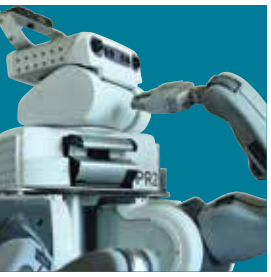
College of Engineering
University of California, Berkeley
Fall 2017
Volume 12

Transforming engineering education
The new essentials

Campus hotspot
V&A Café debuts at Etcheverry

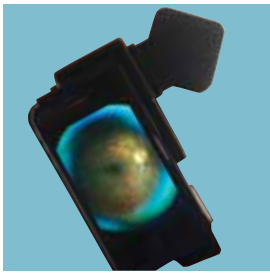
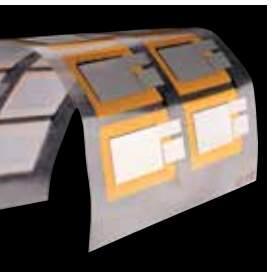
Berkeley ENGINEER

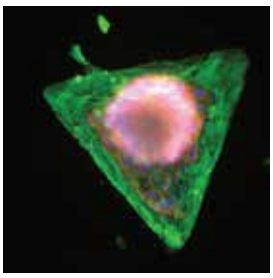






INVENTING THE FUTURE




Future bound: Partners wanted

As we use this issue of *Berkeley Engineer* to benchmark what's in store for the future here at the college, we're also developing a playbook of what it will take to get there. Given our talented students and dedicated faculty, I'm confident in our plans. But I'm thinking a lot about what connects vision to reality.

One great advantage that we have in contributing our vision of the future is that we're operating in an environment that continually strives for open collaboration and shares a mission of innovation at the service of society. We have a long history of forming partnerships — within the college and broader community, as well as with government and industry — that create high-impact technologies and advance meaningful solutions to the most challenging of problems.

By tradition, engineering and professional schools have been broadly connected to the outside world. But as we go forward, we also need to partner with parts of the university that traditionally have not relied on close relationships with industry or outside organizations. For example, in augmented reality/virtual reality (AR/VR), we're currently developing a wonderful partnership with the faculty in Theater, Dance and Performance Studies; Art Practice; and the Center for New Media. They see that the future of dance, performance, music, sports — and indeed the future of how we teach, the future of education — is going to be transformed by AR/VR devices.

In talking to Shannon Jackson, Berkeley's new Associate Vice Chancellor of Arts and Design, we've come to this conclusion: At Berkeley, we've been great at educating right brains and left brains separately. Why don't we educate the whole? Berkeley students are superb, and we'd be selling them short if we didn't make this our goal.

It's not enough anymore to design, work, ideate and create in silos of expertise or experience. Instead we need to think how to foster connections and build networks — and then share the uniqueness of the university environment. We're seeing this happen in remarkable ways at spaces across campus (Jacobs Hall, Sutardja Dai Hall and Blum Hall for example), and these relationships will be more critical than ever as we seek to shape the future.

As you may know, I will be stepping down as dean and returning full-time to my faculty position at the end of this academic year. It has been my privilege and pleasure to serve as the dean at Berkeley Engineering during the past ten years. This has been a period of transformation, innovation and tremendous growth for the college, and I thank you for your invaluable partnership during my tenure and for your critical role in all we will continue to build together in Inventing the Future!

As always, I welcome your thoughts and ideas.

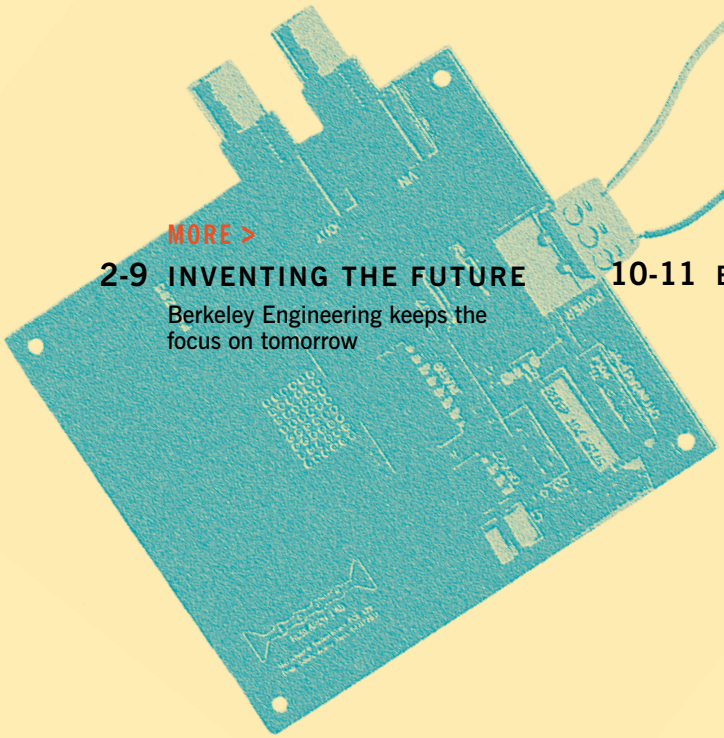
—*S. Shankar Sastry*
DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING
DIRECTOR, BLUM CENTER FOR DEVELOPING ECONOMIES

Thank you for your critical role in all we continue to build together.

Noah Berger

in this issue

BerkeleyENGINEER FALL 2017



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Berkeley Engineer is published twice yearly to showcase the excellence of Berkeley Engineering faculty, alumni and students.

Published by: UC Berkeley College of Engineering, Office of Marketing & Communications, 312 McLaughlin Hall #1704, Berkeley, CA 94720-1704, phone: 510-642-2024, website: engineering.berkeley.edu/magazine

Reach editors: berkeleyengineer@berkeley.edu

Change of address? Send to: engineerupdates@berkeley.edu **or submit at:** engineering.berkeley.edu/update.

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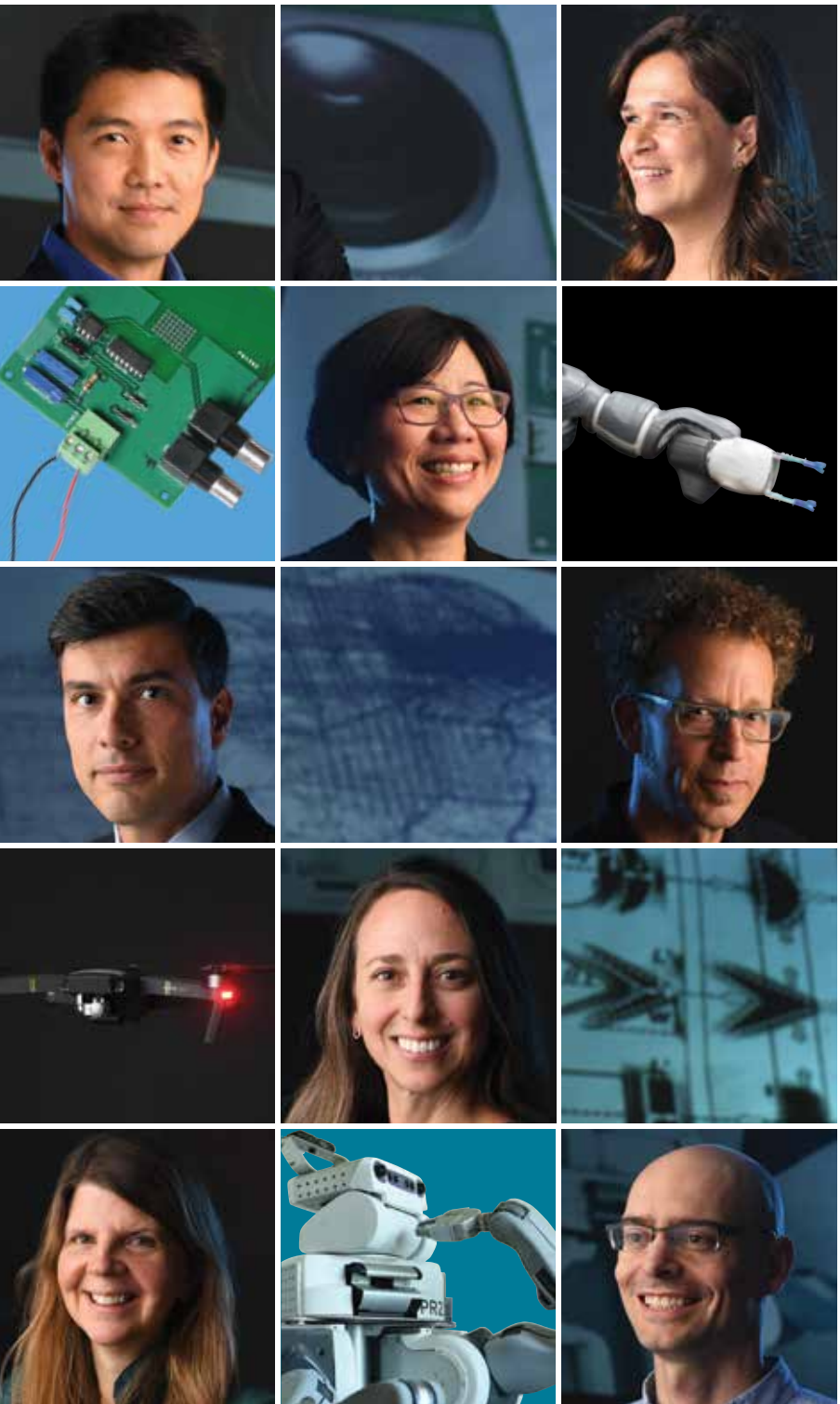
INVENTING THE FUTURE



Berkeley Engineering keeps the focus on tomorrow

INTERVIEW BY KAREN HOLTERMANN
PROFILES BY DANIEL MCGLYNN • PHOTOS BY NOAH BERGER

New buildings, new degree programs, new majors, new research centers and institutes, new curricula and entirely new areas of technology — Berkeley Engineering has been in a constant state of innovation over the last decade. Overseeing it is Berkeley's Dean of Engineering, Shankar Sastry. Dean Sastry, however, is not one for retrospectives. He sat down with *Berkeley Engineer* to talk about Berkeley's role in inventing the future.

What excites you most about what engineers will achieve in the next 25 years?

Engineering has been a catalyst of change in society for several hundreds of years, at least from the time of the industrial revolution. Each revolution has substantially changed how we live. Now there is a noted acceleration in the pace of technological change, coupled with business change, coupled with social change. It is increasingly important for engineers to shape the future.

In the past change has happened to society. We should not let the future happen to us. We should make the future what we'd like it to be.

So engineers will have a greater role in managing the change they create?

In some instances technology caused social disruption, and it took sometimes hundreds of years to settle down. In the 1970s, sociologists speculated about how information technology would change the world. Now there is the Internet of Things [IoT], data analytics, machine learning, artificial intelligence — and new business models emerging from this.

Technology is changing how we live. It's changing how we work. It's changing the nature of companies that are being produced. We are thinking about what jobs will be like — people talk about the gig economy where people work flexible hours. I think it's better that this all doesn't happen unchecked. To a large extent, engineers and technologists are creating these instruments of big social change, and we have a duty to address how we integrate them into designing a better world as we go forward. We have to think about how we integrate emerging technologies, but also about the value frameworks that go into how we apply them.

The story of engineering has always been a social one. It has been about how to make available, for all, what is available to elites today by relentlessly driving down the cost curve. For example, the healthcare debate today is primarily about insurance models, but an underlying problem is how to help people live longer and also reduce costs as you provide new solutions. Today, every new cure is an axiom for increased cost. The ethos of engineering has a huge role in producing solutions that enable better care.

Where is the transformational potential of new technology greatest today?

First, it's evident in the digital transformation of industry. The Germans call it Industry 4.0, integrating automation and cyber-physical systems to guide processes. Millions of sensors are embedded in value chains, be it the smart grid for the delivery of energy, water networks, telecommunications networks. Across industries, leaders are mandating this kind of digital transformation, integrating AI, cloud computing, IoT.

In the energy sector, energy companies like C3 IoT are taking the data from the instrumented world, analyzing it and making available new services that could not be offered before. In transportation networks, detailed information about how various components function helps us fundamentally re-think how services are provided; this has triggered the emergence of the sharing economy — Airbnb, Uber, Lyft. In healthcare, United Healthcare wants to use these technologies for preemptive healthcare, making better use of electronic medical records to, for example, change drug dosages before problems occur.

"For Berkeley Engineering, that next step is an Institute for Inventing the Future. We're envisioning a hub, both physical space and a collection of centers, focused on some of these areas with the most transformational potential."

—DEAN SHANKAR SASTRY

Farming is already a very automated sector in this country. If you listen to John Deere or Caterpillar, they know that farmers are very open to the notion of precision farming. Sensors allow farmers to monitor the level of nutrients and water in the soil on a daily basis, to truly regulate what goes in. This knowledge has huge cost benefits and reduces the effluent that pollutes our waterways. It lets us think about a world where new kinds of crops can be grown, like protein-rich plants.

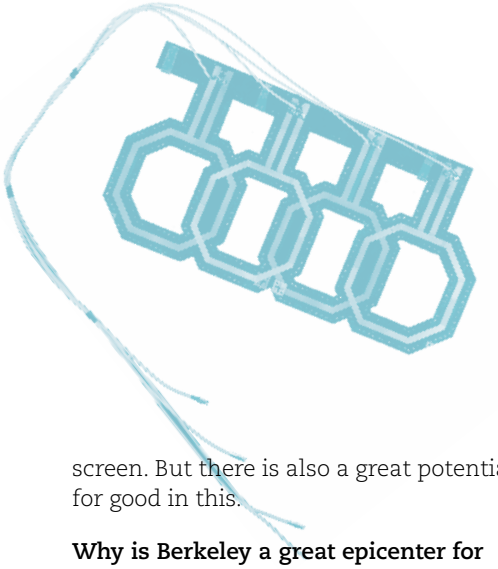
And at Berkeley we have a fledgling Health@Home initiative that is addressing how to bring more of our healthcare into the home and out of the hospital. It exemplifies the use of sensitized value chains. In manufacturing you call it preemptive diagnostics — they monitor processes and send in people to fix problems before something breaks down. Health@Home is preemptive diagnostics for the human body — monitor patients in their homes and send in health providers before people fall ill.

Where do you see momentum building for other major advances?

We are looking at biological systems with a similar approach — the interaction of gene-protein networks that is much like an interaction between software and embedded hardware. What began as synthetic biology is now focused on genetic engineering, thanks to tools like CRISPR-Cas9, pioneered at Berkeley.

In materials science, Gerbrand Ceder and Kristin Persson, who joined our faculty in 2015, are national advocates for a Materials Genome Initiative. They are proposing a genomic way of thinking about evolving new materials. Computer modeling and machine-learning techniques could generate huge libraries of potential new materials, based on the successes and failures of thousands of lab experiments. The best would be synthesized and tested. We'll be able to choose the properties we want and readily create new materials with those properties, making for a more sustainable future.

Our Berkeley engineers are also involved in neuroscience, combining robotics, AI, neuromorphic computing, brain-machine interfaces and augmented reality. A goal is to augment human cognitive capability. Of course, as I speak there are scary scenarios about bionic minds, and Hollywood has already been downloading brains on



screen. But there is also a great potential for good in this.

Why is Berkeley a great epicenter for this kind of thinking? How do we craft roadmaps to accelerate these advances?

That's a really important question, because the agendas we are talking about are large and will span institutions and countries. However, I do think Berkeley is a place to nucleate this change. First, over the years we have built up an ecosystem with a healthy interplay of tech-push and systems-pull, of developing new technologies and integrating them into systems. Most engineering schools are disproportionately focused on tech-push. At Berkeley, for example, I see EECS, materials science and engineering and mechanical engineering as tech-push departments. IEOR and civil and environmental engineering are systems oriented, synthesizing these new technologies into systems. It's not surprising that bioengineering straddles both — as the newest department it represents a trend toward balancing tech-push and systems development.

Second, Berkeley also has a strong commitment to serving society. We strive to think not just about what we're developing but really what it means for society. We've created CITRIS [the Center for Information Technology Research in the Interest of Society]; the Blum Center for Developing Economies, focused on alleviating poverty; and Professor Alice Agogino's launch of Development Engineering, technology for improving economic prosperity. Finally, we've created institutes such as the Sutardja Center for Entrepreneurship and Technology, the Jacobs Institute for Design Innovation, the Fung Institute for Engineering Leadership and several others that now populate our academic landscape. We're uniquely positioned from having done these experiments. They've given us a taste for how we can take the next step and up the ante for new educational directions.

For Berkeley Engineering, that next step is an Institute for Inventing the Future. We're envisioning a hub, both physical space and a collection of centers, focused on some of these areas with the most transformational potential.

What will all of this change do to jobs and the nature of work in the future?

This is societal change. It is difficult. People are worried that all these technologies will take away jobs. And not just manufacturing or mining jobs. The American Association of Economics is concerned that learning analytics will play havoc with the jobs of economists in the future. Banks have similar concerns. It is a time to be really careful.

I think we technologists tend to be blindly optimistic. Over time it'll all work out, we think, and new jobs will be created. But the people losing jobs today are not the ones who are going to get the new jobs tomorrow. So what do we do for these people? What does retraining mean? How do we get people prepared for this new world?

Broadening our educational mission is another part of our agenda for shaping the future. We need to be more involved in continuing education. We owe it to society to provide, in a manner that is compatible with a work life, continued educational opportunities to those who need new skills.

Robots on the job, implantables for health, driverless cars — what would you say to people who fear this future?

Transparency is the best we can do. It's important not to deny fears and anxieties but to allow people to voice them and to understand whether the concerns are real and what mitigations could be put in place. Classes, town halls, public lectures, salons — I think all of the above would help us have this open exchange with the public. This social mission of the university is something that we need to define.

How must Berkeley Engineering evolve to meet this challenge?

To start, we need to create the Institute for Inventing the Future as a catalyst for change on our own campus. What change? First, there is a need for more engineers, and we need modest growth in the College of Engineering. There is great demand, and our acceptance rates for new students are extremely low. For Berkeley students outside the college, we need to evolve the curriculum for those who have a taste for the union of technology, entrepreneurship and design. We've begun this work, but it needs to grow.

Second, our departments are evolving. We can no longer be rigid about who does what. For instance, a huge piece of the IoT agenda is in civil infrastructures. Transportation is suddenly ground zero for creating new business models. In fact, our Department of Civil and Environmental Engineering is evolving to play a lead in these areas, as well as in engineering systems, designing resilient communities and other areas that are key to our collective future.

Finally, we need to do more in the college to unify tech-push and systems-pull. I hope we can have more cross-department faculty appointments, more curricula that span departments. In my own field of controls, the entire curriculum is being revamped because it's now being taught in multiple departments, which is unnecessary. We have made our first steps in offering programs of study that combine engineering with unexpected disciplines — what I call Engineering + X or Computer Science + X. How we scale this to meet the demand is a challenge.

What will Berkeley Engineering look like in 20 years?

I'd love to see it as a place where people in the workforce can come and learn as knowledge and technology advance. I'd like us to be surrounded by concentric rings of entrepreneurial companies, even big companies, like a modern-day research park. I want us to develop better, integrated ways of engaging with clinical practice. Access to industry and medical institutions is key — these are where new solutions are tested.

And, of course, over the next decades Berkeley will just get better and better as an exceptional place for engineering education. BE

Working at the interface of technology and society, **Berkeley Engineering faculty are shaping the future** with their ambitious research, in high-impact areas from health to work to infrastructure. Here are nine examples of the groundbreaking work taking place across the college:

ROBOT LEARNING

PIETER ABBEEL'S VISION OF THE FUTURE IS *one where machines are learning responsibly.*

GOAL-ORIENTED ARTIFICIAL INTELLIGENCE

Intelligence, artificial or otherwise, requires learning. People have all kinds of learning styles, but how do robots learn best? That's a question taken up by electrical engineering and computer sciences professor Pieter Abbeel as he trains the Berkeley Robot for the Elimination of Tedious Tasks, better known as BRETT.

There are two main educational philosophies for developing artificial intelligence. Deep supervised learning trains a neural network to understand input-output combinations from examples. Apple's Siri uses deep supervised learning, as does Amazon's Alexa. Deep reinforcement learning, on the other hand, develops artificial intelligence for goal-oriented tasks by repeatedly trying to achieve the desired goal, learning from both past successes and failures.

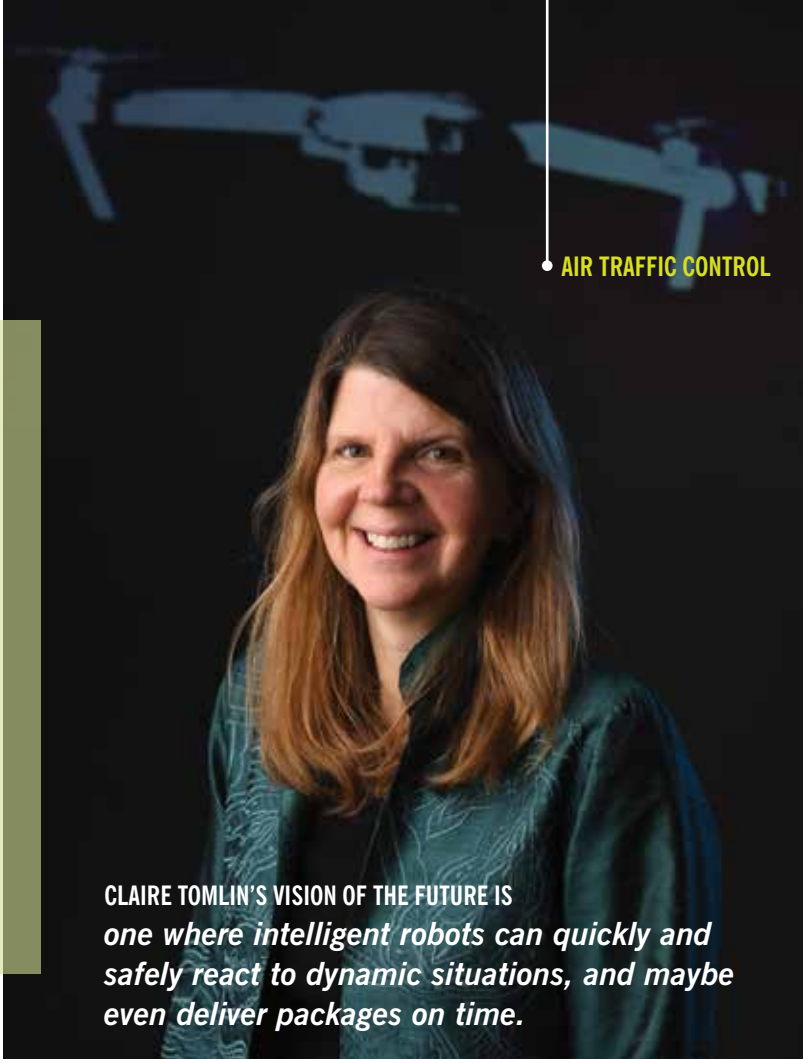
What makes Abbeel's BRETT research so novel is that his group was the first to show deep reinforcement learning success on real robots (much other work with deep reinforcement learning largely focuses on teaching artificial intelligence to play video games). The ultimate goal is to create helper robots that not only learn how to perform assigned tasks but are also capable of coping with changing situations and unscripted moments. Future applications might be in homes and offices as well as in manufacturing and logistics.

AIRSPACE MANAGEMENT

Mail carriers were responsible for developing the early aviation systems in the United States, delivering airmail and opening new possibilities for air travel. After World War II, Congress began setting rules for the skies, resulting in the National Airspace System, which created an increase in both commercial and military uses of domestic airspace.

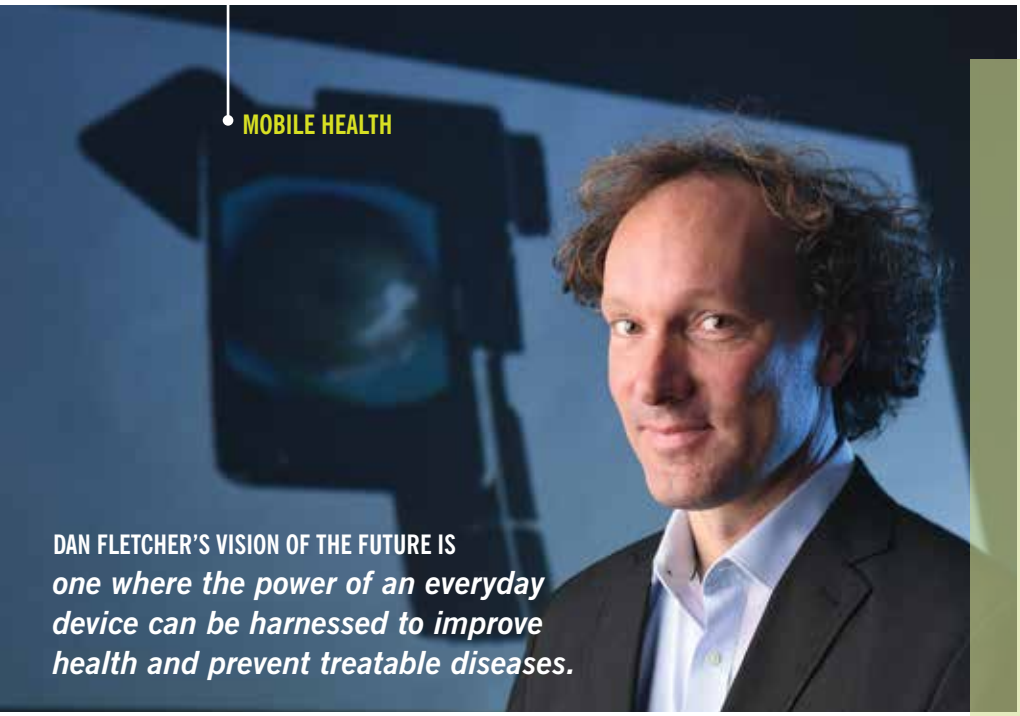
If Internet commerce trends continue, then parcel delivery may once again disrupt aviation systems. As companies such as Amazon and Google are experimenting with how to build the most effective package delivery drone, electrical engineering and computer sciences professor Claire Tomlin is using her expertise in control theory and machine learning to figure out the most efficient way to integrate unmanned aircraft into the National Airspace System.

Designing tomorrow's airspace is not without its challenges, safety being chief among them. But Tomlin has an idea. She is investigating the possibility of using the space above sparsely populated regions, such as waterways and railways, as drone expressways, where tightly grouped unmanned aircraft could zing along at altitudes between 200 and 400 feet — high enough to not interfere with ground-based activities, but low enough to not be a nuisance for manned air travel.



AIR TRAFFIC CONTROL

CLAIRE TOMLIN'S VISION OF THE FUTURE IS
one where intelligent robots can quickly and safely react to dynamic situations, and maybe even deliver packages on time.



MOBILE HEALTH

DAN FLETCHER'S VISION OF THE FUTURE IS
one where the power of an everyday device can be harnessed to improve health and prevent treatable diseases.

MOBILE LAB

In developing countries and other low-resource areas, lack of access to medical facilities with diagnostic equipment means that otherwise treatable diseases run rampant.

Bioengineering professor Dan Fletcher is working to address that problem by building devices that enable decentralized diagnostic medicine.

"More people have access to mobile phones than clean water," Fletcher says. "Could we harness mobile phone technology for disease diagnostic purposes?" Over the last eight years, Fletcher's lab has built many iterations of the CellScope, converting ordinary smartphones into a powerful diagnostic tool.

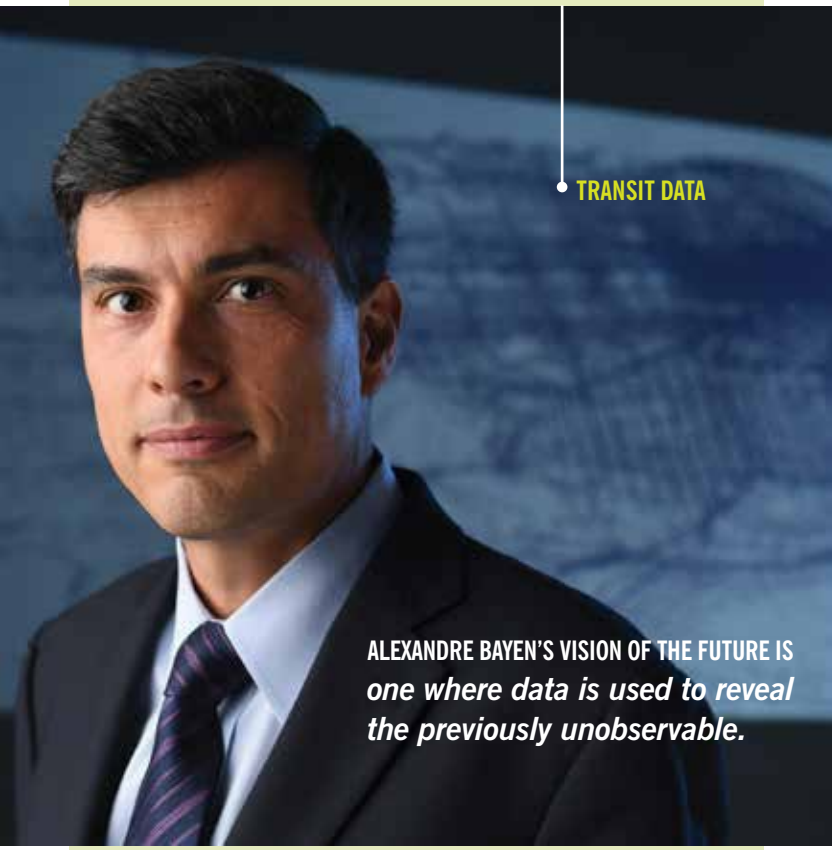
In addition to tuberculosis and malaria, CellScopes also enable safe treatment of river blindness in Africa and test for soil-transmitted parasitic worms. Besides sputum, blood and stool tests, the technology can also be used for primary care. A commercialized version of the CellScope helps detect ear infections in children, and a new device under development enables visualization of the retina for diabetic retinopathy screening.

TRANSIT DATA TRENDS

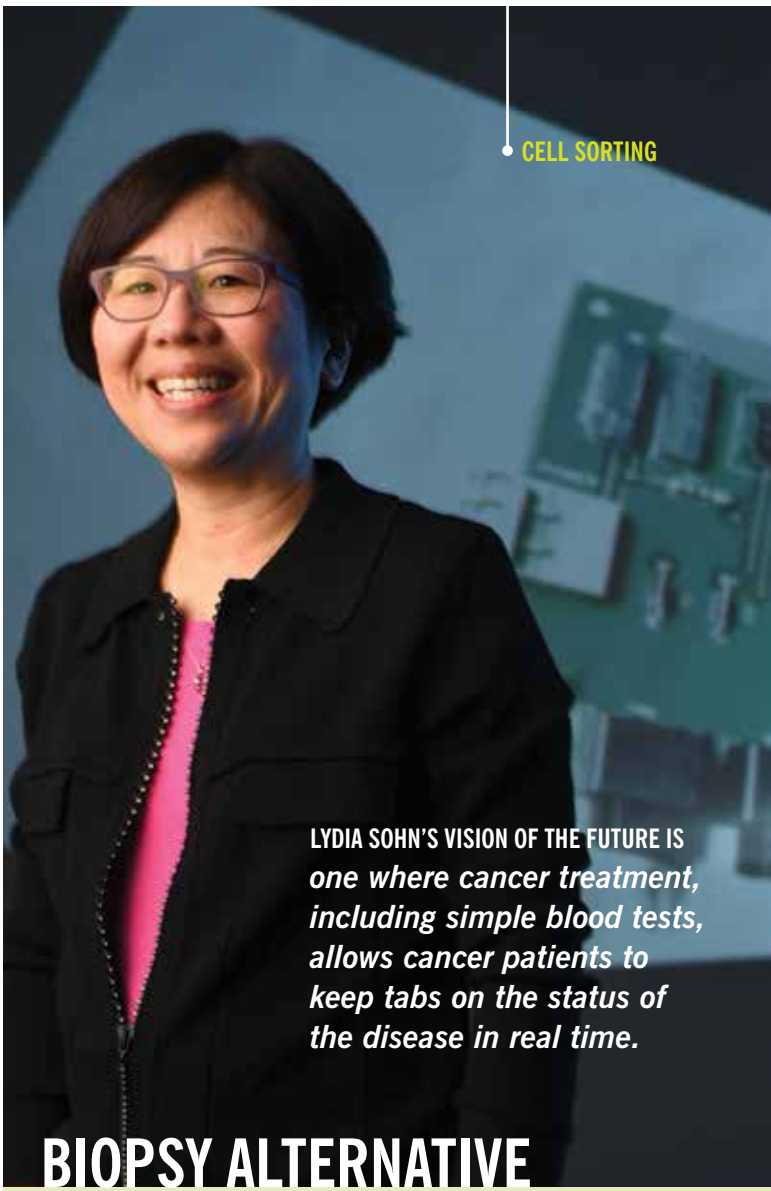
In recent years, the emergence of massive data sets from devices like mobile phones and connected vehicles has created unprecedented opportunities for urban mobility modeling. Going beyond traditional transportation models, which were built on census and demographic information, the new deluge of fine-grained data allows for more precise demand modeling — benefitting both public agencies and the driving public.

New mobility-as-a-service companies have millions of users in California, and hundreds of millions in the world, all using similar apps; a better understanding of large-scale mobility patterns, particularly in mega-cities and urban environments, has the potential to unleash tomorrow's smart city operations.

For Alexandre Bayen — professor of electrical engineering and computer sciences and civil and environmental engineering, as well as director of the Institute for Transportation Studies (ITS) — the future of large-scale mobility rests on open data platforms that allow for transit systems to be modeled holistically across scales of time and geography. ITS was established in 1947 by the state legislature to address a lack of investment in public infrastructure during the WWII years and has been responsible for many technological innovations since: algorithmically-controlled metering lights on the Bay Bridge, platoons of connected-automated vehicles on California roads and the launch of one of the first traffic-monitoring smart phone apps.



ALEXANDRE BAYEN'S VISION OF THE FUTURE IS *one where data is used to reveal the previously unobservable.*



LYDIA SOHN'S VISION OF THE FUTURE IS *one where cancer treatment, including simple blood tests, allows cancer patients to keep tabs on the status of the disease in real time.*

BIOPSY ALTERNATIVE

Mechanical engineering professor Lydia Sohn is developing a simple blood test to reduce, or even eliminate, the need for invasive biopsy. Sohn's test targets rogue cancer cells that carry the markers of a metastasizing tumor. She calls the search for these cells a needle-in-a-haystack problem: a blood sample might contain billions of cells, but only a handful are cancerous.

To isolate cancer cells, Sohn is building a microfluidic device that sits on a simple printed circuit board. Inertial and acoustic forces sort blood cells by size — cancer cells are larger than red blood cells and the majority of white blood cells — and don't damage or alter the properties of the sample in a way that simple filtering or applying protein signatures might. Once the cells are sorted, they can be tested for biochemical and mechanical markers, revealing information about a cancer's status.

ROBOTIC COWORKERS

KEN GOLDBERG'S VISION OF THE FUTURE IS
one where machines work together with humans to refine their respective skills and expertise.

DEXTEROUS ROBOTS

Despite years of research, robots remain remarkably clumsy. But it may be possible to facilitate deep learning of robust robotic grasping and train robots using a synthetic dataset of 6.7 million point clouds generated from thousands of 3-D models, according to recent work by published by industrial engineering and operations research professor Ken Goldberg and Ph.D. student Jeff Mahler from the Berkeley Laboratory for Automation Science and Engineering (or AUTOLAB). Traditional robots are programmed by painstaking human coding; now, with the right data, the traditional machine-learning curve can be shrunk from months to days. "Dex-Net 2.0 achieves 99 percent precision," Goldberg says. "That includes many difficult-to-grasp objects it was not trained on, such as an old sneaker and a piece of fabric."

Better robot dexterity has immediate applications for factories and warehouses. Looking ahead, teachable robots might also be welcomed into hospitals and homes.

VR CAPTURE

REN NG'S VISION OF THE FUTURE IS
one where better optics — integrating both hardware and software — improve everything from computer vision and medical diagnostics to family photos and immersive entertainment.

COMPUTATIONAL IMAGING

As a Ph.D. student, Ren Ng worked on light field camera technology. A light field camera uses a new kind of sensor to capture fundamentally more information than a traditional camera — the four-dimensional field of light flowing along every ray into the camera as opposed to conventional two-dimensional images. Since a light field photograph contains more detailed image data, the technology allows a user to manipulate depth of field and focus in post-production, among other things.

After graduating from Stanford in 2006, Ng launched Lytro, a company that commercialized his doctoral research and brought consumer light field cameras to market. Today, the company is known for building camera systems for high-quality virtual reality and cinema. In 2015, Ng joined the electrical engineering and computer sciences faculty and is applying his expertise to computer vision, virtual reality and neuroimaging.

As part of research funded by the National Science Foundation, Ng is rethinking the way that hardware and software can be combined to fully capture light and produce images containing more information. Target applications for such computational imaging systems include everything from miniaturized lenses to cameras for virtual reality capture to imaging the brain.

MEDICAL DIAGNOSTICS

AMY HERR'S VISION OF THE FUTURE IS *one where measurements of microscopic differences between cells replaces the traditional "one-size fits all" healthcare model.*

CUSTOMIZED MEDICINE

If human bodies are made up of molecular machines cycling through biological processes, then proteins are the fuel for life. Because of the role that proteins play in the way a body functions — they contain genetic information, ignite metabolic reactions and transport critical material — they are useful biomarkers. Almost like timestamped data packets, proteins contain crucial information, including the state of an illness, even one that may not be showing outwardly. The problem is that these windows into overall health are like stars in the night sky: there are millions of proteins in a human body, and they are constantly changing.

"How do you measure proteins in a packet of life that is so small and so inaccessible?" bioengineering professor Amy Herr is fond of asking when presenting her work to build microfluidic tools capable of measuring proteins in each individual cell — among thousands of cells — all at once. The answer, it turns out, is found inside of a smart phone.

This time, it's not an app, but the way that cell phones and other mobile devices are manufactured that is useful. As part of her research, Herr is trying to figure out how to build new diagnostic equipment using the same advanced manufacturing processes used to build the electronics inside mobile phones.

PRINTED ELECTRONICS

Electrical engineering and computer sciences professor Ana Claudia Arias sees a disconnect between the way our electronics are currently built and the way we use them. Her proposal: design and build devices that can conform to our bodies. Specifically, she is looking for ways to change how medical diagnostics are performed.

"At Berkeley, we are bringing this vision of flexible, lightweight electronics to magnetic resonance imaging (MRI)," Arias said during a World Economic Forum talk. Current MRI technologies are good at producing images related to soft tissue health and function, but because of the way the machines are set up — the coils that produce the images are not immediately next to the body — the process can take some time.

Currently, Arias is experimenting with developing flexible electronics by using a method similar to how silkscreen t-shirts are made. Instead of ink, electronics are joined to flexible membranes, which can then be manipulated into a variety of shapes.

FLEXIBLE IMAGING

ANA CLAUDIA ARIAS'S VISION OF THE FUTURE IS *one that includes electronics and diagnostic equipment that fits the body of a patient and is capable of quickly producing high resolution images, all the while providing a more comfortable experience, particularly for children.*

Arda Ozilgen

DIAGNOSTICS

Chest sound waves

The current clinical gold standard for detecting pneumonia is the chest x-ray, but cost and other barriers can make this method inaccessible to certain patient populations. To provide a convenient and low-cost alternative, student researchers have created a medical device that uses soundwaves to diagnose pneumonia. The device, called Tabla, quantifies and charts changes in sound during percussive physical examinations, in which a physician taps the sternum and back and assesses the resulting sounds. Created by **Adam Rao,** a medical student at UCSF and a student in the UC Berkeley/UCSF joint Ph.D. program in bioengineering, and **Chen Bao** and **Jorge Ruiz,** both 2017 M.Eng. graduates in mechanical engineering, Tabla began as a classroom project during the Interactive Device Design course at the Jacobs Institute for Design Innovation. The project was the top winner in the 2017 Big Ideas at Berkeley competition and was recently named the winner of the student category of Fast Company's 2017 Innovation by Design Awards.

VIRTUAL REALITY

No sense, no feeling

Emerging Virtual Reality (VR) technologies are pushing the bounds of immersive, digital worlds. Currently, objects in these virtual worlds can't be touched, and when users try to grab, hold or pick something up, the reality experience is broken. That's why haptics, or perception aided by the sense of touch, is viewed as the next VR frontier. Now, a team at the BEST Lab — including 2017 M.Eng. graduates **Arielle Maxner, Diego Rivas** and **Kingston Xu,** working with mechanical engineering professor **Alice Agogino** and postdoctoral fellow **Euiyoung Kim** — has developed TACTO, a glove equipped with haptic feedback technology that will transmit the sense of feel from the virtual world around them.

Courtesy the researchers

HAPTIC TACTO GLOVE COMPONENTS

Accelerometers: Measure the change of velocity and are useful for sensing movement and orientation changes.

Control circuit: Connects the sensors with the haptic motors to create a touch experience.

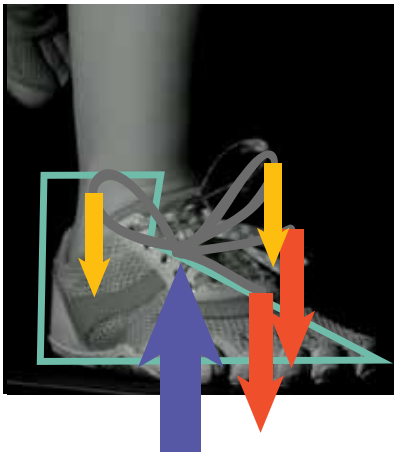
Haptic motor: Creates vibration in the glove's fingertips.

Ultrasonic sensor: Measures distance between sensor and an object using sound waves.

MECHANICS

Shoestring theory

Why do shoelaces keep coming untied? It's a question everyone asks, often after stopping to retie their shoes, yet one that nobody had investigated. Now, a study conducted in the lab of **Oliver O'Reilly,** professor of mechanical engineering, suggests the answer is that a double whammy of stomping and whipping forces acts like an invisible hand, loosening the knot and then tugging on the free ends of your laces until the whole thing unravels. The study is more than an example of science answering a seemingly obvious question. A better understanding of knot mechanics is needed for sharper insight into how knotted structures fail under a variety of forces. "When you talk about knotted structures, if you can start to understand the shoelace, then you can apply it to other things — like DNA or microstructures — that fail under dynamic forces," says **Christopher Daily-Diamond,** who co-authored the study with fellow graduate student **Christine Gregg.** "This is the first step toward understanding why certain knots are better than others, which no one has really done."

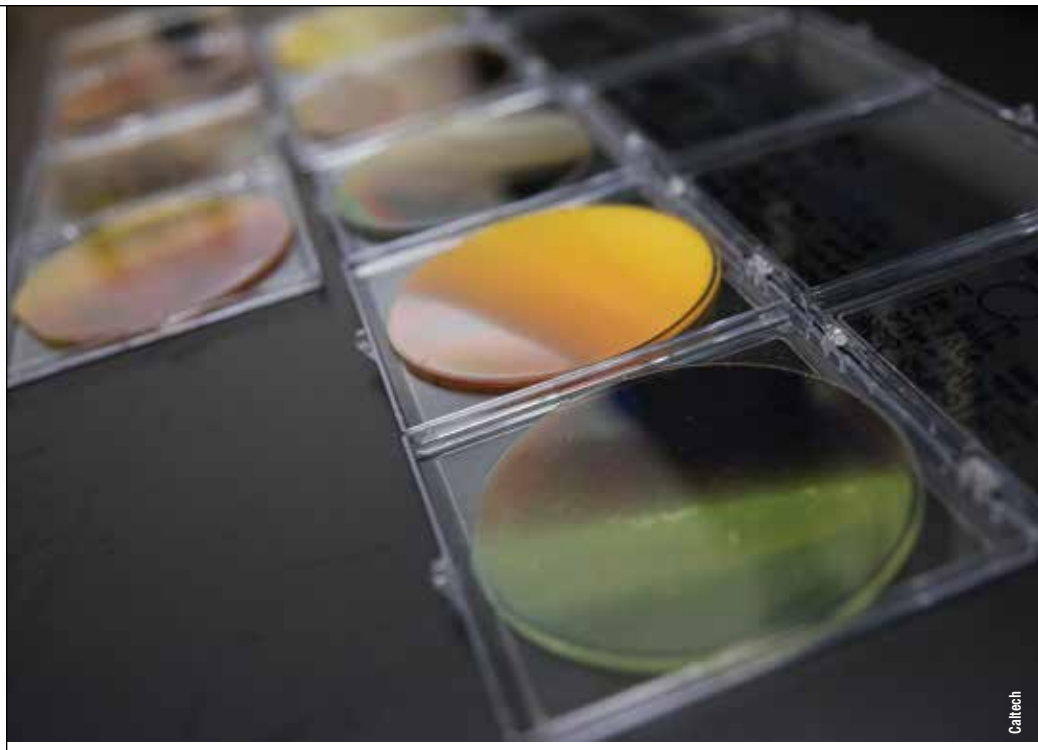


Courtesy the researchers

BIOMATERIALS

Artificial skin grafts

Putting the whole chicken-or-egg argument aside for a moment, Berkeley bioengineers recently participated in a study about how an organism's cells become specialized; in this case, they looked at the path followed by generic chicken skin cells as they developed into feather follicles. The study — done in collaboration with Amy Shyer, Alan Rodrigues and Richard Harland from the molecular and cell biology department — grew skin taken from a week-old egg atop engineered materials. Many of these materials were generated by graduate student **Elena Kassianidou,** who works in bioengineering professor **Sanjay Kumar's** lab investigating the role of mechanical forces on the biology of cancer and stem cells. The study's findings could provide tips on how to grow artificial skin for grafts that looks like normal human skin, complete with hair follicles and sweat pores. Just the right tension on growing skin could set up these organized structures without the need to add chemicals to trigger them.



Caltech

ENERGY

Materials genome to solar fuels

It took four decades for researchers to find 16 photoanodes, or materials that will generate electrical current in response to light. But using a new set of research tools, a team from Berkeley Lab and Caltech, including materials science and engineering professor **Kristin Persson,** has recently identified 12 more. The discovery is significant because photoanodes hold promise for creating solar fuels by converting sunlight, water and carbon dioxide into a usable form of energy without creating noxious emissions. But maybe even more significant is the method by which the new photoanodes were found. Using Berkeley Lab's Materials Project — which Persson directs — and in collaboration with the Joint Center for Artificial Photosynthesis, the Molecular Foundry and the National Energy Research Scientific Computing Center, the researchers were able to mine the Materials Project database for good solar fuel candidates. Then using a high-throughput theory-experiment pipeline, the team was able to quickly identify, synthesize and test the best candidates, a process that holds promise for future materials research.

HEALTH

Needleless vaccines

Imagine giving yourself a vaccine, using a needleless technology that jet releases a stream of vaccine inside your mouth. This may soon be possible, thanks to technology developed by Berkeley researchers. A recent study demonstrated that their portable technology, called Mucojet, effectively delivers vaccine-sized molecules to immune cells in the mouths of animals. Although the study did not test vaccine delivery in people, MucoJet is a step toward improved oral vaccine delivery, which holds the promise of building immunity in the mouth's buccal region of cells, where many infections enter the body. Data suggests that the MucoJet can trigger an immune response that is as good as or better than delivery with a needle, especially for mucosal pathogens. The researchers hope the MucoJet — developed by researchers in the labs of **Dorian Liepmann,** professor of mechanical engineering and bioengineering, and **Niren Murthy,** professor of bioengineering — can be available in five to 10 years.

Stephen McNally

HOW DO I FIND OUT MORE?

Find video, links to source articles and expanded coverage at **engineering.berkeley.edu/magazine.**

THE NEW ESSENTIALS

The future of engineering education

Engineering education at Berkeley isn't what it used to be

BY PHIL KAMINSKY

I recently met with bioengineering alumna Ann Lee-Karlon, senior vice president at Genentech and past president of the Association for Women in Science. We had a conversation about things that had changed on campus since she graduated in 1989. Some things, she told me, were the same at Berkeley — exceptional students, cutting-edge research, and, she was delighted to say, the same commitment to changing the world.

However, she said, the way we educate engineering leaders today has an entirely new look.

She is absolutely correct. To meet the needs of the 21st century, Berkeley Engineering has made critical and meaningful additions to our academic culture. We still provide the best, most rigorous technical education in the world — that will never change. Today, however, that's not enough. We are working to make sure that Berkeley engineers graduate with a new suite of essential skills and characteristics: leadership skills, an appetite for risk, flexible mindsets, the ability to integrate knowledge and experience working in diverse teams.

Phil Kaminsky is the Executive Associate Dean as well as a professor of Industrial Engineering and Operations Research.

THE NEW ESSENTIALS

To develop these qualities, we immerse our students in design thinking and the entrepreneurial mindset — fresh ways of looking at engineering challenges — and we do this starting on day one.

Imagine how a design problem engages creative students. In Jacobs Hall, the college's new design hub, some 3,000 students enrolled in courses last year to grapple with real-world problems and dream up solutions. Examples of these design-centered courses are intriguing. In the course Bringing Biomedical Devices to Market, students bridged the gap between proof-of-concept for a new device and landing an FDA-approved product in the marketplace. In the class Designing Technology to Counter Violent Extremism, students worked with the Department of State and other federal agencies to design and prototype ways to dispel extremism — including technology to enhance civic engagement, identify early signs of radicalization, remedy issues of discrimination and improve relationships with law enforcement. The students in Reimagining Mobility took on issues of how we interact with new modes of transportation, from car sharing to automation.

Today's Berkeley engineering curriculum also helps students develop an entrepreneurial mindset. Entrepreneurship is already a hallmark of the University of

Doug Birnbaum

"HOW IS IT THAT HE MAKES SUCH A LARGE CLASS FEEL PERSONAL?" SAYS STUDENT KEVIN LIN. "THAT IS WHAT JOHN IS FOSTERING HERE: NOT JUST GREAT COURSES OR A NEW GENERATION OF COMPUTER SCIENTISTS, BUT A SOCIETY OF CARING PEOPLE THAT TOGETHER MAKE COMPUTING EDUCATION ACCESSIBLE TO EVERYONE."

Teaching tech with tech

When John DeNero first started teaching an introductory computer science course — CS 61A: The Structure and Interpretation of Computer Programs — in 2011 as a part-time instructor, the class had an enrollment of about 500. Since then, DeNero has joined the electrical engineering and computer sciences faculty and this year was named the inaugural Giancarlo Teaching Fellow. And the course has grown dramatically. After a complete revamp to make the intro to computer programming more accessible without sacrificing rigor, and by fine-tuning how the course is managed, 1,686 students are enrolled this semester. The course is not only popular, but the learning experience also receives rave reviews from the students. To keep pace with the growing demand for computer science education, DeNero uses automated technologies and a small army of student instructors to make the course run. Grading software gives students feedback in real-time, so they don't have to wait for evaluations and instead can fix coding errors immediately while working through assignments. There are over 400 students involved in teaching the course: 55 teaching assistants are employed to lead course discussion and lab sections, and 48 course tutors are hired to lead small-group mentoring sections, grade assignments and host drop-in office hours. Another 301 academic interns help answer questions during lab and office hours. "One of the secondary goals of the course is to involve undergraduates in the teaching process," DeNero says. "The world is going to need a lot of computer science educators, and I think students really master the material when they teach it."

CS 61A / BY THE NUMBERS | TEACHING AT SCALE

1,686
Record enrollment for the intro course this semester (not including the waitlist)

349
Number of course tutors (48) and academic interns (301) who support the course

55
the number of teaching assistants employed to lead course discussion sections and lab sections

1
The Daily Californian named longtime CS 61A instructor, John DeNero, best faculty member in 2016

Top 5
CS 61A was listed among the top 5 computer science courses in the country by Bloomberg


Noah Berger


Roland Saekow


Roland Saekow


Roland Saekow

Design

Designing a new narrative

Two years ago, the Jacobs Institute for Design Innovation began offering courses in the new Jacobs Hall, attracting students from across campus interested in the intersection of art, technology, design and engineering. One of the major draws to Jacobs Hall is that students get to work with tools and machines to prototype and build their ideas and projects. "Students like hands-on education," says mechanical engineering professor Grace O'Connell. "It's fun to watch students throughout the process. In the traditional lecture style, the instructor gives an assignment, and then students turn it in and they are done. With design education, the process is more iterative. You have to figure out how to improve the assignment and then do it again, which I think is closer to life after college." This semester O'Connell, who studies the biomechanics of musculoskeletal tissues, taught an undergraduate course at Jacobs that focused on building medical devices. Forty-five students from various engineering disciplines partnered with Bay Area companies and nonprofits such as e-NABLE, a nonprofit that brings together individuals from around the world to create free 3-D printed prosthetic hands for those in need.

California; since 2010, 536 Berkeley students have launched 468 companies — by far the most of any public university and second among all universities. Although founding a company may not be the goal of every student, all of them will benefit from the ability to think like an entrepreneur: to strive for innovation, take risks, see value, rely on teams, learn from failure and question the status quo.

Our Sutardja Center for Entrepreneurship and Technology is a nexus for this training. There, students learn the traditional cornerstones of entrepreneurship — case studies, frameworks and tactics to give students a broad toolset to recognize opportunities, design products for market introduction, raise funds, devise business models and understand sales and marketing.

But we go beyond that, through a uniquely Berkeley method of teaching entrepreneurship. Over years of study, we have found that the best entrepreneurs share a set of behaviors — they give and accept help, collaborate, communicate through stories, trust others, seek fairness, are resilient, have diverse personal networks, understand that "good enough" is fine when time and resources are limited and believe that they can change the world. Students develop this mindset at Berkeley through games and exercises that teach trust, risk assessment, effective communication, overcoming social barriers and dealing with rejection and failure.

How does this work? In one exercise, students take to the streets of downtown Berkeley with an assignment: convince random strangers to give you their shoes. This is a sure-fire way to learn how to deal with failure. With a video recorder running, the students make their pitch and, if rejected, they move on, refining their appeal for the next person. One of our teams encountered Berkeley professor and former U.S. Secretary of Labor Robert Reich — he was so impressed with the students that he actually agreed to hand over his shoes.

TEACHING, TODAY AND TOMORROW

Design, entrepreneurship and other teaching innovations are now foundations of a Berkeley engineering education — and we continue to build on that foundation.

New interdisciplinary courses are emerging, many that make use of the studio and maker spaces in Jacobs Hall. At the Sutardja Center's new "collider

space" at California Memorial Stadium, ideas are born through the "collision" of students, entrepreneurs, venture capitalists and managers — different people from different worlds. In challenge labs, student teams compete to find solutions to big challenges, from alleviating the refugee crisis in Greece to developing the best mobile health app. Undergraduate research opportunities are on the rise; one program in civil and environmental engineering, funded by donors, offers top freshman admits a chance to work alongside faculty and graduate students in a lab — a great experience for a budding engineer and a terrific tool for recruiting the best to Berkeley.

Our journey toward inventing the future of engineering education is far from over. At Berkeley we're working to answer big questions for tomorrow's students:

• *How can we integrate engineering with other fields?* Technology today is critical in every field. Understanding it and embracing the new essentials needs to be part of the core curriculum for all 21st century students. We've begun to explore the idea of "Engineering + X" majors that combine engineering with unexpected disciplines across campus. Our new Management, Entrepreneurship, & Technology (M.E.T.) program is giving us experience with the power of such combinations, allowing exceptional students to earn Berkeley degrees in both business and engineering in four years of (hard) work.

• *California and the world need engineers — how do we meet the demand from students and employers?* Today's students don't see their instructor as the "sage on the stage" but rather as the "guide on the side." Some prefer to view lectures online, later exploring the material in depth with instructors in small classroom sections. We're getting very good at this way of teaching, and it helps us meet the burgeoning student demand in many of our popular courses. For example, CS 61A, The Structure and Interpretation of Computer Programs, enrolls up to 1,700 students a semester, yet it is always top-rated. How is this possible? We deploy one of the campus's top teachers, innovative technology to give students instant feedback on their work and creative approaches to discussion sections and advising.

Entrepreneurship

Creative teaching

Today, many dominant and innovative big brands — such as Amazon, Tesla and Google — are led by engineers. So it makes sense to teach engineering students how to build and run companies. But for Ken Singer, managing director of Berkeley Engineering's Sutardja Center for Entrepreneurship and Technology (SCET), the need to educate engineers about entrepreneurship has a more urgent reason. "Recent advancements in technology — AI, autonomous vehicles, blockchain — will change the entire topography of employment," says Singer. "If we don't teach students to adapt to the future, then we are training a generation of unemployable engineers." Traditional education is often about knowledge transfer, with systems designed to reinforce, test and evaluate based on existing knowledge. But for Singer and his SCET colleagues, just transferring information isn't enough. Instead, they designed the curriculum to foster self-directed learning and creativity. "Students are comfortable being creative if they feel like they won't be judged for failing," he says. "We measure the attempt, not the outcome, and we grade them on what they say they learned, not if they can recite back our lecture notes."

Noah Berger

• *How do we prepare our students for the changing future of work?* Technology being invented today will dramatically and rapidly change the way we work. To prepare for this uncertain future, we must produce lifelong learners with strong, adaptable skills. The people who succeed in this environment will be connected, flexible, creative, smart, entrepreneurial — and will have deep technical competence. Our teaching must help today's graduates react to technological shifts during their careers. And it's not just engineers who will face this changing future — we are gearing up to educate not only the finest engineers but to expand our reach across the Berkeley campus and beyond, offering training for non-engineers that will make for more technology-literate and savvy citizens.

• *In a world in flux, how do we continue to educate engineers throughout their careers to use the latest technologies to benefit the public good?* At Berkeley, we are committed to deepening our focus on continuous education for working professionals and on offering professional master's degrees like those we have pioneered in our Fung Institute for Engineering Leadership. Through both professionally-oriented graduate studies and continuing education, we must teach engineers not only to conceptualize new technologies but also about their impacts and consequences; equitable use and availability; legal and ethical implications; and their successful integration into existing or new industries. To be sure, our new directions in teaching design, entrepreneurship and innovation can serve us well in these arenas. Our students must also learn how design systems that incentivize behaviors to benefit society, and to embrace the important legal, ethical and moral responsibilities that come with implementing new technology.

We believe in the transformative power of a Berkeley education, and we're excited about the new directions we've forged for Berkeley engineers. Innovating the future is what Berkeley Engineering does best: with innovations in how we educate engineers, our graduates will have the tools to shape that future. BE


Roland Saekow


Matt Beardsley


Golnaz Shahmirzadi

"DESIGN, ENTREPRENEURSHIP AND OTHER TEACHING INNOVATIONS ARE NOW FOUNDATIONS OF A BERKELEY ENGINEERING EDUCATION — AND WE CONTINUE TO BUILD ON THAT FOUNDATION."

Noah Berger

2010+

David Breslauer (Ph.D.'10 BioE) is the co-founder and chief scientific officer of Bolt Threads, a company that uses the science behind spider silk to produce garments. The company recently announced a limited-release tie collection that garnered extensive media attention; future plans include a collaborative project with Patagonia.

Raghav Chandra (B.S.'11 EECS) founded UrbanClap, a startup that aims to optimize the on-demand services sector in India. UrbanClap aggregates 107 local services and 65,000 providers, enabling customers to request services through its website or mobile application. Previously, he was a software engineer at Yelp and Twitter; he also founded the startup Buggi.

Baiyu Chen (B.S.'14, M.S.'15 CEE) and his research partner, Anthony Barrs, won the top prize for their design of "Hyperlane," a highway system that features a reserved lane for self-driving cars to travel at high speeds. The pair were awarded a $50,000 prize at the Infrastructure Vision 2050 Challenge by transportation experts, who believe this idea could be achieved as soon as 2050.

Kathryn Cook (B.S.'10, M.S.'11 MSE) leads a Facebook team that is creating solar-powered drones to deliver Internet access to remote areas of the world.

Patrick Goodwill (Ph.D.'10 BioE) is the co-founder and CTO at Magnetic Insight Inc. The medical imaging startup was recently selected by the Angel Capital Association for the 2017 Luis Villalobos Award for ingenuity, creativity and innovation.

Kaleb Hatfield (M.Eng.'16 NE) studies radiation and transport at Tri Alpha Energy, using physical and computational analysis of current and future nuclear fusion devices. In a February interview posted on Medium, he described his work and responded to public concerns about nuclear energy.

Lavanya Jawaharlal (B.S.'16 ME) is the president and co-founder of STEM Center USA, which received a $50,000 small business grant to further their mission to help children learn about science, technology, engineering and math (STEM), close the gender gap and enrich the lives of children through innovation. STEM Center USA was also featured on an episode of *Shark Tank.*

2000+

Sarah Bergbreiter (M.S.'04, Ph.D.'07 EECS) is an associate professor in the Department of Mechanical Engineering and Institute for Systems Research at the University of Maryland in College Park. She is also the director of the Maryland Robotics Center and oversees both the Micro Robotics Lab and the Robot Realization Lab. Her research interests include micro-robotics, microelectromechanical systems, microactuators, soft robots and millimeter-scale power systems. She has received many accolades — including NSF CAREER, DARPA Young Faculty and PECASE awards — and was named one of "25 Women in Robotics You Should Know About" by the robotics website Robohub.

EECS Distinguished Alumni Award

Anantha P. Chandrakasan (B.S.'89, M.S.'90, Ph.D.'94 EECS) has been named dean of MIT's School of Engineering. Earlier this year, he received Berkeley's Electrical Engineering Distinguished Alumni Award.

PHOTO BY PATSY SAMPSON

Dawn Tilbury to head NSF Engineering Directorate

Dawn Tilbury (M.S.'92, Ph.D.'94 EECS), a mechanical engineering professor at the University of Michigan, will lead investments in fundamental engineering research and education as the newly-appointed head of the National Science Foundation's Directorate for Engineering. Prior to her appointment, Tilbury was the associate dean of research at the University of Michigan's College of Engineering. She joined Michigan's faculty in 1995, where her research has spanned distributed control of mechanical systems with network communication, logic control of manufacturing systems, reliability of ground robotics and dynamic systems modeling of physiological systems. She was elected an IEEE fellow in 2008 and an ASME fellow in 2012.

PHOTO COURTESY JOSEPH XU, MICHIGAN ENGINEERING COMMUNICATIONS & MARKETING

VR maker named to "30 under 30" list

Han Jin (M.Eng.'12 IEOR), founder and CEO of Lucid VR, was recently named to Inc.'s "30 under 30" list. Lucid VR's first product is the LucidCam, a virtual reality camera that lets users capture the world in 3-D. Geared toward the average consumer, the camera converts the world it sees into 3-D photos or videos that can be viewed through Google Cardboard, Lucid's $30 phone case and other VR devices. The LucidCam acts like a GoPro in that it captures experiences from the user's point of view. Jin personally uses the LucidCam to stay in touch with his family around the world. Since completing the M.Eng. program in 2012, Jin has lectured at Berkeley and worked closely with the start-up incubator, SkyDeck. In August, **Jack McCauley** (B.S.'86 EECS), a co-founder of the virtual reality company Oculus, joined Lucid VR as chief engineer.

PHOTO BY GOLNAZ SHAHMIRZADI

Lizzie Blaisdell Collins (M.S.'05 CE) received the 2016 Earthquake Engineering Research Institute's Shah Family Innovation Prize for her creativity, innovation and entrepreneurial spirit. A specialist in earthquake risk mitigation and management, she is the director of engineering for Build Change and leads the technical development for supporting cities in implementing disaster mitigation programs.

Khalid Kadir (M.S.'02, Ph.D.'10 CEE), a lecturer at Berkeley, was honored at the 58th Annual Distinguished Teaching Award ceremony on campus for his inspiring teaching. He teaches courses for the Global Poverty and Practice program and the College of Engineering. While doing research for his Ph.D., he received a Fulbright Fellowship to work on wastewater treatment systems in Morocco. He was chosen to be a Chancellor's Public Scholar in 2013 to create and teach an interdisciplinary engineering course, and was also awarded the Chancellor's Award for Public Service for Service-Learning Leadership in 2014.

Andrew Ng (Ph.D.'03 CS), chief scientist at Baidu, is an adjunct professor at Stanford University, where he is the founder and leader of the Google Brain project, which develops massive-scale deep learning algorithms. In 2011, he led the development of Stanford University's Massive Open Online Courses (MOOC) platform, which led to the founding of Coursera to offer high quality online courses at universities all over the world.

1990+

Eleanor Allen (M.S.'97 CEE) is the CEO of Water for People, a nonprofit that aims to provide sustainable, long-term access to high-quality drinking water and sanitation services throughout the world. She was recently awarded the prestigious WEF Fellows designation by the Water Environment Federation.

Yoky Matsuoka (B.S.'93 EECS) was featured as one of Interesting Engineering's "17 Awesome Women Engineers" in 2017. She is currently working at Google's parent company, Alphabet, as the CTO of Nest.

1980+

Charles Giancarlo (M.S.'80 EECS) is the new chief executive and member of the board at Pure Storage. Most recently, he was a senior executive at Silver Lake Partners. He is also a member of the Berkeley Engineering advisory board.

Yongdong Wang (M.S.'88, Ph.D.'92 CS) has been named global senior vice president of Microsoft. He is currently the CTO of the Microsoft Asia-Pacific R&D Group; previously, he served as the vice president of engineering at Yahoo.

Denis Shing Fai Yip (B.S.'89, M.S.'91 EECS) is the CEO of Digital China Holdings Limited, focusing on integrating big data and cloud computing technologies into the company's industrial system. Previously, he served as president of EMC Greater China. He has been working in the information management, software and global sales industry for 26 years, and has been a key figure in the integration of DELL and EMC in the greater China region.

1970+

Sanjay Mehrotra (B.S.'78, M.S.'80 EECS) is Micron's new president and CEO. Previously, he co-founded SanDisk, later joining Western Digital when it acquired the company in 2015. He holds 70 patents in flash memory systems and volatile memory design.

1960+

Charles Jennings (B.S.'62 CEE, B.Arch.'67) is the principal architect for the expansion of McKeon Pavilion at Saint Mary's College in Moraga. Previously, he worked on the Golden State Warriors Practice Facility in Oakland, the West County Times Building and Kaiser Hospital in Redwood City. He has been practicing architecture in the Bay Area for over 45 years with both Charles F. Jennings Architects and Polytech Associates.

New campus hotspot

The Berkeley Engineering community has an inviting new space for meetings and collaboration following the grand opening of the V&A Café in Etcheverry Hall over the summer. The café, located on the third floor near the breezeway between Etcheverry and Soda halls, was made possible by a generous donation from **Andrew** (M.S.'72, Ph.D.'78 IEOR, M.B.A.'76) and **Virginia Rudd.**

PHOTO BY NOAH BERGER

Dubón appointed Vice Chancellor for Equity and Inclusion

Oscar Dubón (M.S.'92, Ph.D.'96 MSE), formerly the Associate Dean for Equity and Inclusion at the college, was recently appointed Berkeley's next Vice Chancellor for Equity and Inclusion. He will lead the Division of Equity & Inclusion in broadening programmatic access; creating equitable experiences for students, staff and faculty; ensuring a welcoming campus climate; and facilitating, advising and consulting with the campus on issues of diversity, equity and inclusion. Earlier this year, he received the Chancellor's Award for Advancing Institutional Excellence and Equity as a record of his accomplishment in promoting diversity and inclusion throughout UC Berkeley. During his time as Associate Dean for Equity and Inclusion, he established the Center for Access to Engineering Excellence, which offers programs and support for engineering students from underrepresented backgrounds.

PHOTO BY NOAH BERGER

BERKELEY 150 1868 ★ 2018

In 2018, Berkeley Engineering — along with the UC Berkeley campus — will mark its 150th anniversary. Look for a year-long series of special events and programs to be announced in early 2018 at **engineering.berkeley.edu.**

Charles "Chuck" Thacker (B.A.'67 Physics), a pioneer in the development of the personal computer and computer networking, died in June at age 74. In 1968, he joined the Department of Electrical Engineering's Project Genie team, which built an early computer time-sharing system; he and others eventually left to form the Berkeley Computer Corporation, where Thacker led the design of a new computer processor and memory system. He later was project leader of the team at Xerox PARC (Palo Alto Research Center) that built the Alto, the first modern personal computer. Alto had a revolutionary graphical user interface, which was used by Apple and Microsoft in making the Macintosh and Windows operating systems. He was also co-inventor of the Ethernet local-area network, and was a key contributor to the first laser printer. In 1983, he helped start Digital Equipment Corporation Systems Research Center, where he led the hardware development of Firefly, the first multiprocessor workstation. He then joined Microsoft's Tablet PC group in the late 1990s, where he oversaw the design of the first prototypes. In 2009, Thacker received the Turing Award, considered to be the "Nobel Prize in Computing," for his many contributions to modern computing.

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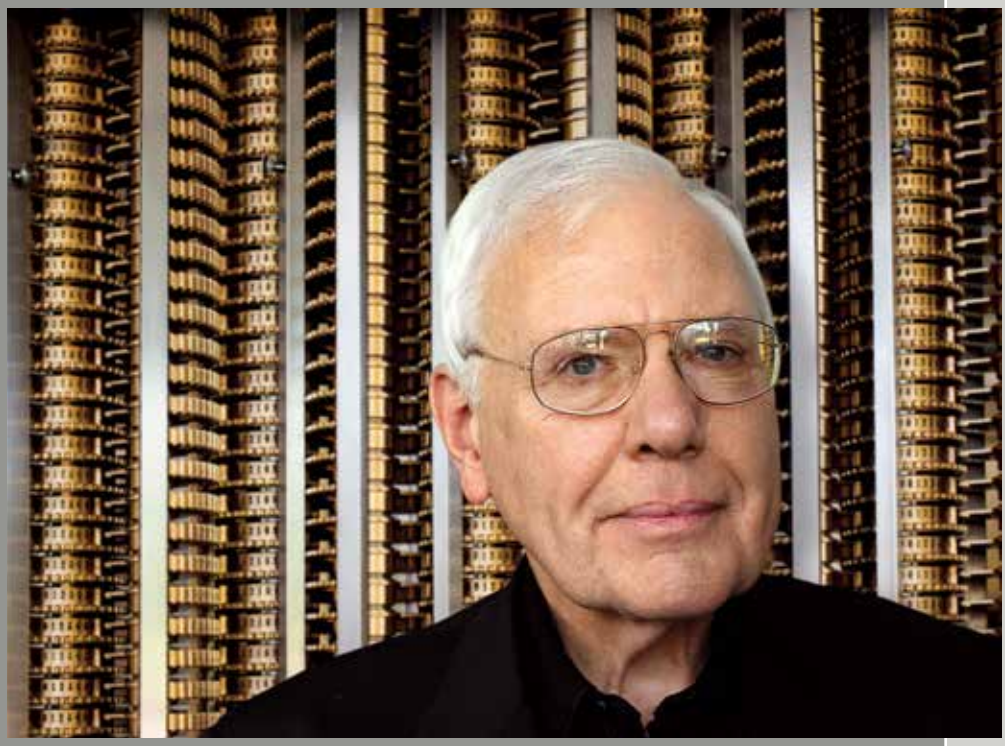

Robert Warren Bixler (B.S.'48 EE) died in December at the age of 96. He served as a weather officer in World War II and started his career at the Pacific Telephone Company. He was one of the first engineers to develop microwave transmission stations in Nevada. After retiring in 1980, he became a financial planner and investment adviser.

Gary Dean Hornbuckle (B.S.'61, M.S.'62, Ph.D. '67 EECS) died in March at age 77. He worked on the research staff at MIT before launching several companies, including Applicon, IMPRES and Hornbuckle Engineering. By the time he retired in 2000, he had served as president of five technology companies in Texas and California.

Dennis Jang (M.Eng.'82 CE) died in June at age 62. He was a senior vice president and structural engineer at T.Y. Lin International, which he joined in 1987. He served in key leadership roles for projects including the Panama Canal Fourth Crossing, San Francisco-Oakland Bay Bridge East Span, Arthur Ravenel Jr. Bridge and Taiwan's high-speed rail project.

Lyle Morris Jenkins (M.S.'57 CE) died in September at the age of 84. He served as an officer in the U.S. Navy before a 40-year career at NASA.

James H. Kleinfelder (B.S.'56, M.S.'64 CE) died at age 82. He founded his own geotechnical and materials testing company, J.H. Kleinfelder and Associates, which grew to have more than 600 employees and annual revenues of $37 million. He also taught engineering at the University of the Pacific. A member of the American Council of Engineering Companies and the American Society of Civil Engineers, he served as president of the Hazardous Waste Action Coalition and the Associated Soils and Foundation Engineers.

Stephen "Quon Chew" Lee (B.S.'51 CE) died in March. A member of two civil engineering honor societies, he worked for CalTrans for 39 years, serving as project engineer on the Caldecott Tunnel Third Bore, among many other projects.

John Everett Noble (M.S.'79 MSE) died in September. After Berkeley, he earned additional master's degrees from the University of Tulsa and the University of Houston-Clear Lake. He worked for the U.S. Forest Service, Philips Petroleum and Advantek, and later became a high school chemistry teacher.

William R. Prindle (B.S.'48, M.S.'50 Physical Metallurgy) died in December at the age of 90. He served in the U.S. Navy in World War II before attending Berkeley, and then earned his Sc.D. in ceramic engineering from MIT. He began his career with the Continental Can Company and retired in 1992 from Corning International as division vice president. He was once president of the International Commission on Glass and had been named a distinguished life member and fellow of the American Ceramic Society and Glass Man of the Year, among other accolades.

Llewellyn K. Rabenberg (M.S.'80, Ph.D.'83 ME) died in November at the age of 60. He began his 30-year academic career at the University of Texas, where he specialized in electron microscopy.

Frank Nguyen, B.S.'84 ME

A lasting legacy

When Frank Nguyen (B.S.'84 ME) thinks back on his experience at Berkeley, he is grateful for the tremendous personal growth, intense academic challenges and lifelong friends that he made here. But one of the highlights of his undergraduate years was the opportunity to work and conduct research in mechanical engineering professor David Dornfeld's lab for nearly two years.

Professor David Dornfeld, 1949-2016

This year, Nguyen decided to establish an endowed scholarship fund for mechanical engineering undergraduates in memory of Dornfeld, as a meaningful way to acknowledge his mentor's leadership, help and kindness.

"I cannot tell you how fortunate I am, from being airlifted out of Vietnam at the war's end [in 1975], to having the opportunity to go to one of the greatest universities, to having a long and satisfying career in technology," says Nguyen, who himself had benefitted from an undergraduate scholarship and graduate fellowship. "I want younger people to have the same opportunities that I did."

Thanks to his mentor, Nguyen understands how education can be life-changing. His gift honors the impactful contributions of Dornfeld — and forever connects that legacy to exceptional Berkeley Engineering students.

You, too, can create a legacy gift that benefits students and faculty at Berkeley Engineering while offering tax and other economic benefits for yourself and your family.

To learn more, contact Engineering College Relations at (510) 642-2487 or visit **engineering.berkeley.edu/give**.

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NOAH BERGER PHOTO

Looking into the future

CalSol, the UC Berkeley Solar Vehicle Team, took top prize this summer at the Formula Sun Grand Prix in Austin, Texas. Racing with their eighth-generation solar vehicle, Zephyr, the team bested 18 other college teams in the annual solar vehicle endurance track race. CalSol also won the Best Teamwork Award for their outstanding performance.

Your gift to the Berkeley Engineering Fund supports students such as these as they design, invent and collaborate — both in and out of the classroom.

Learn more and make your gift at: **engineering.berkeley.edu/give.**

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