Vetter** for help. Vetter explained that because water serves as an excellent shield, radiation extends only inches from contaminated materials. In any case, the 30-year half-lives of the isotopes in question means that only a quarter remain today.

Nonetheless, Vetter brought a team to Half Moon Bay to test the submersible. Sure enough, there was no evidence of contamination.

HOW DO I FIND OUT MORE?
Find links to source articles, news details and expanded coverage at **engineering.berkeley.edu.**



Zhen Ma

← When spatially confined, differentiating human induced pluripotent stem cells self-organize into cardiac microchambers. Myofibroblasts are green, cardiomyocytes are red and the nuclei are blue.

Microscopic Models of the Human Heart

STORY BY PAUL PREUSS • PHOTOS BY NOAH BERGER AND ZHEN MA

A decade ago, stem cell research was in turmoil. Kevin Healy, professor of bioengineering and materials science and engineering, recalls that "with embryonic stem cell research, we had to have labs that were carved out" — segregated, to track every penny of federal funding — "and we could only do certain kinds of work."

When the first stem cell lines were derived from human embryos at the University of Wisconsin, in 1998, Congress had already banned federal support for research with human embryos. In 2001, the ban was extended to embryonic stem cells. Except for research on a score of pre-existing cell lines, grants had to come from private or other sources. Researchers couldn't even use test tubes bought with federal money.

Everything changed in 2006. Researchers at Kyoto University succeeded in transforming ordinary skin cells from adult mice into pluripotent stem cells — which, like embryonic stem cells, could be coaxed to become virtually any tissue in the body, including heart, liver and nerves. In 2007 the technique was extended to human cells.

"Induced pluripotent stem cells really changed the whole equation," says Healy. "The political issues we had to deal with are all gone. It's such a relief just to do the science."

Since then, Healy's laboratory has been a source of rapid advances in the technology of human induced pluripotent stem cells, or hiPSC (often shortened to iPS). Earlier this year, Healy and his collaborators and colleagues introduced two novel structures based on human cardiomyocytes — heart muscle cells — derived from iPS cells.

One is a "heart on a chip," a thousand or so cardiomyocytes arranged on a silicon chip, beating with the regularity of a human heart. The other is a "heart on a dot," a three-dimensional chamber of throbbing cardiomyocytes, self-organized inside a microscopic circle on a flat surface. Both devices are measured in micrometers (millionths of a meter), their greatest dimensions no wider than a few human hairs.

These miniature models of the human heart open new vistas for science, and promise new drug screening methods more accurate and far more efficient than current industry standards.

A HEART ON A CHIP

"Biology didn't really get started in the materials field until the early 1990s," says Healy, who got his Ph.D. in bioengineering from the University of Pennsylvania in 1990 and spent the next 10 years on the faculty of Northwestern University. At first, like most other such programs, "the biomaterials program at Northwestern was largely abiotic — involving no cells and no real biology," he says with a laugh. "When you put an implant in the body" — the Teflon component of a vascular graft, say, or a metallic stent — "you had to wonder, how long is this going to last?" Change was well underway by the time Healy came to Berkeley in 2000. "It had become obvious to ask, 'What if you made these implants out of biological materials instead?'"

Bioengineering professor **Kevin Healy** and team have developed a template for growing beating cardiac tissue from stem cells, creating a system that could serve as a model for early heart development and as a drug-screening **tool.**

Noah Berger

The advent of nanostructured materials and, later, adult stem cells encouraged Healy to envision different miniature organs, housed on chips reminiscent of integrated circuits. "Instead of conducting electricity, there would be spaces where cells can sit and nutrient fluids would bathe the cells in a controlled manner," he says.

Intrigued by this vision and its potential applications, Anurag Mathur joined Healy's lab as a postdoc in 2012. Mathur's parents, doctors in India, inspired him "to contribute to medicine and biology — in my case, through bioengineering."

The smallest unit of the heart consists of layers of cardiomyocytes confined between supporting collagen fibers. Mathur and postdoc Peter Loskill worked with Healy and bioengineering professor Luke Lee to model this structure on a chip. They reproduced naturally aligned, layered heart cells in a silicone confining chamber, 150 micrometers wide and less than a millimeter long.

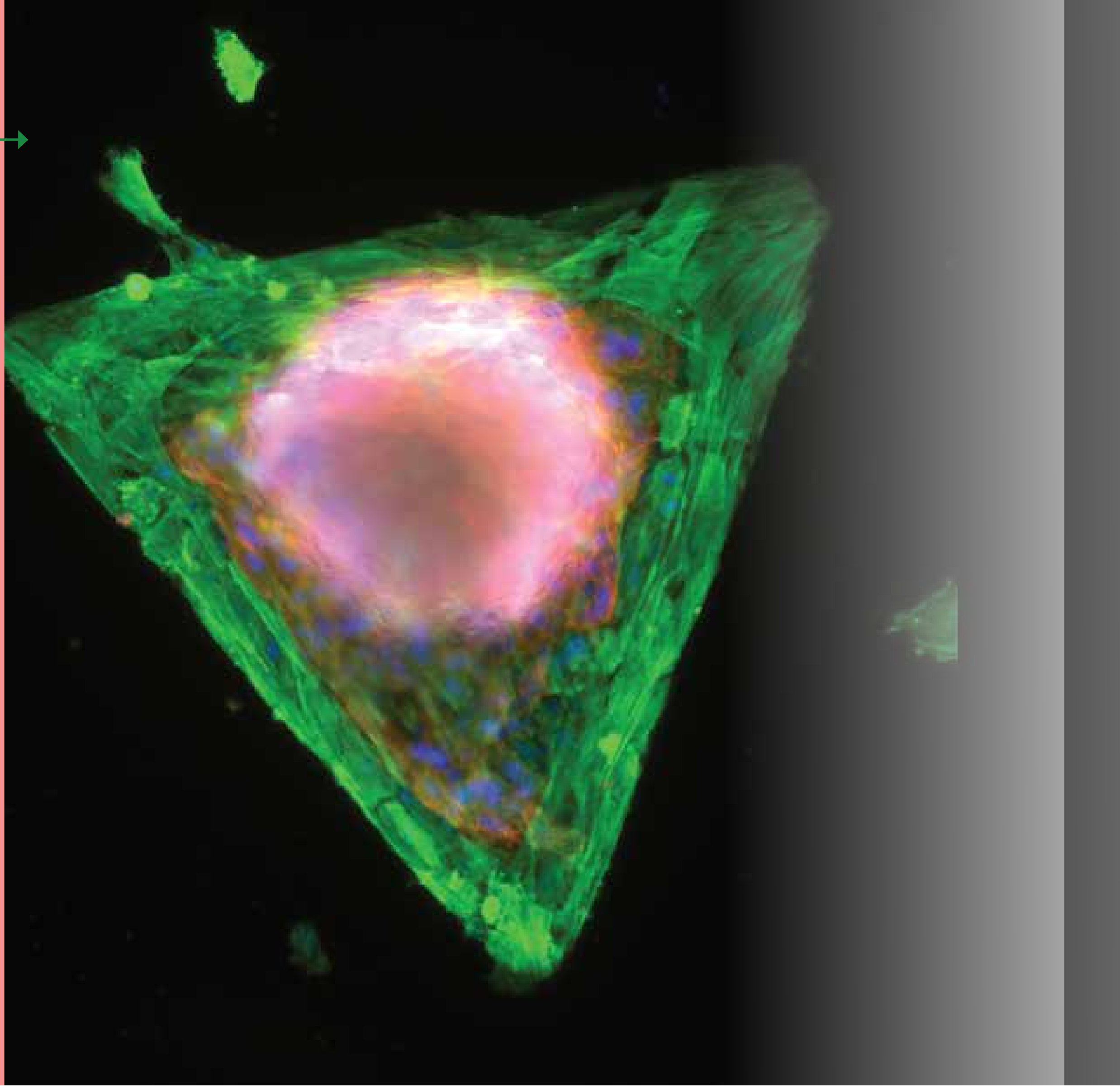
Mathur fabricated the chamber's support system the way integrated circuits are printed on silicon, in etched layers. Large channels imitate blood vessels, supplying nutrients to the cells. Channels only two micrometers in diameter perforate the confining chamber's walls, allowing the nutrients to bathe the cells gently, much as blood diffuses through a protective layer of epithelial cells.

Human iPS cells were supplied by Healy's collaborator Bruce Conklin, of the Gladstone Institutes and UC San Francisco. In the Healy lab, the stem cells assumed their cardiomyocyte identity through a process called differentiation, the carefully timed application of chemicals that activate specific genes.

Two weeks after differentiation began, the cells were loaded into the confining chamber. Within 24 hours they began beating, 55 to 80 beats per minute. Within a week, they formed into multiple layers, aligned themselves and beat in unison.

The researchers tested four kinds of well-studied cardiovascular drugs on their tiny model, comparing the rates of its beating cells to the drugs' known effects on the human heart rate. Some results were far more accurate than those from animal tests or other methods. For example, based on mouse studies, Verapamil, a treatment for high blood pressure, would be considered too dangerous for humans. But a human heart averages 60 beats a minute. A mouse heart beats 600 times a minute, producing test results that cannot reliably be extrapolated to humans. The heart on a chip reaffirmed clinical observations showing Verapamil to be safe.

To develop and launch a new drug takes 10 to 15 years, at an average cost of $5 billion; heart or liver toxicity often shows up late in the process. Says Healy, "Reducing the number of animal experiments and better predicting the effects of drugs under development could significantly drive down the average cost per drug" — and shorten the time to market by years — "because you haven't wasted



Zhen Ma

The most common **birth defects** involve the heart. Hundreds of thousands of pregnant women each year are exposed to drugs that could threaten the fetus, but current tests can't cover the early stages of heart tissue formation.

all that money on drugs that fail after you've taken them so far down the pipeline and into clinical trials."

A HEART ON A DOT

Meanwhile, the Healy lab was pursuing a parallel approach to how materials influence cell behavior, which led to a different, surprising model of the human heart.

"My strength was in polymer engineering," says Felicia Svedlund, who joined the Healy lab as a graduate student in 2010. "Kevin asked me to work on patterning a polymer surface to study the effects on human stem cell behavior."

With undergraduate Jason Wang, Svedlund layered a thin film of polyethylene glycol (PEG) onto tissue-culture polystyrene plates. Then they etched away circles of the PEG, 200 to 600 micrometers in diameter. Inside the circles, stem cell colonies that could not grow on PEG could grow on the culture-friendly plates. Gladstone's Bruce Conklin was a collaborator and provided the iPS cells.

Svedlund and Wang established that colonies would form and maintain themselves in the patterned surface she'd devised. When Svedlund turned to other research for her Ph.D., a new postdoc in the Healy lab, Zhen Ma, took over research on the colonies.

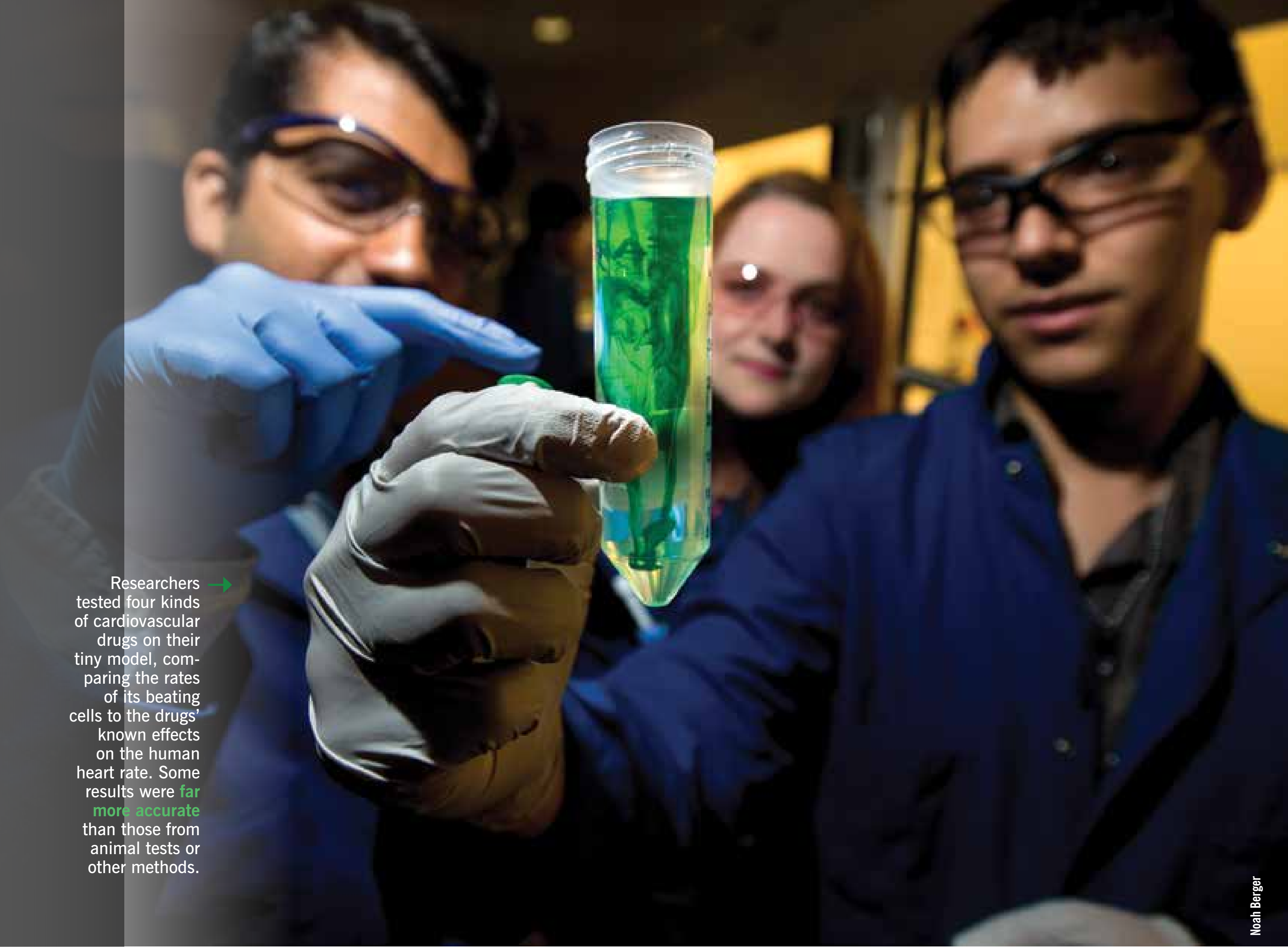
Ma began his education in China as an electrical engineer. He used lasers as nanoscale medical instruments in his doctoral work at Clemson University, until a project involving stem cells and cardiomyocytes changed his focus. He says, "I found I was moving to the biology side."

Says Healy, "In the chip model, it takes up to two weeks for the stem cells to differentiate into cardiomyocytes before we can put them in the chip." In the case of the dots, "we can put the stem cells right on the patterned surface. We expose them to the same chemistry, only now they're differentiating inside the dot."

The original plan was to follow the stem cells to the point where they lost their pluripotency and committed themselves to a specific tissue type. Instead, says Ma, "We saw cells spatially organizing themselves into two different types in one colony." Confined geometry, plus chemicals in the differentiation protocol, sent cells in the center of the colony moving toward the edge, where they formed a dense ring resembling the epithelium that lines and protects many organs.

To find out what would happen next, Ma and Wang extended the protocol. After two weeks, the uncommitted cells in the center of the dots began differentiating into cardiomyocytes, then kept going, forming 3-D structures with hollow interiors. They started beating — "pumping" like the chamber of a heart, absent the blood. "None of us, including Kevin, saw this project going so far," says Ma.

Consider a microscopic collection of cells that first organizes a supporting ring and then builds a chamber of beating heart muscle within it, echoing the



Researchers tested four kinds of cardiovascular drugs on their tiny model, comparing the rates of its beating cells to the drugs' known effects on the human heart rate. Some results were far more accurate than those from animal tests or other methods.

Noah Berger

emergence of the developing heart itself. This remarkable discovery had obvious potential for developmental biology.

However, Ma says, "We are engineers. Engineers think about how this work can be used for the real world. Why not use it to screen the drugs which have toxicity during fetal development?"

The most common birth defects involve the heart. Hundreds of thousands of pregnant women each year are exposed to drugs that could threaten the fetus, but current tests can't cover the early stages of heart tissue formation.

The researchers exposed their miniature hearts to a drug infamous for birth defects, including heart defects: thalidomide. A small amount damaged the microchambers, weakened the contractions, and retarded the beat rates.

Of the heart on a dot, Healy concludes, "This system can be highly predictive of drugs we know have significant toxicity on early heart-chamber development."

INTO THE FUTURE

The miniature hearts offer two approaches to disease modeling, one of the notable promises of stem cell technology. "We are now developing a chip that will link cardio, liver and fat as a triad," says Healy, with the goal of modeling the interactions of these vital organs. Drugs are metabolized in the liver; fat supplies energy and has important roles in metabolism.

"Almost half the drugs are taken off the market because they are toxic to the heart or liver," says Anurag Mathur. Interactions between the two organs are synergistic, "so integrating the two chips will be a significant problem. There's a difference in scale we somehow have to replicate. And we have to find a common nutrient — artificial blood, if you will."

The miniature heart on a dot presents other challenges. "Because of our present differentiation protocol, we reach the point where these microchambers naturally stop developing," Healy says. "We're approaching the problem from a pharmacological point of view, using different chemicals, learning the details of the genes that are expressed."

Maintaining progress in iPS technology requires advances in many areas, and Healy refuses to oversell current results. "We don't want people thinking, hey, we've solved everything," he cautions. His lab is hard at work on answers to pressing questions, including stem cell maturity and longevity.

Imagine the regeneration of organs as disparate as heart, spinal cord, even brain — to address Parkinson's disease or ALS. Imagine growing organs from scratch and transplanting them with no fear of rejection by the immune system. Imagine drug treatments — say, for breast cancer — targeting an individual's or even a tumor's specific genetics. The coming months and years will see advances in a technology whose future seems almost limitless. BE

Watch video on beating heart cells at **engineering.berkeley.edu/magazine.**


1
2
3
4

Heavy lifting

OUTFITTING THE GLASER LAB

At the northeast corner of campus, a stone's throw from a century-old mine shaft meandering toward the Hayward Fault, lies another cavernous wonder: The Glaser Lab. Over the past two decades, civil and environmental engineering professor **Steven Glaser** has modified the space within the venerable Hearst Memorial Mining Building with an eclectic array of equipment to run research projects ranging from seismic safety and geothermal energy monitoring to designing intelligent sensor grids to measure Sierra snowpack.

TEXT BY THOMAS WALDEN LEVY • PHOTO BY PRESTON DAVIS

1. CO_2 stored in the **RED TANKS** is heated and highly pressurized to "super-critical" levels to simulate a geothermal zone when injected into the silver-wrapped vessel to the left containing hot sand. "It's thought that if instead of water you use super-critical CO_2 — a very strange state of matter that's halfway fluid, halfway gas — there's a big improvement in efficiency," says Glaser.

2. With a two-foot-long section of **BATTLESHIP CANNON** repurposed into a "true triaxial testing" device, Glaser simulates underground geothermal conditions by squeezing an 11-inch cube of rock differentially in all three directions, at up to 200 psi, while heating it with steam up to 180 degrees Celsius or 356 degrees Fahrenheit. The device is set to simulate conditions at The Geysers geothermal power plant 72 miles north of San Francisco, a facility that produces about 60 percent of Northern California's electricity.

3. Glaser is a coffee aficionado, specifically espresso, which he makes by grinding beans he's roasted in this **GENE CAFÉ ROASTER.** Sweet Maria's in Oakland sells him Espresso Monkey blend beans by the 50-pound bag. The coffee scent was too much for one student, so they MacGyvered the silvery aluminum tube that snakes up to a vent.

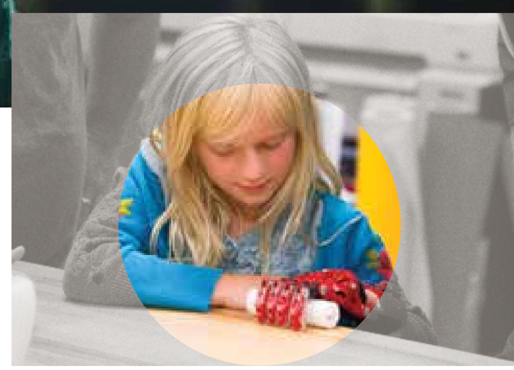
4. This **SIERRA SENSOR,** like one of 150 Glaser that installed in the upper reaches of the American River basin to monitor snow conditions, is part of a wireless sensor network. The three-year-old National Science Foundation-funded project is, as Glaser puts it, "the largest ecological wireless network in the world." The network monitors snow melt and water balance in the Sierra Nevada with sensors that measure snow depth, temperature, humidity, solar radiation effects and water content in the soil every 15 minutes at several levels — crucial information, Glaser points out, because Sierra snow melt constitutes 65 percent of California's water supply.

5. The **ABELL-HOWE CRANE**, one of two in Glaser's lab, can lift up to two tons — a must with many large experiments underway.

6. Glaser rescued the vintage **CLAUSING LATHE,** manufactured in Kalamazoo, Michigan, in 1962, from the psychology department, which was throwing it away.

Sop

Noah Berger



STORY BY DANIEL MCGLYNN • PHOTOS BY NOAH BERGER AND ADRIEL OLMOS

hie's super hand

Sophie is eight years old. Her favorite animal is the cheetah. Her career aspirations, in no particular order, include: singer, preschool teacher, mother, President of the United States, veterinarian, environmentalist, and photographer or videographer. Sophie also has an arch nemesis: the monkey bars.

It's not a strength issue — Sophie is strong like a gymnast (she's prone to bust out some moves when the opportunity presents itself) — it's just that she can't grip the bars enough to keep her momentum going. Her mom, Alexa Koenig, remembers Sophie coming home from school one day last spring, her left wrist covered in bruises. When Koenig asked Sophie what she had been doing, she answered flatly: "I was trying to get all the way across on the monkey bars."

Sophie can't grip the monkey bars because she was born with a hand difference called symbrachydactyly. The four finger bones on Sophie's left hand never developed. Instead, she has a thumb and four partial fingers that hand specialists call "nubbins." The condition is caused by poor blood circulation in utero, during the window when a fetus's hand structure is developing, around six weeks. There is no way for a mother to know this is happening or to prevent it. It is estimated that, every year, 30,000 to 40,000 babies are born with some form of symbrachydactyly, which can range from minor finger anomalies to hands completely missing from the forearm down.

Sophie is adaptable and not prone to letting things slow her down, but every once in a while, learning a new skill — like riding a bike, for instance, or gripping the monkey bars — presents a new level of challenge. But with the help of a designer and an engineer working out of the CITRIS Invention Lab, where they are experimenting with 3-D printing to build low-cost, customizable prosthetics, some of Sophie's everyday challenges might just get a little bit easier.

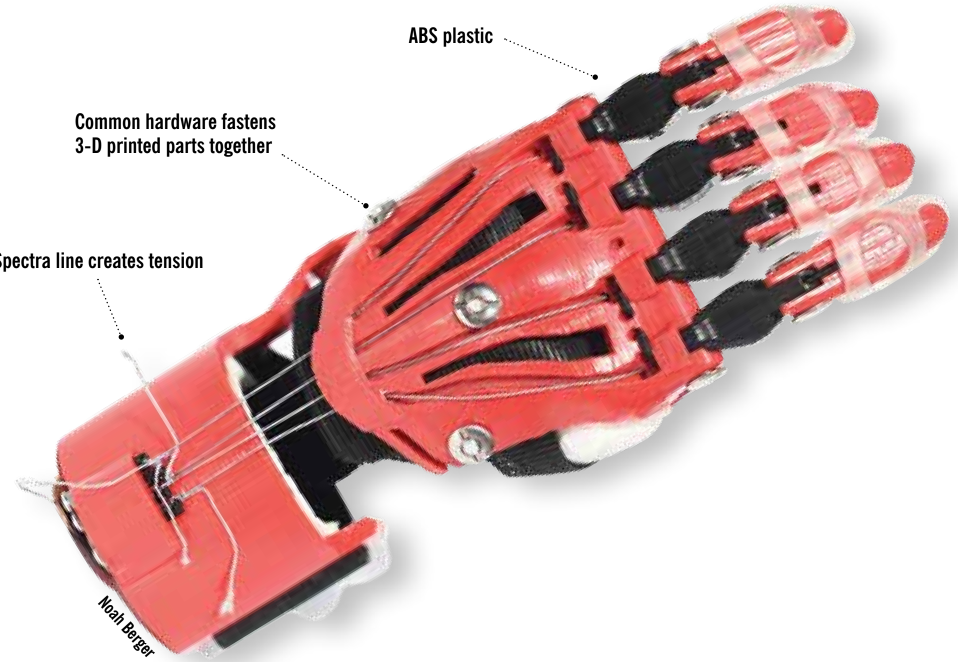
Sophie's journey to the Invention Lab started last February after the *New York Times* ran a piece on the front page of the science section called "Hand of a Superhero: 3-D Printing Prosthetic Hands that are Anything but Ordinary." The story described how **open-source design and 3-D printing are revolutionizing the prosthetic industry.** Emerging digital manufacturing, the article explained, could allow makers to build low-cost and customizable prosthetics, on demand, for the users who need them.

The story mentioned several boys with hand differences similar to Sophie's. Koenig saw the story and left a copy of it out on the family's kitchen table. She wanted to see if Sophie had any interest in prosthetics but not force the issue. Sophie saw the story and gravitated toward the photos of the kids playing — one of the boys is an aspiring goalkeeper for his soccer team — and she also liked the superhero spin. "In the *New York Times* story, the kids had super hands," Koenig says. "They weren't framed as a prosthetic, but as a super part." The 3-D printed hands in the story were part of an open-source project called Cyborg Beast, which was created at Creighton University in Omaha, Nebraska and is supported by NASA and others.

Koenig is the executive director of the Human Rights Center (HRC) on the Berkeley campus. Soon after she saw the *Times* story, she was visiting the CITRIS Invention Lab with some colleagues, getting background for a new HRC initiative that incorporates technologies into war crime investigations and prosecutions. During the tour, Koenig noticed a bank of 3-D printers along one of the lab's walls. With Cyborg Beast in mind, she asked CITRIS deputy director Camille Crittenden if she knew of any faculty or students working on prosthetics.

Soon, Invention Lab manager Chris Myers got an email from Crittenden making introductions. Myers, in turn, sent a message out to active users of the Invention Lab asking who was interested in working with Sophie.

Adriel Olmos



Daniel Lim responded. Not only was he interested, but he also wanted to get working immediately. He had just completed his master's in engineering (M.Eng.) at the college's Fung Institute for Engineering Leadership. Before that, he had studied mechanical engineering in his native South Korea. In 2013, Lim came to the United States on a brief student-exchange program. That's when he learned about Berkeley. "I got to thinking that maybe the Bay Area is best for me. When I returned home, I made the Campanile my screen saver." When it came time to apply to graduate school, the decision was easy. "It was like a dream coming true," he says.

Lim's student-exchange trip also exposed him to 3-D printing. While in the United States, one of his friends bought a 3-D printer on Kickstarter, the crowdfunding site. He was blown away by both crowdfunding and 3-D printing. When he got back to South Korea, he says, he wanted to continue working with 3-D printing, but couldn't find a suitable machine, so he wound up building one. "It was horrible," in comparison to some of today's off-the-shelf printers, he says, "but at least you could make out the shape of what I was printing."

After completing the M.Eng. program, Lim decided to stay in the United States. When he got the email from Myers, he thought that the project sounded like the perfect use of his skill set. "I studied engineering for the past five years, and I thought this is the first project where I can directly improve someone's life," Lim says. "When I saw Sophie's picture, I wanted to do this."

Lim and Myers met with Sophie and Alexa, as well as Sophie's 10-year-old brother, Zander, and father, Don, at the beginning of June in the Invention Lab. During the first meeting, they took measurements of Sophie's hand and talked about modifying the Cyborg Beast files for the best fit. The parts are printed from ABS plastic (the same material as Legos) and put together with some straightforward hardware, meaning each prototype costs less than $10 to make. Lim and Myers modified the thumb on the design files because the stock prosthetic template has a thumb, which Sophie does not need.

In the months since the *New York Times* piece appeared, there have been other high-profile articles in the media challenging the notion that a democratized open-source prosthetic movement is a good idea. Prosthetics are a specialized tool, designed, built and fitted by experts. Building them in garages, basements and makers spaces, critics argue, could endanger the safety of end users.

Proponents of the open-source prosthetic movement say that some technologies developed in the 15th and 16th century — such as the opposing-hook prosthetic hand that is attached and operated using a series of tensioning straps — are still used in contemporary prosthetic design. "Existing prosthetics are very archaic," Lim says.

Myers is somewhere in the middle. He thinks that existing prosthetics need an update and that they cost too much — estimates vary, but customized prosthetics can range from $5,000 to $40,000. But he is also quick to manage expectations about the strength, durability and limited functionality of a prosthetic downloaded from the Internet and printed on a 3-D printer. At one point, when Sophie was trying the first prototype that he and Lim built, Myers said, "This might break in a day."

Nevertheless, during the second meeting, and after some adjustments, Sophie tries her new super hand, which was printed in red and black ABS (like Iron Man, Lim says). After a few attempts, she is able to clench the fingers closed. They open and close depending on the amount of tension Sophie puts on them when she curls or releases her wrist. The wrist curl contracts thin Spectra line, a type of thread that is stronger than carbon fiber and favored by offshore fishermen for its durability and lack of stretch.

Myers adjusts the tiny cables so that the fingers work in unison. The fingers all pivot on a single bolt that threads through their base, like a straight-lined knuckle; he repositions the device so that it aligns better with the wrist.

Sophie puts it back on and is tentatively flexing and relaxing it. She picks up a plastic tube, the width of a fat magic marker, with her super hand and passes it to her dad, he passes it back to her, and she is able to grab it. It's impressive, and everyone breathes a sigh of relief — the hand actually works.

Zander speaks up first. "I see a flaw in this plan," he says. "You won't be able to use chopsticks."

"And," he goes on. "The strings are too long. Sophie, can you poke dad?"

"Zander, do you see anything positive about this?" Lim asks him jokingly.

"Yeah," Zander says, looking at Sophie, "now you have another hand."

Two weeks later Sophie and her family are back in the Invention Lab. Myers and Lim are eager to hear how the modified super hand held up. Sophie took it with her to Winning Hands camp, which is put on by Shriners Hospitals for kids with hand differences. Koenig asks Sophie if she tried the monkey bars at camp. Myers cringes.

"Yeah," Sophie says, "I slipped off."

But, Koenig says, "Sophie did manage a few cartwheels when we were leaving last time."

Myers prepares to cast Sophie's hand in resin so that he and Lim can continue modifying future versions of her prosthetic without her having to come to the lab each time. Lim found some old *Tom and Jerry* cartoons on YouTube for Sophie to watch while the resin cures. Myers asks Sophie questions about how she is using the hand.

"If she gets to help design it, then it's hers and she'll have a sense of ownership, and it won't just be a fancy version of a store-bought version that we made in the lab," Myers says. 'I'm a big proponent of getting kids involved with technology at a young age, so they can know more about how their world works."

Myers and Lim both consider this an ongoing project. "Right now it's a simple mechanism for gripping something," Lim says, and then, starting to brainstorm out loud, "In the next version, I want to put sensors in it and try to make it more intuitive. One of the first things we can do is make it more aesthetically pleasing and improve the user experience."

Lim spent some of his time over the summer reading journal articles about prosthetics. He's thinking about building his Ph.D. research around low-cost prosthetic design. He also thinks a lot about how to make Sophie's hand better.

"In the end," he says, "we want Sophie to be able to do the monkey bars." BE

1 Sophie shows her family how the super hand works.

2 Daniel Lim with Sophie.

3 Sophie watches Chris Myers prepare a mold for her hand.

4 Myers checks the fit.

5 The hand can be adjusted and fine-tuned.

6 Sophie in her element.

Watch video of Sophie using the superhand at **engineering.berkeley.edu/magazine.**

Adriel Olmos

1

Adriel Olmos

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Adriel Olmos

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Noah Berger

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Adriel Olmos

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Adriel Olmos

5

CellScope Loa

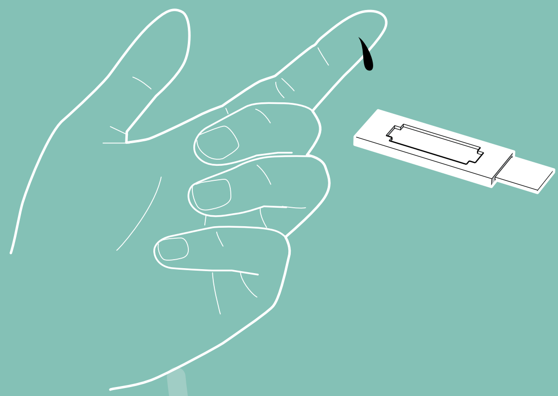
FOUR STEPS TOWARD SAFE TREATMENT FOR RIVER BLINDNESS

Eight years ago, when mobile phones with megapixel cameras were becoming popular, bioengineering professor **Dan Fletcher** borrowed his sister's Nokia and challenged his undergraduate class in optics and microscopy to photograph the microscopic world. The goal was to make the phone's camera comparable to an expensive laboratory microscope. "The constraint was they couldn't alter the phone's optics. It had to be a clip-on," Fletcher says. The students stuck with the project until they'd turned the cellphone into a *cell* phone, producing sharp images of bacteria, malaria parasites and red blood cells that could be transmitted by email or analyzed directly on the phone.

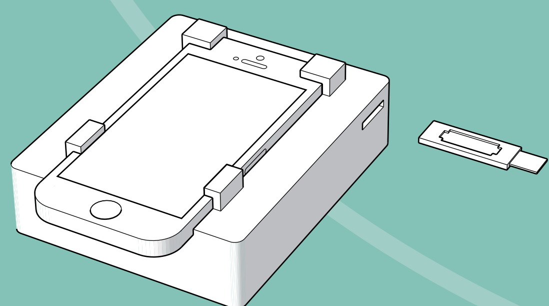
In the years since, the CellScope has enabled studies of everything from retinal disease in Thailand to water quality in southern California. Instead of rushing to the emergency room when kids have earaches, parents can use the clip-on otoscope from CellScope, Inc., a startup founded by students from Fletcher's lab, to send a smartphone video to the pediatrician.

This fall, the CellScope team at UC Berkeley is rolling out a new device. CellScope Loa enables safe treatment of river blindness (onchocerciasis) by detecting parasitic *Loa loa* worms in the blood. Patients with *Loa loa* infections cannot safely take the drug ivermectin (IVM), standard treatment for river blindness. Initial deployment of the device will target 30,000 people in Cameroon this fall.

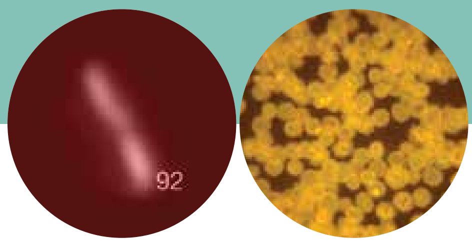
TEXT BY PAUL PREUSS, ILLUSTRATIONS BY JASON LEE, PHOTOS COURTESY FLETCHER LAB



1 Prick finger for a blood sample.



Load capillary containing blood into the device. **2**



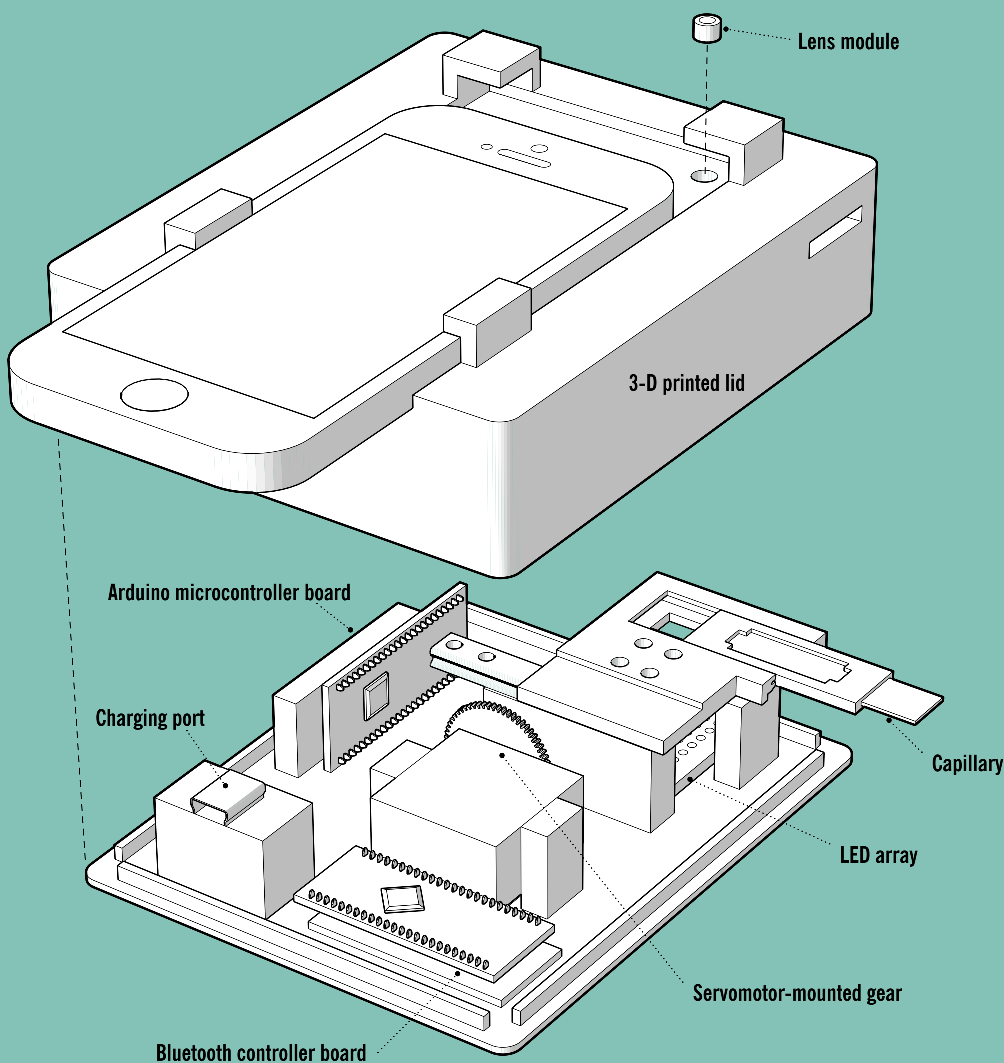
CELLSCOPE APPLICATIONS

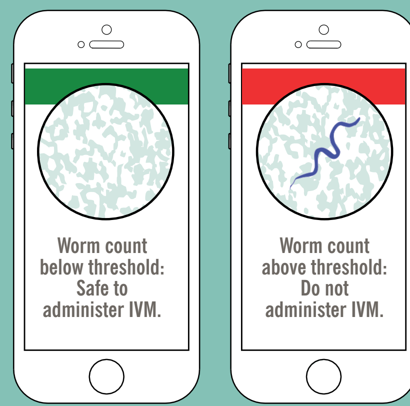
TUBERCULOSIS AND MALARIA

In 2009, the CellScope was shown to detect malaria in blood samples and tuberculosis in sputum samples.

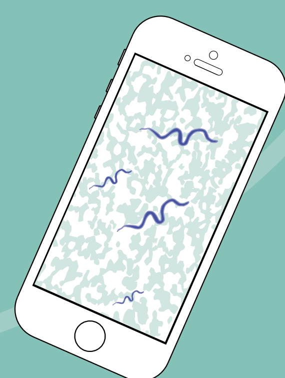
EAR INFECTIONS

The first commercialized use of CellScope technology was the otoscope, introduced in 2011 to detect ear infections in children.

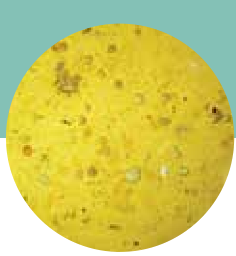




4 Follow instructions on screen.



Automatically capture and analyze videos for movement of worms. **3**



NEGLECTED TROPICAL DISEASES

In Ivory Coast, the CellScope has been deployed to detect soil-transmitted parasitic worm (helminth) infections from stool samples.

WATER QUALITY

The Southern California Coastal Water Research Project used the CellScope to detect pollution by monitoring natural flora and fauna in water sources.

OCULAR DISEASES

Two new CellScope devices for the eye are used to detect cytomegalovirus retinitis infections, diabetic retinopathy, corneal lesions and trachoma.

2010+

John C. Duchi (Ph.D.'14 CS) won a 2014 Association for Computing Machinery Doctoral Dissertation honorable mention for his work "Multiple Optimality Guarantees in Statistical Learning." He is now an assistant professor of statistics and electrical engineering at Stanford University. His research interests include computation, statistics, optimization and machine learning. He also spends time working at Google Research.

Wenchao Li (Ph.D.'13 EECS) received the 2015 SIGDA Outstanding Dissertation Award, presented every year in recognition of a dissertation that makes the most substantial contribution to the theory and/or application in the field of electronic design.

Sophi Martin (B.S.'05 Eng.Physics, Ph.D.'10 MSE) serves as the associate director of institutional relations at the Development Impact Lab (DIL), where she builds and maintains relationships with companies, practitioners and organizations looking to partner with the DIL consortium. Previously, she worked for the College of Engineering at the University of Illinois at Urbana Champaign in corporate relations and research administration.

Gregory McLaskey (Ph.D.'11 CEE) received the 2014 American Geophysical Union's Keiiti Aki Young Scientist Award. Each year, the award is given to just one young scientist in the field of seismology in recognition of their accomplishments within three years of receiving a Ph.D.

Jack Reilly (Ph.D.'14 CEE) received the Milton Pikarsky Memorial Award in Science and Technology from the Council of University Transportation Centers for his dissertation, which focused on new methods for decentralized freeway traffic control to help create connected corridors and increased traffic flow. "Knowing that your research has real-world impact gives much more weight and longevity to your work," he says. He now works at Google in the maps data group.

Matei Zaharia (Ph.D.'13 EECS) won the 2014 Association for Computing Machinery Doctoral Dissertation Award for his thesis, "An Architecture for Fast and General Data Processing on Large Clusters." He is now an

Toy tinkerer makes good

Walk into **Jack McCauley**'s (B.S.'86 EECS) office, and you'll see some of the rewards that come from being an engineering wizard: a 1969 certificate from Tinker Toys, proclaiming the nine-year-old McCauley a master "Toy Tinkerer" and promising a $1,000 scholarship; some of the dozen or more patents he's earned; and then there are six colorful electric guitars, signed by Metallica's Kirk Hammett and Flea of the Red Hot Chili Peppers, among others.

McCauley is currently president of R0R3 Devices, a product design and development firm. But he's perhaps best known for inventing the first scrolling feature of the computer mouse and for engineering the Guitar Hero video game series. He was also chief developer of several virtual reality technologies for gaming, including the Oculus Rift VR headgear, and was one of the originators of the Universal Serial Bus (USB) port standard for computer peripherals. He also pioneered the use of microelectromechanical systems (MEMS) technology in the gaming industry.

In 2014, McCauley gave the inaugural lecture of the Berkeley Innovators lecture series, which led to his involvement with SkyDeck/Berkeley, the university-affiliated business accelerator. The reconnection also inspired him and his wife, Eileen Larkin McCauley (B.A.'82 English), to make a $2.5-million gift to establish the McCauley Family Fund in Design Innovation.

For all his successes, McCauley simply considers himself a creative person, driven by curiosity and problem-solving. His advice to future engineers? "In order to be in the band, you have to play an instrument," he says. "That's why I went to Cal — I wanted to learn those skills. Just learn your instrument."

STORY BY KIRSTEN MICKELWAIT • PHOTO BY ANNIE AVERITT

assistant professor at MIT's Computer Science and Artificial Intelligence Laboratory. He is also co-founder and chief technology officer of Databricks, the big data company commercializing Apache Spark.

2000+

Dan Garcia (M.S.'95, Ph.D.'00 CS), computer science professor at Berkeley Engineering, recently consulted on a documentary film addressing the digital divide of gender and ethnicity in the tech industry. *CODE: Debugging the Gender Gap* reveals the scarcity of women and minority software engineers and examines the reasons for this gap. The film premiered in April at the Tribeca Film Festival.

Arjun Gupta (B.S.'08 CEE) received a 2015 Climate Fellowship from Echoing Green. The fellowship, given to next-generation social entrepreneurs committed to working on innovations in mitigation and adaptation to climate change, will support his efforts to eliminate wasted fossil fuels in India by offering affordable clean energy to large buildings and factories.

Daniel Kim (B.S.'03 ME) joined the Los Angeles office of the engineering firm Arup in 2008 as a mechanical engineer. He now has 12 years of experience in the field, with an emphasis in sustainable, low-energy and LEED-certified projects.

Lane Martin (M.S.'06, Ph.D.'08 MSE) has received the 2015 American Associate for Crystal Growth Young Author Award, which is presented to those under 35 years of age who have shown outstanding achievement in the field of crystal growth and epitaxy. He was selected for this award based on his research on heteroepitaxial crystal growth of complex oxide thin films. Last April, he also received the prestigious Presidential Early Career Award for Scientists and Engineers. He joined Berkeley's materials science and engineering faculty as an associate professor in 2014.

Andrew Minor (M.S.'99, Ph.D.'02 MSE), professor of materials science and engineering, has been appointed facility director of the National Center for Electron Microscopy (NCEM) at the Lawrence Berkeley National Laboratory. A leading researcher in nanoscale mechanical behavior of materials, Minor pioneered an analytical and imaging approach combining nanoindentation-based in situ testing with transmission electron microscopy (TEM). He has recently applied TEM to a broader range of materials.

Scott Moura (B.S.'06 ME), assistant professor of civil and environmental engineering at Berkeley, was honored with a Hellman Fellows Award to support the battery-side of his research laboratory, Energy, Controls & Applications Lab (eCAL). Moura teaches in the department's Systems and Energy, Civil Infrastructure and Climate programs.

Sylvia Ratnasamy (Ph.D.'02 CS) is an assistant professor of computer science at Berkeley, where she focuses primarily on the design and implementation of networked systems. She was given the 2014 Association for Computing Machinery Grace Murray Hopper Award for her contributions to the first efficient design for distributed hash tables, a critical element in large-scale distributed and peer-to-peer computing systems. Her innovative design and implementation of networked systems enables a data object in a network to be located quickly without requiring a central registry. Her recent research introduces RouteBricks, an approach that makes networks easier to build, program and evolve, and is used as a way to exploit parallelism to scale software routers.

Athulan Vijayaraghavan (M.S.'05, Ph.D.'09 ME) is the chief technology officer and co-founder of System Insights, as well as a lecturer in Berkeley's mechanical engineering department. While at Berkeley, he was an early developer of the MTConnect standard, and built and deployed the first suite of MTConnect-enabled applications in research and industrial environments. He is currently a member of the Technical Advisor Group of the MTConnect Institute and is an active participant in the development of the standard.

Junqiao Wu (Ph.D.'02 AS&T), associate professor of materials science and engineering at Berkeley, was honored at the White House last April. He received the Presidential Early Career Award for Scientists and Engineers, the highest honor bestowed by the U.S. government on science and engineering professionals in the early stages of their independent research careers.

For her pioneering work in the field of engineering and medicine, **Rikky Muller** (Ph.D.'13 EECS) co-founder of Cortera Neurotechnologies, has been recognized as an honoree on MIT Technology Review's 2015 list of "35 Innovators Under 35." Muller and her colleagues — including co-founders **Peter Ledochowitsch** (Ph.D.'13 BioE) and EECS professors **Jan Rabaey** and **Michel Maharbiz** — are focused on developing innovative medical devices to study and treat neurological disorders. Under Muller's leadership as chief technology officer, Cortera is a key contributor to a DARPA program (as part of President Obama's BRAIN initiative) aimed at developing neurotechnology as a therapy to treat neuropsychiatric disorders, such as major depressive disorder and post-traumatic stress disorder. Additionally, Cortera has developed a catalog of unique and commercially available products for neuroscientific research and discovery.

PHOTO COURTESY RIKKY MULLER

1990+

Jonathan Bray (Ph.D.'90 CE), Berkeley's Faculty Chair in Earthquake Engineering Excellence, was elected to the National Academy of Engineering in 2015 for his contributions to earthquake engineering and advances in mitigation of surface faulting, liquefaction and seismic slope failure. He joined the Berkeley Engineering faculty in 1993.

Gerbrand Ceder (Ph.D.'91 MSE) joined the college's materials science and engineering faculty in July. His research interests lie in the computationally-driven design of novel materials for energy generation and storage. He has worked for 18 years in the battery field, optimizing several new electrodes materials, and has regularly served as scientific advisor to companies and investors in this area. He has published over 300 scientific papers and holds several U.S. patents.

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.

Tejal Desai (Ph.D.'98 BioE), professor and chair of the Department of Bioengineering and Therapeutic Sciences at UCSF, was awarded the 2015 Brown Engineering Alumni Award Medal in recognition of her career achievements. She is an expert in therapeutic microscale and nanoscale technologies and uses semiconductor manufacturing tools from Silicon Valley to make drug delivery devices capable of pinpoint accuracy. Results from her lab include the use of silicon nanowire coated silica beads as adhesive drug-delivery vehicles, especially to the human gut; the micro/nanoscale cage or biocapsule for controlled drug delivery; and nanostructured thin-film devices for controlled ocular drug delivery.

Raymond Lai (M.S.'99 CEE) is a structural engineer in Arup's San Francisco office. He has worked as a project engineer through all phases of design throughout his 14 years in the field. He has also worked in several other Arup offices, including its London and Hong Kong branches.

1980+

Adda Athanasopoulos-Zekkos (Ph.D.'08 CE) received the 2015 Thomas A. Middlebrooks Award from ASCE's Geo-Institute. She and civil and environmental engineering professor **Ray Seed** (B.S.'80 CE, M.S.'81, Ph.D.'83 Geotechnical Engineering)

This summer, **Jill Hruby** (M.S.'82 ME) became the president and director of Sandia National Laboratories and the first woman to lead one of the three National Nuclear Security Administration laboratories. Hruby most recently served as a vice president overseeing Sandia's efforts in nuclear, biological and chemical security; homeland security; counterterrorism and energy security.

"Leading Sandia is a tremendous responsibility because of its importance to the security of our nation and the phenomenal engineering and scientific talent here," Hruby says. "I embrace the opportunity to maintain the U.S. nuclear deterrent and lead Sandia in solving the difficult security challenges we face as a nation. I'm proud to be the first woman to lead an NNSA laboratory, but mostly I'm proud to represent the people and work of this great lab."

Hruby joined the technical staff at Sandia's California laboratory in January 1983. During her career, she also has done research in nanoscience, hydrogen storage, mechanical-component design and microfluidics.

PHOTO COURTESY SANDIA NATIONAL LABORATORIES

Margret Schmidt (B.S.'92 EECS) has a wealth of good business advice — as one would expect from the chief design officer and vice president of design and engineering at TiVo, a company which is changing the television landscape.

After college, Schmidt made the surprising decision to become a real estate broker. She liked the independence, but it wasn't really what she wanted to do. So Schmidt moved on to jobs more firmly on the technological side of home selling. Then, in 2001, she landed a job as TiVo's UI (user interface) manager and found herself doing what she was truly passionate about: design. In 2006, Schmidt and her TiVo team won an Emmy for Outstanding Achievement in Interactive Television.

Schmidt speaks passionately about the dynamic and fulfilling nature of product creation — of making something beautiful and new that truly delights someone — and says there is no better place for participating in that future than Berkeley and the Bay Area. "At the end of the day," she says, "what we're trying to do is put something wonderful out in the world that makes people go 'Wow, this makes my life so much easier. *I love this.*'"

PHOTO COURTESY MARGRET SCHMIDT

were selected for the award on the basis of their paper, "Simplified Methodology for Consideration of Two-Dimensional Dynamic Response of Levees in Liquefaction-Triggering Evaluation," which was published in the *Journal of Geotechnical and Geoenvironmental Engineering* in November 2013.

Connie Chang-Hasnain (M.S.'84, Ph.D.'87 EE), the college's associate dean for strategic alliances and John R. Whinnery professor of electrical engineering and computer sciences, received the United Nations Educational, Scientific and Cultural Organization Medal, recognizing her work in the fields of nanoscience and nanotechnologies.

James Demmel (Ph.D.'83 CS) received the Association for Computing Machinery's Paris Kanellakis Theory and Practice Award for his work on numerical linear algebra libraries, including LAPACK (Linear Algebra Package), a standard software library that forms part of the standard mathematical libraries for many vendors. The software and standards he developed enable users to transition their computer programs to new high-performance computers without resorting to basic building blocks. He is a professor of mathematics and computer science at Berkeley.

Rhonda Righter (M.S.'82, Ph.D.'86 IEOR) co-authored this year's International Teletraffic Congress, an annual event that provides a venue for researchers from academia and industry interested in design and control of communication networks, protocols and applications.

Eugene L. Tu (B.S.'88 ME) has been named director of NASA's Ames Research Center in Moffett Field, California. He most recently served as their director of exploration technology. After Berkeley, he earned his master's and doctoral degrees in aeronautics and astronautics from Stanford University.

1970+

Patrick D. Allen (M.S.'78 IEOR) recently published his second book, *Cloud Computing 101: A Primer for Project Managers.*

1960+

Robert M. Carlile (Ph.D.'63 EE) has published five young adult novels, all part of his *Windwalker* series. His work is available through Amazon, published by Create Space. More information can be found on his website: www.windwalkersthebook.com.

1940+

Leonard C. Beanlano (B.S.'49 ME) will turn 92 this year. He retired from a career at PG&E in 1984. After many years in California, he moved to Washington to be near his son and five grandchildren. "It has been a good life," he says, and he and his family plan to "continue to enjoy it for as long as they can."

Spider-inspired silken threads

Where some people see mere cobwebs, **David Breslauer** (Ph.D.'10 BioE) sees nature's most robust fiber. Spider silk exhibits a unique combination of strength and elasticity that makes it tougher than steel and Kevlar. For decades, researchers have been trying to come up with an affordable way of mass-producing spider silk on a commercial scale.

Now Breslauer — along with Dan Widmaier and Ethan Mirsky — has found a way to produce spider silk without spiders. Their company, Bolt Threads, has genetically modified a yeast that, when fermented with sugar and water, generates silk proteins similar to those produced by spiders. These protein strings are then spun into fibers for knitting or weaving into fabrics and garments.

Bolt Threads is poised to become the world's first company to bring the benefits of spider silk to the masses, in the form of high-performance fabrics, an application that the trio decided would have the biggest early impact. Breslauer says the new fabrics are still as soft, warm and breathable as those made by silkworm silk. And by controlling the amino acid sequence of the silk proteins, Bolt can enhance qualities like stretch, strength, weight and water resistance.

The company — which has nearly 50 employees, including Berkeley alums from engineering and chemistry — is already producing test runs from its Emeryville headquarters. And with sufficient funding in hand, the company is ready to break into the apparel industry in a big way. Their first fabrics will reach store shelves sometime next year.

STORY BY NATE SELTENRICH • PHOTO COURTESY BOLT THREADS

Ernest Kuh, dean, professor emeritus and an internationally renowned expert in electronic circuit theory, died in June. He was 86. Kuh joined the Berkeley faculty in 1956 and made pioneering contributions in active and passive circuit theory, electronic design automation of integrated circuits and engineering education. A member of the National Academy of Engineering, Kuh authored or co-authored six textbooks and several hundred research papers — all while mentoring several generations of graduate students. He also served as chair of the Department of Electrical Engineering and Computer Sciences from 1968 to 1972 and then as dean of the college from 1973 to 1980. During this time, he raised funds for the Bechtel Engineering Center, formalized the Berkeley Engineering Fund and started an industrial liaison program. In 1992, Kuh became a professor emeritus. With his wife, Bettine, he endowed the Ernest S. Kuh Distinguished Lecture Series in 2012 to bring notable scientists and engineers to campus. “Ernest Kuh was instrumental in establishing the College of Engineering as a world leader in research, teaching and public service,” says Dean S. Shankar Sastry. “His legacy will shape our influence and impact for years to come.”

ARCHIVE PHOTO

Floraine Berthouzoz (Ph.D.’13 EECS) died in August. She was a research scientist in Adobe Research’s Creative Technologies Lab specializing in computer graphics and computer-human interaction. At Berkeley, she co-founded CS KickStart, a student-run enrichment program designed to close the gender gap in computer science.

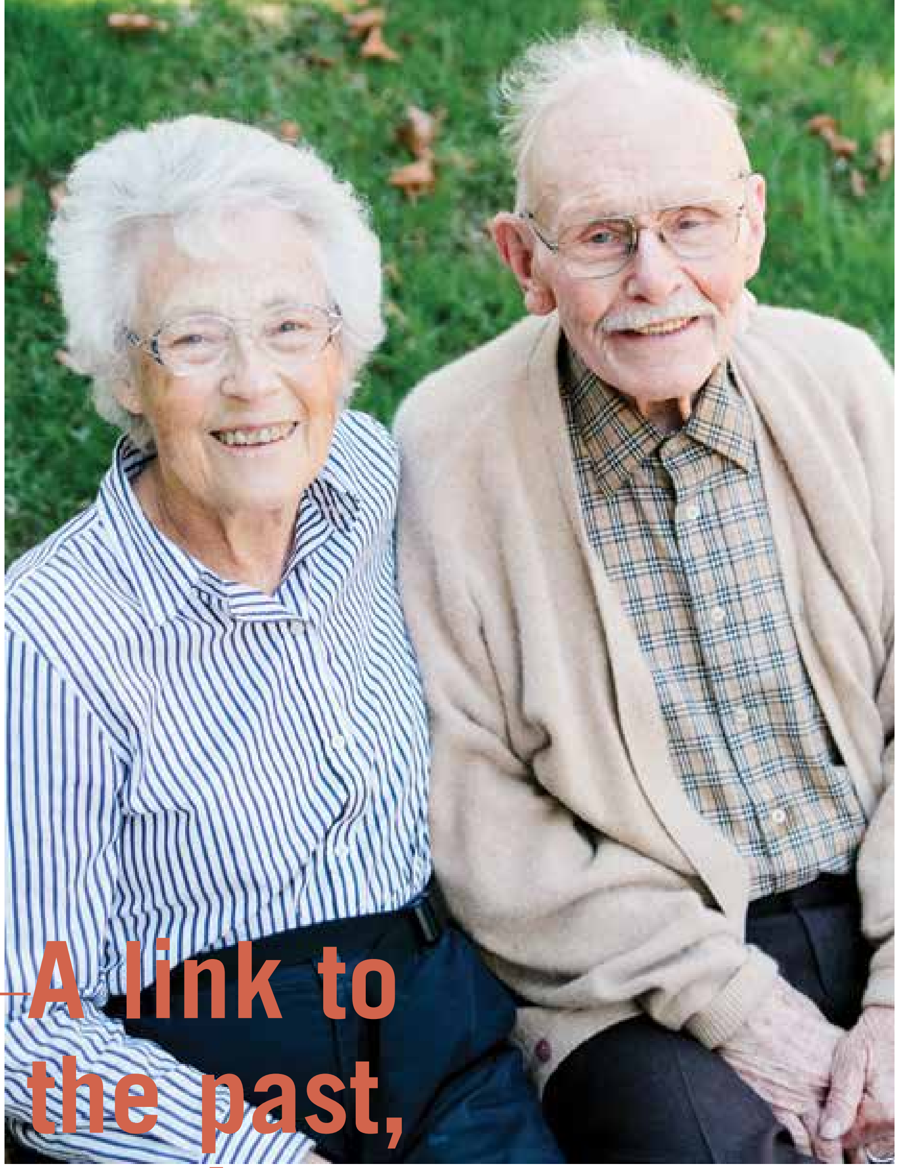
Martin Graham, professor emeritus of electrical engineering and computer sciences, died in March. Graham received his Ph.D. from the Polytechnic Institute of Brooklyn in 1952 and began his academic career at Rice University. In 1966, he joined Berkeley’s electrical engineering and computer science department, where he worked as a professor until his retirement in 1993. He served as associate director of the computer center from 1966 to 1968, chair of computer science from 1970 to 1972 and secretary of the academic senate from 1978 to 1980. His research interests included computer systems, medical instrumentation systems and electrocardiogram analysis.

Henry Miedema (B.S.’61, M.S.’63 CE) died in September 2014 at the age of 75. Miedema worked at Shell Oil Company and the Los Angeles Department of Water and Power and was district engineer for the Santa Margarita Water District and the Santiago County Water District. He also worked for private engineering consulting firms, and, in 2002, formed his own consulting business. Over the course of his career, he authored and co-authored many articles, which were published in a range of civil engineering journals. He also served for many years as a member of the Berkeley Engineering Fund Board of Directors. In 1997, he and his wife created the Henry and Joyce Miedema Chair in civil engineering, which provides support for research or teaching in the area of California water issues.

Stanley Prussin, a nuclear engineering professor for 49 years, died in August. Author of a widely used text, *Nuclear Physics for Applications: A Model Approach,* Prussin was internationally recognized in nuclear physics, chemistry and instrumentation. After the 9/11 attacks, his research turned toward nuclear nonproliferation and pioneering work in nuclear forensics. He earned degrees in chemistry from MIT and the University of Michigan and completed postdoctoral work at the Berkeley Lab before joining the Berkeley faculty.

David T. Swanson (B.S.’56 CE) died in March. He designed and built bridges for the state of California for 12 years, and then worked in the private sector, where he was a pioneer in post-tensioned concrete. He earned many industry honors, was granted numerous patents and served as president of the American Segmental Bridge Institute.

Victor Zackay (B.S.’47, M.S.’48, Ph.D.’52 MSE), professor emeritus of materials science and engineering, died in March at the age of 94. He joined the Berkeley faculty in 1962, later serving as associate dean of the college and associate director for research at the Berkeley Lab. He developed new kinds of superconducting components with high transition temperatures and new ultra-high strength steels. He also consulted on projects with industry partners, including Johnson & Johnson and Gillette. After 17 years at the university, he retired early to found Materials and Methods, where he worked until his retirement in 1989. During his academic and industrial careers, he published over 100 papers and received numerous honors and awards.



Preston Davis

A link to the past, a bridge to the future

As a civil engineer for the past 61 years, alum Charles “Chuck” Seim has worked on all 10 bridges that span the San Francisco Bay, among other high-profile engineering projects around the world. If you ask him, the exceptional education and enduring relationships he built as an undergraduate student have been pivotal to his success.

“It was life-changing,” he says, of his time at Berkeley Engineering.

Chuck and his wife, Janet, hope to pay forward that opportunity. They have chosen to give back to Berkeley Engineering to support scholarships and programs for students, who can then go on to change and improve the lives of others.

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