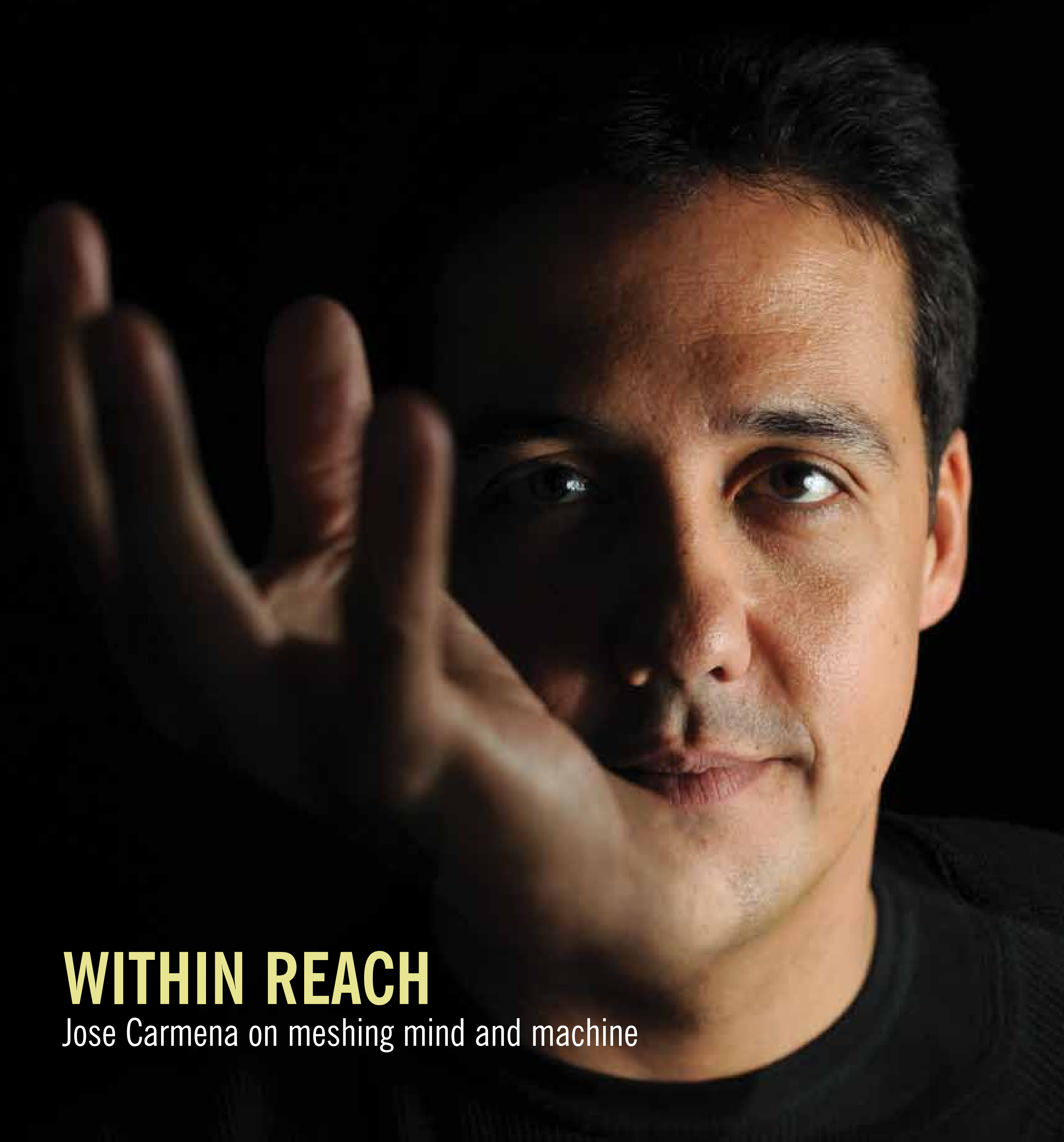
College of Engineering
University of California, Berkeley
Fall 2012
Volume 2

A new loo
Creating safe sludge

Next-generation drug nanocarriers

Smart microgrids in India

Berkeley ENGINEER



WITHIN REACH

Jose Carmena on meshing mind and machine

Innovation by design

Step into room 122 of Hesse Hall on a weekday afternoon, and you're likely to see more than 100 freshmen building—and then bending, melting and even breaking—their own product prototypes.

No, we're not teaching students how to be destructive. Rather, we are introducing engineers to some unfamiliar behaviors: creative problem-solving using intuition, guesswork and a cheerful tolerance of failure.

Designers call this "the art of planning in the absence of complete information." Here at Berkeley Engineering, we think it's high time to embed the design discipline, and its own vocabulary and ways of thinking, into the engineering curriculum. That's why we've enrolled 108 freshmen—far more than we initially expected—in a completely retooled class called E10: Introduction to the Design Cycle. The class is taught singlehandedly by Albert Pisano, a senior member of our mechanical engineering faculty as well as an ardent advocate for sparking creativity in engineering.

To make a device that measures the flexibility of plastic components, for example, the E10 students start by designing a computer model with CAD software. They'll "print" the polymer prototype on a 3-D printer and then subject it to a series of tests. Throughout the process, they extemporize, iterate and ask a lot of questions.

"It's more important that these questions get surfaced and asked than it is for them to be answered," Al tells me. From the outset, the students are confronting issues related to user experience, sustainability, scalability and cost. "We're completing their education by giving them a contextual framework," he says.

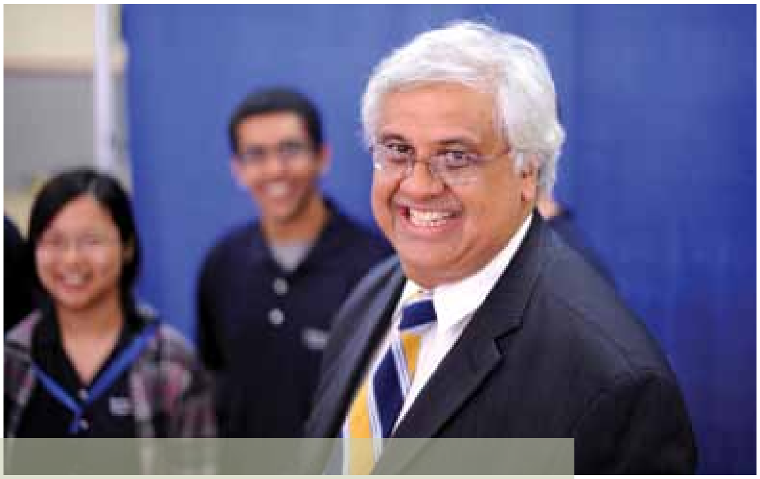
This hands-on immersion in design will not be limited to the freshman year. Across the curriculum, and in all departments, we want to see our students gaining experience in "design studios" that enable them to build and critique innovative prototypes, from tools and products to entire infrastructures.

And, because of Berkeley Engineering's strengths on the manufacturing side, our students will learn how to convert prototypes into market-ready solutions. Our corporate partners tell us they want graduates "who can make things," and we are happy to oblige.

Clearly, the U.S. economy will prosper only if we outfit workers with advanced skills in design and manufacturing, from robotics to nanotechnology. The jobs of the future will not be on the factory assembly line, but in designing and building what's in the factory. We're proud to be meeting this challenge with Berkeley's own blend of ingenuity, creativity and bold ambition.

"The jobs of the future will not be on the factory assembly line, but in designing and building what's in the factory."

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



Noah Berger

WELCOMING THE CLASS OF 2016: Dean Sastry led off engineering student orientation this fall, welcoming 618 freshmen and 242 transfer students, representing 35 states and 25 countries. Women make up nearly a quarter of the freshman class.

in this issue

Bellamy Pailthorp/KPLU 88.5 Seattle

MORE >

COVER PHOTO NOAH BERGER

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Clark Chen

Civil engineering student **Arquimedes Ponce**

STEEL BRIDGE

Fabricating the *ApoCALypse*

Berkeley's Steel Bridge Team, based in the civil and environmental engineering department, competed against 600 students from 47 engineering schools this May to win the 2012 national Steel Bridge title.

The hard-fought victory came after a crushing blow at last year's competition, when the Cal team was disqualified after failing the lateral load test. The setback weighed heavy on the young engineers, and this year the students redoubled their efforts to win or place in many categories, leading to an overall victory.

The 35-member team named their bridge design the *ApoCALypse*. Built at a 1:10 scale, the bridge is a series of interlocking parts that when fitted and fastened together create a structure that is 22.5 feet long, weighs 131 pounds and is able to hold 2,500 pounds.

Entries were judged on stiffness, lightness, display, efficiency, economy and speed. Besides solid engineering, the team's success depended, in large part, on how well they worked together to assemble the bridge quickly and accurately.

WEB EXTRA > Hear more from *ApoCALypse* project manager **Sabrina Odah** (B.S.'12 CEE) in a short video at **YouTube.com/berkeleyengineering.**

COMMENTS

"...!"

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

"Introducing *Berkeley Engineer*," coe.berkeley.edu/berkeleyengineer:
The new *Berkeley Engineer* is a wonderful way of keeping us remote alumni up-to-date on Berkeley engineering passion. Go Bears!
—**Gregory W.,** via Facebook

Just got the premiere issue of *Berkeley Engineer*. Looks great, @Cal_Engineer team!
—**OaklandDD,** via Twitter

New magazine format is great! Keep it up.
—**Anthony Johnson '60,** via mail

Since we are moving to an era of new technology, I think an iPad app that links to a readable magazine would be a good direction for this type of periodical.
—**Danilo R.,** via e-mail

"Steel bridge team wins nationals," innovations.coe.berkeley.edu:
Wow! It's awesome, guys! Keep going, Steel Bridge Team!
—**flash-mob,** via *Innovations*

SO excited for Cal's win. Great job, guys. This team has come a long way—your hard work has paid off!
—**Nathan,** via *Innovations*

"UC Berkeley joins not-for-profit online learning collaborative," Berkeley NewsCenter:
Professors Fox and Patterson are great, plus the material is very exciting. This class is def worth spreading out to the world!
—**Benjamin R.,** via Facebook

HOW DO I FIND OUT MORE?
Find links to source articles, news details and expanded coverage through the college website at **coe.berkeley.edu/berkeleyengineer-links.**

POLICY

Decisions, decisions

It has been a busy year for the Berkeley developers of the new web app, Politify. It was only October of 2011 when Nikita Bier, then a political economy and business major, approached **Jeremy Blalock,** a second-year EECS student, to collaborate on an easy-to-use app to analyze public policy. They developed a non-partisan tool that enables voters to evaluate the costs and benefits of each presidential candidate's promised policies.

"I joined this project because a lot of the news media just deals with the points that they can cover best, which are the soft points," says Blalock. "Politify really presents the flip side of the scale, the economic side of politics. When I listen to NPR I hear a lot of interesting information, but I don't hear how it will affect me, which is a very relevant thing to consider when voting."

Politify curated and parsed open data from the Internal Revenue Service and the Census Bureau, then overlaid economic models from the Tax Policy Center. The result is an economic forecast that shows the candidates side-by-side. The analysis is broken down to the individual level, the local level and national level. The cost and benefits of the candidate's position change based on user-inputted income, tax filing status and zip code.

In the run-up to the election, Politify had received over a million views. Post-election, they plan on continuing the project. "We want this to be applied to other things down the road, and we think this can be used for other policies," says Blalock. "Our overarching goal is to make a more informed voting public. If we can make people more informed, then they will be more engaged."

TRANSPORTATION

Rerouting behavior

Raja Sengupta and **Joan Walker**, both associate professors of civil and environmental engineering, are tackling traditional challenges in transportation planning with a decidedly nontraditional approach—a blend of behavioral theory and smartphone technology. With their latest project, the Quantified Traveler app, the research group is trying to quantify what influences travel behavior and learn how to encourage more sustainable travel.

Conventional transportation models are based on assumptions of rational choice and measured in terms of time and money: build a faster and cheaper train, the logic goes, and people will use it. But travel decisions are often irrational. Routine, peer influence and indelible memories of ill-fated public transportation trips override economic self-interest. But irrationality doesn't have to mean chaos.

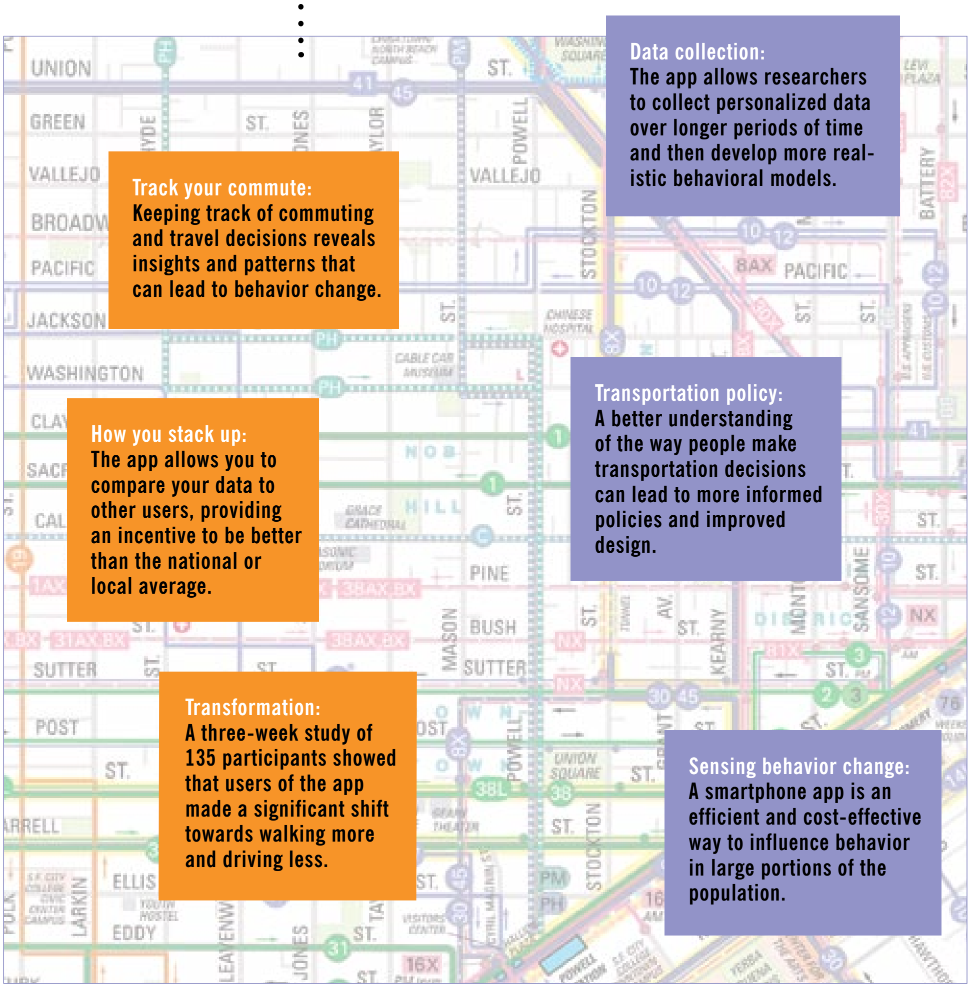
"There's a rhyme and reason behind irrationality," says Walker. "People are processing the information differently. A lot of habit and experience goes into making these decisions."

And since they are not chaotic or arbitrary, travel decisions can be tracked and quantified.

Understanding behavior requires data, which until now came from paper surveys of sample populations and cost millions of dollars. By comparison, a sensing phone app obtains individualized, real-time data with very little cost.

"This takes transportation systems data collection into the big data era," says Sengupta.

The Quantified Traveler app gives users personalized information about their transportation decisions while collecting travel footprint data for researchers.

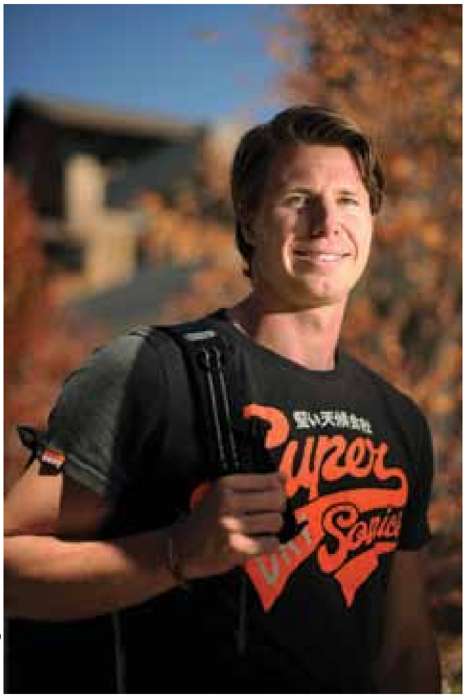


Courtesy San Francisco Municipal Transportation Agency

PROFILE

Olympic-caliber engineer

Olivier Siegelaar's two passions—engineering and rowing—drew him to the Berkeley campus from the Netherlands four years ago. The mechanical engineering student and Cal crew team member competed in the 2012 Summer Olympics in London, where he represented his home country in the heavyweight men's eight rowing event. A competitive rower since the age of 15, Siegelaar had this to say about his experiences as an Olympian and student-athlete:



Noah Berger

On the Olympic final: "We ended up fifth in a race that has never been so close in an Olympic final. We missed out on a medal by 0.5 seconds in a six-minute race. The disappointment was absolutely there, looking at the hours, effort and pain we had put into this final competition. The good thing was that it was our best race so far, and that we left no stone unturned. Unfortunately, it was not enough, but this is part of the sport—and makes it as beautiful as it is."

On Olympic highlights: "Everything. From the first until the last second of it. It was one amazing experience on an intensity you will only get at the Olympics. No event or anything I have done in my life could be compared with the thrill and extremely intense excitement I felt in those two weeks."

On balancing school and sport: "It has everything to do with devotion and willpower. You just have to do it, period. I woke up at 5:30 a.m. to leave for practice at 6, I would come back at 9 to have breakfast and get ready for my classes starting at 10. Then at 4, I would run out of class and jump into the van for the second practice. I would come home around 7 to get some dinner, and then around 9 would sit behind my desk to start learning my midterm or assignment for the next day. It all sounds worse than it was—because I also had time to meet up with friends—but when I had to work, I would work. Since two practices a day take a lot of energy, I certainly had my unintended (but rather nice) naps in some of my classes."

On his enthusiasms: "The core things I love about rowing and engineering differ in a substantial way. In rowing, I love the competition, the suffering, the challenge, the pressure, the extreme team bond. The main thing for me in engineering is the complex puzzling and analytical thinking that is required to solve problems. The only one connection that really matters is that in both worlds I am surrounded by really gifted achievers."

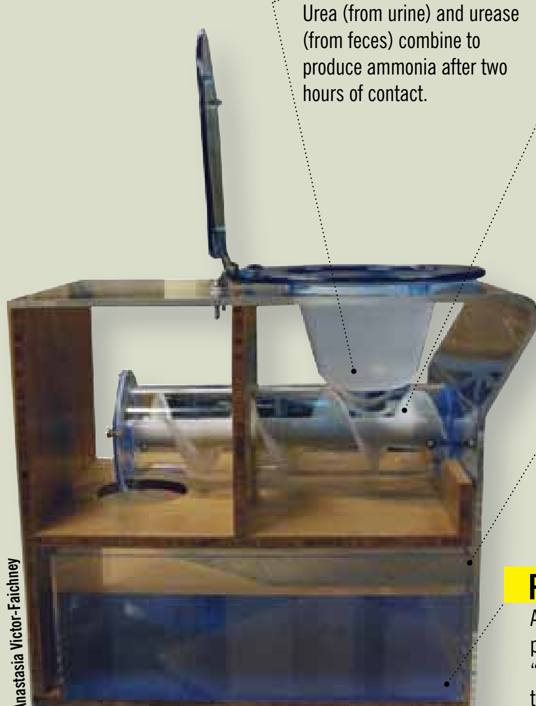
PUBLIC HEALTH

A new loo

Aiming to improve sanitation services in developing countries, the Bill and Melinda Gates Foundation challenged engineers to make toilets clean, affordable and sustainable for the 2.5 billion people—40 percent of the world's population—who lack access to modern latrines. In response, environmental engineering professor **Kara Nelson** and postdoctoral researcher **Temitope Ogunyoku** developed a toilet that safely disinfects waste.

Called the pHree Loo, their design uses a two-step process that raises the pH of the excreta to inactivate harmful pathogens. The resulting waste, or "safe sludge," can then be disposed of without endangering humans or the environment. Their goal is for each toilet to cost less than $50.

Over the next year, the researchers plan to refine their design, test it under actual use conditions and investigate ways to incorporate their solution into existing waste management systems. The display model, shown here, was designed to be transparent to show the toilet's inner components.



Anastasia Victor-Faichney

Q+A on revolutionizing online education

In July, Berkeley announced its partnership with the online education program edX. Based at MIT and formed in collaboration with Harvard, edX is a non-profit organization that aims to increase access to top universities and develop best practices for creating, delivering and scaling free interactive lectures to students worldwide.

Collectively called Massively Open Online Courses (MOOCs), the new digital format also provides alumni and working professionals with the opportunity to stay current on emerging technologies. Several of the college's faculty helped develop open-source MOOC platforms or were early adopters of the format.

Berkeley Engineer sat down with computer science professor **Armando Fox**, academic director for the newly launched Berkeley Resource Center for Online Education, to learn more.

Noah Berger

Diana Wu, dean of Berkeley Extension, and EECS professor **Armando Fox** head up the newly launched Berkeley Resource Center for Online Education (BRCOE), as executive director and academic director, respectively.

How did this start?

Last semester a couple of Stanford professors were starting an online education venture and asked us to adapt our "Software as a Service" course for the online format. They had put together a number of ingredients, and there seemed to be something important there; the idea that this isn't self-paced; there are deadlines. All of the students are working on the assignments at about the same time, and so they have forums where you can ask questions. Ultimately the students feel like they are part of a group.

What are the challenges?

There are some logistical challenges that we didn't anticipate. We did figure out an easy way to install the required software on 28 different types of machines and 10 versions of Windows. And we can manually grade 100 students—it's no picnic, but we can manage—but for 50,000 students, it's got to be automated. We did some extra work to figure that out.

Why is there so much excitement about MOOCs right now?

Cloud computing means that you can teach these courses in places where students have very modest computer facilities, for pennies an hour. Five years ago it would not have been the same: You could reach 100,000 students, but how do you get materials out to them? The software selection was a hassle. But e-books, plus cloud, plus online course equals something really exciting.

What do students get out of it?

Currently, Berkeley students get a letter saying that they've completed the course; down the road there might be other forms of certification. Berkeley Extension has been offering certificates of mastery for a long time.

So why partner with edX?

The decision to partner with edX is a strategic decision. Berkeley's and edX's philosophies are aligned: They both believe in open access and public service, and they both want to figure out how to improve on-campus education. This is a decision that has a long-term impact on the way we deliver education.

Head in the cloud

This fall, the Berkeley Resource Center for Online Education introduced its first two edX courses, offering access to free online courses taught by renowned Berkeley engineering faculty to people around the world. Both courses are adaptations of popular campus-based computer science classes.

CS188.1x: Introduction to Artificial Intelligence
INSTRUCTORS: Pieter Abbeel and **Dan Klein**

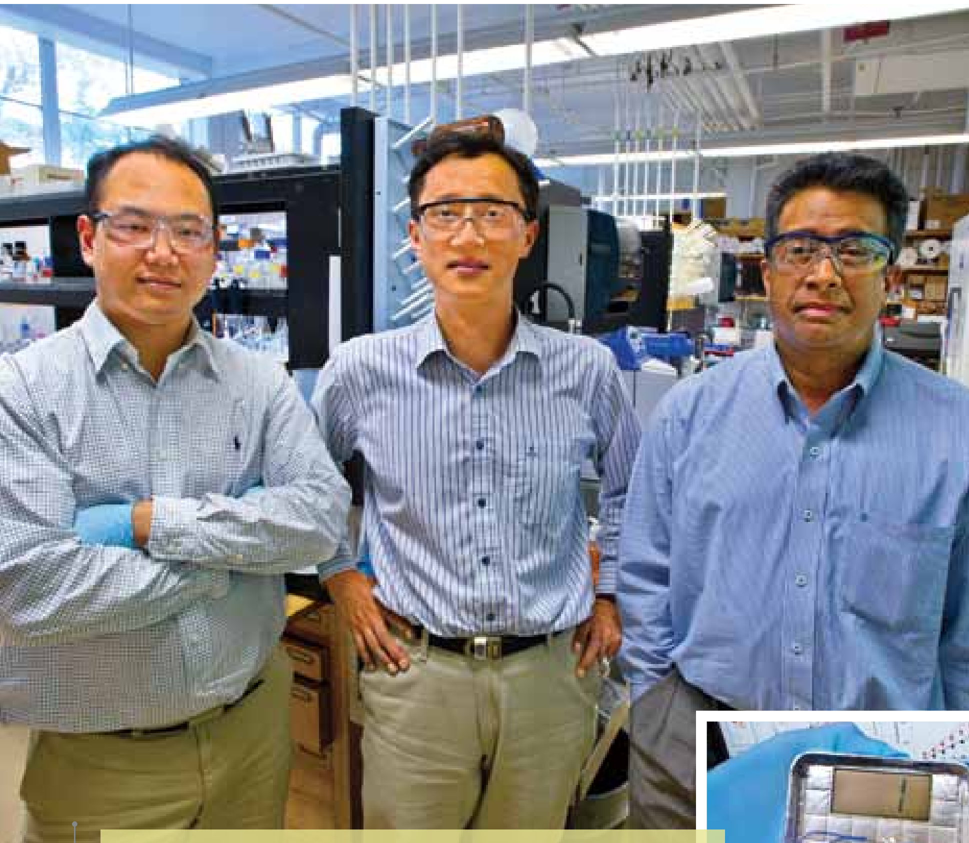
Artificial intelligence (AI) is at the core of many new technologies that will shape our future and transform science fiction into real systems. A modified version of the first half of an upper division class, CS188.1x focuses on behavior from computation. It introduces the basic ideas and techniques underlying the design of intelligent computer systems, with an emphasis on the statistical and decision-theoretic modeling paradigm.

CS169.1x: Software as a Service (SaaS)
INSTRUCTORS: Armando Fox and **David Patterson**

This course covers the basics for engineering software. Students will learn to apply fundamental programming techniques to the design, development, testing and public cloud deployment of a simple SaaS application. Students work on weekly coding projects to learn about the latest methods of creating cloud-based applications.

For more information on course offerings, or to register, see **edx.org.**

WEB EXTRA > Hear **Armando Fox** and **David Patterson** talk about their approach to online education at **edx.org**.



Roy Kaltschmidt / Lawrence Berkeley National Laboratory

A generator that uses viruses to turn mechanical energy into electricity, right, was developed by Berkeley researchers **Byung Yang Lee, Seung-Wuk Lee** and **Ramamoorthy Ramesh**, above.

ENERGY

Electricity goes viral

What if you could create electrical energy with the tap of a finger? Scientists at Lawrence Berkeley National Laboratory have discovered a novel way to do just that.

Bioengineering professor **Seung-Wuk Lee,** materials science professor **Ramamoorthy Ramesh** and researcher **Byung Yang Lee** have developed a generator that uses genetically engineered viruses to convert mechanical energy into electricity. When a finger taps a small electrode coated with the viruses—which are harmless to people—the viruses transform that pressure into current.

Their generator makes enough power to run a small liquid-crystal display and is the first to utilize the piezoelectric properties of a biological material to produce electricity. The researchers hope this development will eventually lead to microelectronic devices that capture electrical energy from the movements of everyday activities, such as walking, climbing stairs or shutting a door.

STEM CELLS

Mistaken identity

In a finding that upends decades of thinking about deadly vascular diseases, researchers at the Berkeley Stem Cell Center have identified a multipotent stem cell as the cause of blocked arteries. Previously, heart attacks and strokes were attributed to the proliferation of smooth muscle cells lining blood vessel walls that combined with cholesterol and fat to clog arteries.

However, the Berkeley research indicates that the blockage is instead caused by a newly discovered type of stem cell, which may remain dormant for decades, then multiply when the blood vessel walls are damaged. The study, published in the journal *Nature Communications,* calls for a focus on vascular stem cells in the search for future treatments.

"For the first time, we are showing evidence that vascular diseases are actually a kind of stem cell disease instead of a smooth muscle disease," says bioengineering professor **Song Li,** the study's principal investigator. "This work should revolutionize therapies for vascular diseases because we now know that stem cells, rather than smooth muscle cells, are the correct therapeutic target."

MOLECULAR SCIENCE

Switched

Like baseball players and politicians, some types of molecules have a distinct left or right orientation, known as chirality. The right-handed and left-handed forms—or enantiomers—of such molecules can display distinct characteristics.

Now, a multi-institutional team of researchers, led in part by mechanical engineering professor **Xiang Zhang**, has created the first artificial molecules whose chirality can be quickly switched from a right to left orientation with a beam of light.

The potential applications for this newfound technology span a wide range of fields, including the detection of toxic and explosive chemicals, advances in wireless communication and high-speed data processing systems, medical research and pharmaceutical drug development.

HOW DO I FIND OUT MORE?

Find links to source articles, news details and expanded coverage through the college website at **coe.berkeley.edu/berkeleyengineer-links**.

BATTERIES

Charged up

As mobile devices and their apps become quicker and more powerful, batteries can't always keep up with their energy demands. To help consumers, a team of engineers from the **Algorithms, Machines and People Laboratory** (AMP Lab) in the EECS department has developed an app that provides individual energy recommendations for mobile phones and tablets.

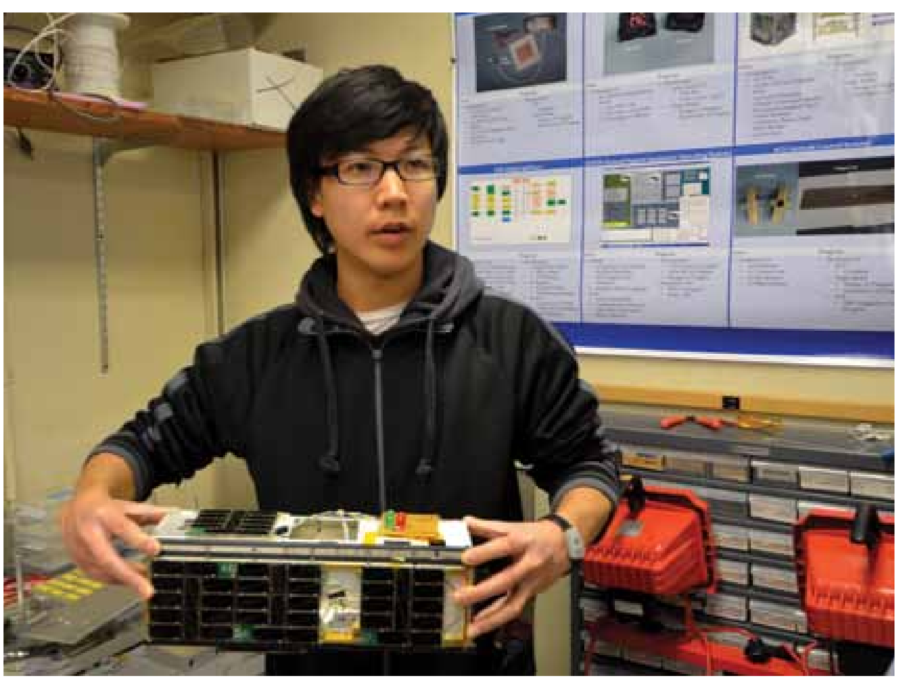
Known as Carat, the app identifies "energy bugs" (apps that use energy unnecessarily) by comparing usage to that of other devices. Once installed, Carat takes periodic measurements about the mobile device and its energy consumption; that data is sent to AMP's servers, which perform a statistical analysis to determine ways to improve battery performance.

After a week or so, the user receives personalized advice about how to increase battery life, such as killing or restarting apps or upgrading the operating system. Carat itself uses almost no power and keeps the collected data anonymous. It can be downloaded for free at the Apple App Store and Google Play Store.

SATELLITE

Piggyback ride

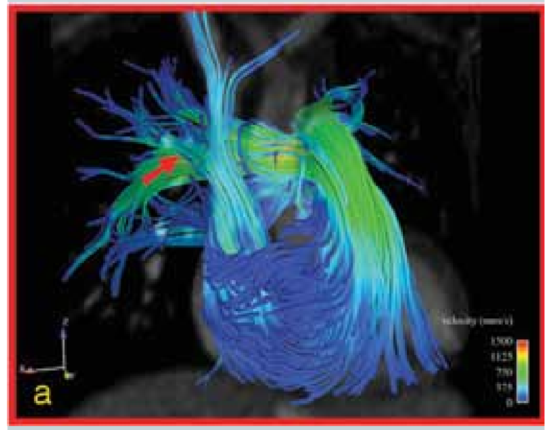
What is the size of a shoebox, weighs eight pounds and flies? That would be CINEMA (CubeSat for Ions, Neutrals, Electrons and MAgnetic fields), one of 11 miniaturized satellites that was launched with an Atlas V rocket into Earth's orbit this past September. Built in three years by an international team of 45 students—including 25 from Berkeley's engineering and physics programs—CINEMA is a relatively inexpensive nanosatellite made to piggyback aboard other NASA missions. CINEMA was constructed from a group of three modular CubeSats, each measuring a standard 10x10x10 centimeters and weighing just over one kilogram. Designed to spend a year in orbit, CINEMA will gather images of the ring current, an electrical current that encircles the Earth and is responsible for geomagnetic storms. Below, **Jerry Kim** (B.S.'11 ME) holds the CINEMA nanosatellite.



Robert Sanders/University of California, Berkeley

DIAGNOSTICS

Image makers



Courtesy the researchers

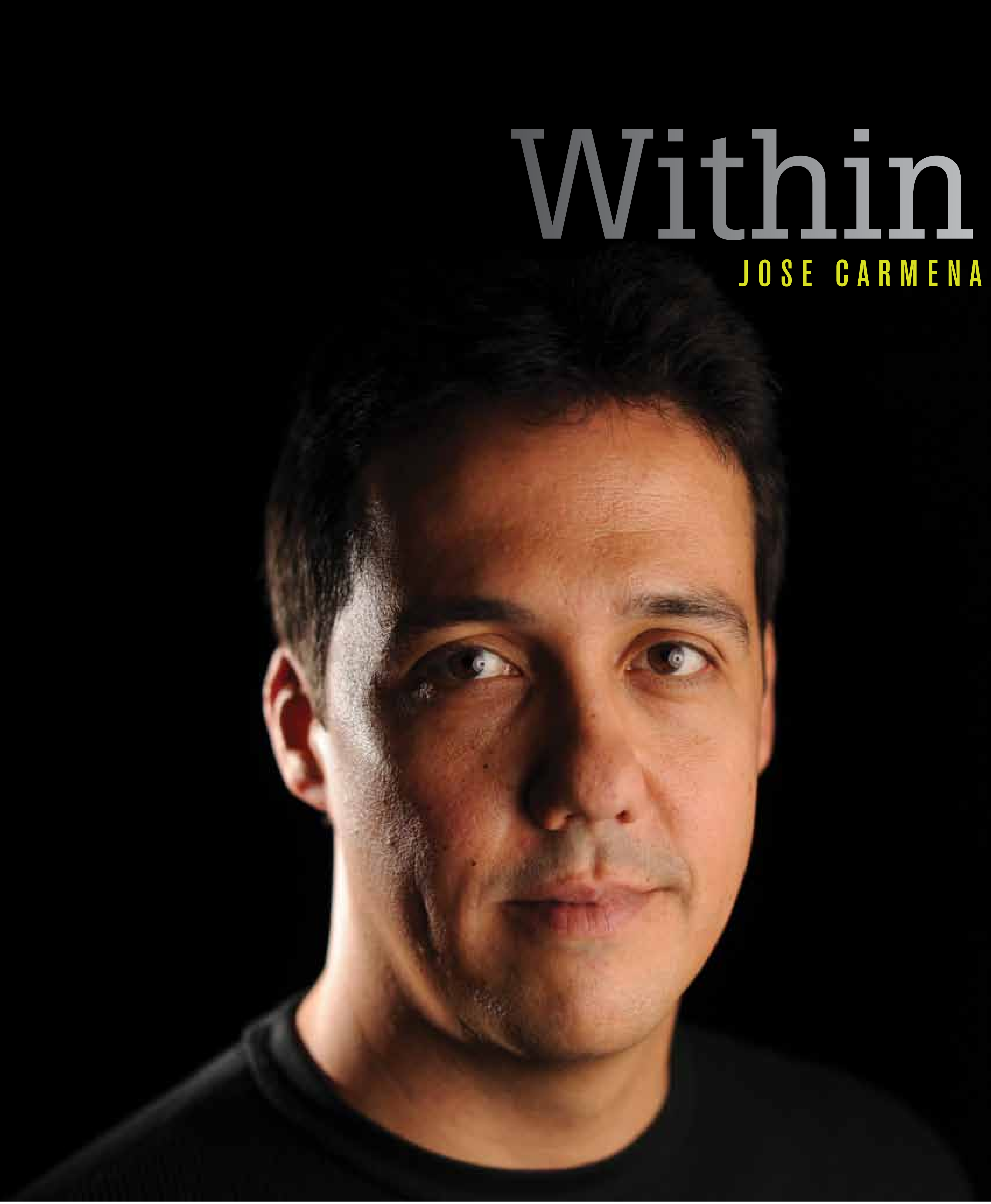
Magnetic resonance imaging (MRI) can provide diagnostic images of organs and soft tissues that are much more detailed than computed tomography (CT) scans, without exposing the patient to radiation. But a major limitation to MRIs has been the slow imaging speed, relative to CT scans, and patients must remain motionless during the screening.

Staying still can be particularly tricky for pediatric patients, increasing the need for general anesthesia, which carries its own risk of complications. To reduce or even eliminate the use of anesthesia for pediatric patients, professors **Michael Lustig** and **Kurt Keutzer** of electrical engineering and computer sciences—in collaboration with Shreyas Vasanawala and Marcus Alley at Lucile Packard Children's Hospital at Stanford, GE Healthcare and **Mark Murphy** (Ph.D.'11 EECS)—have developed a solution that drastically reduces the time needed to conduct MRI exams.

Based on a theory known as compressed sensing, this technique performs rapid imaging by collecting fewer MRI measurements than traditionally required, then converts the reduced data into high-resolution images. The process produces images that are sharper and easier to read and results in a safer and more comfortable experience for the youngest (and wiggliest) of patients.

Within

JOSE CARMENA



reach

ON MESHING MIND AND MACHINE

STORY BY GORDY SLACK • PHOTOS BY NOAH BERGER

In the booming field of neuroprosthetics, new work shows that deploying brain-machine interfaces may be simpler, and the results more naturalistic, than expected. The brain is well equipped to adopt a robotic arm—or just about anything else you can plug into it.

Plugging a machine directly into a human brain—whether to allow a paralyzed patient to move a cursor and drive a wheelchair, to direct an artificial limb or to permit wireless brain-to-brain communication—is a Rubicon of human-machine intimacy. And we are crossing it.

Just a decade ago, when Jose Carmena went to his first Society for Neuroscience meeting, in Orlando, Florida, only a few engineers and neuroscientists had the audacity to imagine that a plug-and-play brain-machine interface (BMI)—a kind of USB port to the brain—would be possible in the foreseeable future. "There was just one small session on one afternoon in one small corridor with some posters," says Carmena, now an associate professor in the Department of Electrical Engineering and Computer Sciences (EECS) and in the Helen Wills Neuroscience Institute at Berkeley.

In contrast, the same conference last year was all BMI all the time. "There was a session pretty much every day. Often there were overlapping sessions with posters and talks. It has been a huge transformation," says Carmena.

Advances in materials science, machine learning, signal processing, robotics, neurosurgery, neuroscience and micro-electronics are all coming together to make BMI a reality, says Carmena, director of the Brain-Machine Interface Systems Lab and co-director of the Berkeley-UCSF Center for Neural Engineering and Prostheses (CNEP).

Earlier this year, a group at Brown University and Massachusetts General Hospital succeeded in helping a quadriplegic patient guide a robotic arm with a BMI to pick up a water bottle and bring it to her mouth. At UCSF, neurosurgeon and CNEP co-director Edward Chang and his colleagues are currently developing a speech prosthetic that Chang believes will soon be able to read words from a paralyzed patient's brain and convert them into a synthesized voice.

Despite such progress, one benchmark of success remains frustratingly defiant: the easy and natural operation of a fully articulated prosthetic arm that can be controlled directly by its user's intentions. Celebrated robotic arms, such as the super-high-tech DARPA arm, are terrific in theory, but amputees who try them regularly revert to the simpler, lighter, less expensive and much easier-to-use hooks from half a century ago. Prostheses that rely on foot controls or other outside-the-brain manipulations require a level of concentration disproportionate to the control they deliver. Similarly, the robotic arm and its BMI unveiled at Brown earlier this year require intense focus to conduct even the simplest tasks. You don't want to have to try with all your might just to raise a cup to your lips.

"The field now needs to transform BMI systems from one-of-a-kind prototypes into clinically proven technology like pacemakers and cochlear implants," Carmena wrote in the March 2012 issue of *IEEE Spectrum*. "We want a device that is essentially plug-and-play."

At Carmena's BMI Systems Lab and at CNEP, a new model is emerging that may make that vision a reality. This January, Carmena and colleagues published a *Nature* paper demonstrating that with appropriate feedback, rats can weave a BMI device seamlessly into their own neuronal environments so that using it becomes second nature. Not only do parts of the motor cortex quickly adapt so that they can direct a cursor, but neural activity in other brain structures, such as the dorsolateral striatum (related to automatized skill learning, habit formation and motor skill learning) are also engaged.

That these BMI-proficient animals have turned-on dorsolateral striata suggests that use of their new brain add-ons has become "internalized" and automatic, says Amy Orsborn, a graduate student in Carmena's lab.

If the BMI Systems Lab can make a prosthetic arm's use second nature, and if Carmena can design it so that it sends sensory feedback from the hand back to the brain, the lab will have achieved a kind of gold standard for BMI.

Carmena believes that achievement will not stem simply from developing more complicated algorithms or neuronal decoders. Rather, it will come from letting the brain take the lead in learning how to incorporate a new device naturally and then augmenting that with artificial decoders that can be adapted online.

His approach plugs the BMI into the brain and lets the brain learn to use it by providing it with the feedback key to all adaptive neural activity. When certain neurons fire, the prosthesis goes up. The subject's brain, given clear feedback, senses that and quickly learns to fire those neurons on command. The brain will try new combinations—if they work, they will get stronger; if they don't, the will weaken.

Like learning to play tennis or ride a bike, the process is gradual and requires no step-by-step planning. "It's like it has become an extended part of the user," Carmena says.

"Instead of us trying to decode the neurons," says Orsborn, "we let the neurons themselves figure out what they need to do to produce skilled BMI controls. And over 10 days or so, they learn to play BMI." Rats described in the *Nature* paper learned to direct a "sound cursor" that creates specific tones that, once achieved, would release specific rewards. Primates in the BMI lab have since learned to do the same thing with both a computer cursor and a robotic arm.

This insight is a windfall for BMI researchers, says UCSF's Chang. If they can get reliable, high-quality information about the world to the brain, then the brain does the computational heavy lifting.

Since the *Nature* paper, Carmena's lab has also been developing ways to amplify that natural process with algorithms that adjust the decoder to the brain's own adaptations to the new data. The idea is to get the brain and the BMI's decoder each adapting to and accommodating the other toward the same aim, the automatic coordinated motion of the prosthetic arm.

"Synergizing these two adaptive mechanisms is key," says Carmena. "In this approach, neuroplasticity takes care of incorporating the prosthetic into the brain's real estate. Simultaneously adapting the decoder lets the user learn faster and boost performance."

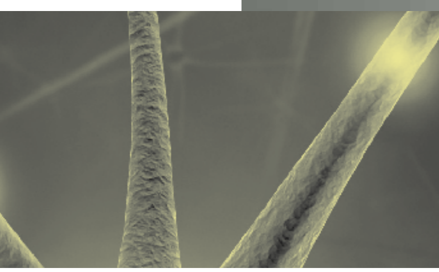
Carmena and his team are applying these principles to a new collaboration, funded late last year by a $2 million National Science Foundation grant. Working with EECS professor Claire Tomlin, mechanical engineering professor Masayoshi Tomizuka and what Carmena calls "an army of excellent students and post-docs," they are developing an interface control for an exoskeletal arm that may someday allow paralyzed patients to "perform tasks of daily living." Users would wear the device over their immovable arm and would manipulate it, via BMI, with their minds alone.

"Making a good enough BMI to naturally drive a prosthetic arm has exciting problems in pretty much every discipline from every part of campus," says Carmena. First, there's the basic neuroscience. You have to adequately understand what's going on in the brain itself. Psychology and neuroscience professor Robert Knight is a giant in that field and a key player at CNEP. Chang, one of Knight's protégés, is another. And Carmena himself is focused on understanding the basic science around neuroplasticity, or the brain's ability to change and adapt.

Then there are the material and engineering requirements of the electrodes implanted in the brain. These have to remain immobilized so they continue to read from the same cohort of neurons. They must be dense and sensitive enough to read brain activity at a high resolution, and they must not damage the brain itself even though they are placed on or into it. Finally, since they require neurosurgery to install or repair, they need to do all of these things for a lifetime.

"Neuroplasticity takes care of incorporating the prosthetic into the brain's real estate. Simultaneously adapting the decoder lets the user learn faster and boost performance."

Jose Carmena, director of the Brain-Machine Interface Systems Lab and co-director of the Berkeley-UCSF Center for Neural Engineering and Prostheses (CNEP), holds a neural interface (inset) while **Amy Orsborn**, a bioengineering graduate student in Carmena's lab, looks on. The neural interface is surgically implanted on the motor cortex, the part of the brain that controls movement.



Michel Maharbiz, assistant professor of EECS, is developing miniature grids of implantable electrodes that record at very high resolution. The challenge is in the "plumbing," as he calls it, of getting electrodes and neurons to interface seamlessly. Pushing the boundaries of such meshing in one recent experiment, Maharbiz inserted a porous electrode into a pupating larval beetle's eye tissue, which grew around and through it so that the electrode "was like a part of the eye itself," he says.

Then there are the microcircuits that do preliminary processing of the signals coming from the electrodes. These need to be small enough (in a wireless version) to be positioned beneath the skull without displacing brain tissue, use very little power and to be rechargeable through the skull.

Maharbiz works closely with both Carmena and EECS professor Jan Rabaey, who is developing a wireless chip that can transmit information directly from each of Maharbiz's electrodes or from a network of them. Going wireless means patients will be less prone to infection and won't have to contend with wires coming out of their heads.

Then there is the decoder itself, a program that interprets the brain signals and sends commands to (and eventually from) the prosthetic. The decoder and the algorithms that define it are Carmena's bailiwick, along with the basic neuroscience. And finally, there is the prosthetic itself, in this case, a robotic or exoskeletal arm.

Today, most prostheses rely only on visual feedback. But when a person learns to do something like wash her face, she uses tactile senses and a proprioception system that connect to receptors on muscles and joints that tell them where her hands are in space and what they are doing. Carmena is learning to simulate tactile sensation and proprioception with something called intracortical electrical microstimulation. He is sending signals back from the prosthetic hand and arm to appropriate parts of the brain. His former grad student Subramaniam Venkatraman conducted experiments that delivered a tiny reinforcing stimulus to a rat subject's cortex every time the rat hit a target with its whisker, which the rat could not sense. The rat quickly learned to precisely hit targets with that whisker in exchange for a drop of fruit juice. In effect, it learned to track the whereabouts of the end of a whisker it could not feel.

Carmena is wary of raising expectations too high too soon. At a recent Christopher Reeve Foundation conference where he gave a talk about his BMI work, paralyzed patients in the audience were looking at him, he says, "with eyes that said 'OK, when is this going to be ready?'" But help for patients suffering from spinal cord injury, amyotrophic lateral sclerosis or stroke, for example, may still be a decade or more away.

On the other hand, so many of the bottlenecks are being addressed at the same time, in parallel, and by the best people in the business. "It could," Carmena says, "move along very fast."

Integrating human brains, computers and the machines those computers control has begun in the clinical realm, but few on the inside expect it to end there. If a plug-and-play BMI is routinized and commercialized, all kinds of non-medical applications may follow. Surely there will be challenging legal and ethical implications, as well.

We may be crossing a Rubicon of human-machine intimacy, but what happens on the far side of the river is up for grabs. BE

Precious cargo

TING XU'S NEW NANOCARRIER DELIVERS DRUGS DIRECTLY TO TUMORS, THEN DISASSEMBLES AND SAFELY LEAVES THE BODY

The use of nanoparticles to deliver chemotherapy drugs to cancerous tumors started in the 1980s. Since then, researchers have experimented with different styles of nanocarriers to hit upon the right combination of size and materials to release drugs to the heart of tumors without punishing side effects.

Too large, and the nanocarriers cannot penetrate a tumor cell for a direct hit. Too small, and they get lost in the bloodstream before finding the target. Besides, introducing a material into the body that cannot get out again may cause side effects that negate the benefits of treatment.

Researcher **Ting Xu** has conceived of a solution that greatly advances the science and offers promising clinical implications for cancer patients and for sufferers of other diseases and conditions.

Using a soap-like material whittled down to a neat 15 nm size, Xu has developed a nanocarrier that slips into a tumor cell to release treatment where it can have its most powerful effect. The nanocarrier then dissolves into small bits that pass quickly and safely through the body without toxic accumulation.

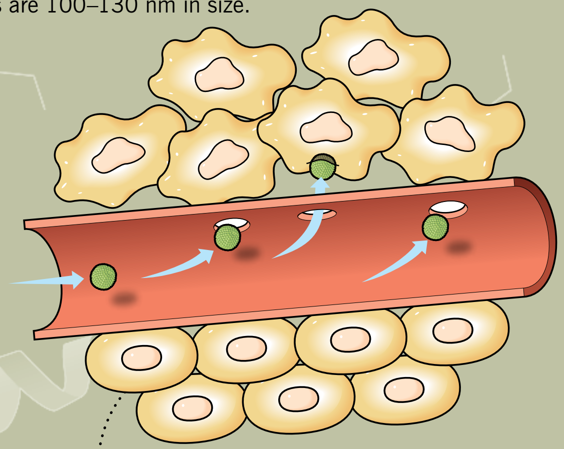
"I look at this as a beautiful marriage of basic science and real-world application," says Xu, who holds faculty appointments in materials science and engineering and chemistry.

TEXT BY DANIEL MCGLYNN , PHOTO BY NOAH BERGER, ILLUSTRATIONS BY JASON LEE

Working with both biological and synthetic components, **Ting Xu** is combining the best of different drug delivery methods to create a more effective cancer treatment. Controlling all of the nanocarrier's phases, from assembly to disassembly, has practical implications for other kinds of drug delivery, including vaccinations and treating chronic diseases.

2 DELIVERY

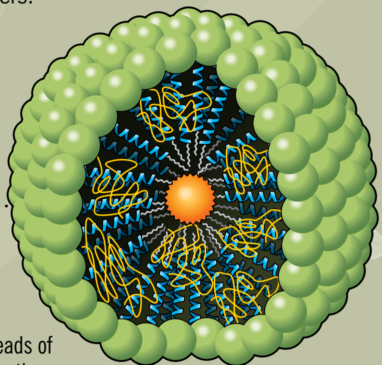
Researchers found that the optimal size for a drug nano-carrier to travel well through blood vessels and infiltrate a tumor is between 10 and 30 nm. The carriers Xu has tested are 15 nm in diameter. Currently, FDA-approved nanocarriers are 100–130 nm in size.



Healthy tissue is made up of uniform, tightly packed vascular spaces. Cancerous tumors grow chaotically, making them more permeable. If sized correctly, the drug carrier will enter the tumor passively.

1 ASSEMBLY

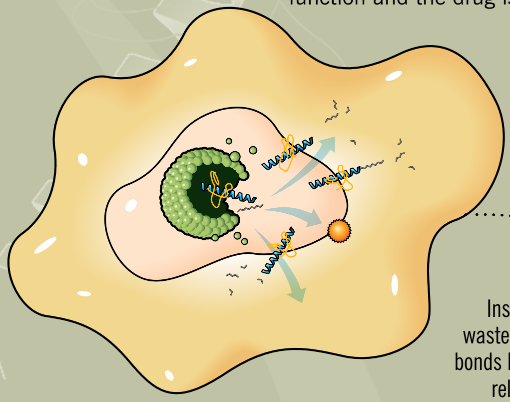
This distinct drug carrier combines different nano-technologies to achieve its small size and ability to exit the body safely. The design crosses one of the leading ingredients in laxatives, polyethylene glycol (PEG), with soap's chemical structure. The result is a peptide-polymer particle that is able to circulate longer in the bloodstream and leaks less cargo than other types of nanocarriers.



Driven by polarity, the heads of these molecules bind together, while the helix tails (in blue) tuck inside, forming a sphere called a micelle. Attached to the tails are the hair-like PEG polymers (in yellow).

3 DISASSEMBLY

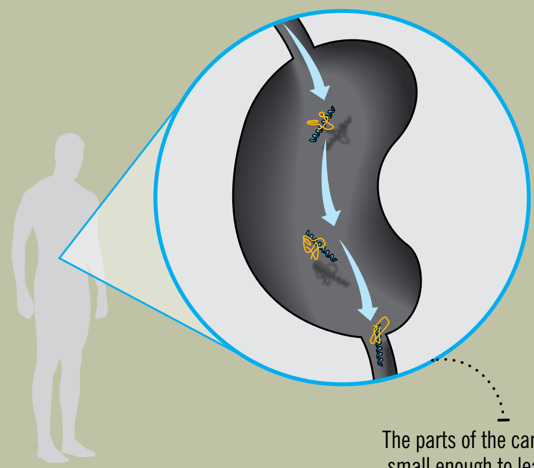
Delivering and dispersing the drug cargo to all parts of a tumor is critical to preventing regeneration. Once inside the tumor, the nanocarriers are broken down by the cell's own debris-clearing function and the drug is released from the carrier.



Inside the tumor, the cell's waste-eating enzymes break the bonds holding the micelle together, releasing the drug within.

4 SAFE PASSAGE

After delivering the drug, the nanocarrier breaks down into its original components, which can pass through the kidneys. "After they do chemo, a lot of people have liver failure because the clearance pathway is not right," Xu says.



The parts of the carrier become small enough to leave through the urinary tract without causing infection or damage.

PREPAID

POWER

STORY BY DANIEL MCGLYNN
PHOTOS COURTESY GRAM POWER/JACOB DICKINSON

HOW ONE INTERNATIONAL DEVELOPMENT PROJECT IS LIGHTING THE WAY FOR AN EMERGING ENGINEERING FIELD

Over a two-day stretch at the end of July, huge portions of India's power grid collapsed, causing the world's largest blackout. Vast swaths of the country went dark; trains stopped, manufacturing halted and hospitals scrambled to fire up backup diesel generators. By the time the lights came back on, 670 million people had been affected.

Only a few weeks before, two recent Berkeley Engineering graduates, Yashraj Khaitan and Jacob Dickinson, had installed a demonstration microgrid 130 kilometers south of Jaipur, Rajasthan, in a region often referred to as the heart of India. While most of the country was dark for those two days in July, the lights in the 15 households connected to their grid shone brightly.

The Rajasthan microgrid project is the latest evolution of a startup called Gram Power. The young company is quickly refining new ways of delivering electricity to places that are too remote or where household energy demand is too low to have cost-effective connections to traditional utility-scale power grids.

"We didn't want to develop another intermittent solution in the form of a solar lantern or a rechargeable battery, but something that is a full-fledged electrification solution for rural India," says Khaitan, the founder and CEO of Gram Power. In India alone, the potential market for their services is about 700 million people; globally, it exceeds two billion.

Gram Power is using a clever blend of a business model borrowed from the exploding telecommunications industry and smart meter technology. The venture is also an example of a new wave of international development collaboration, where engineering is the linchpin that connects social science research with development agencies like the United States Agency for International Development (USAID) to build sustainable and useful technologies and create opportunities for economic growth.

An interdisciplinary team back in Berkeley is trying to ride the crest of this new wave. By pooling people and expertise, the Blum Center for Developing Economies, the Center for Effective Global Action (CEGA), the College of Engineering and other research centers on campus are working to create a training program, career path and academic support for development engineers who, like Khaitan and Dickinson, want to turn their talent and education toward finding solutions for the challenges facing some of the world's most marginalized communities.

While growing up in Jaipur, Khaitan didn't spend much time outside the city. But in 2008, after his first year in the electrical engineering and computer sciences (EECS) department at Berkeley, he traveled to remote areas around his hometown to do some scouting for a potential class project. "That was the first time I really toured through rural India," he says. "We identified several projects, and electrification was right up my alley. The impact that reliable and affordable electricity can have on a community was very noticeable."

When he returned to Berkeley for his second year, Khaitan began developing and designing a modular power system based on an intelligent, micro-storage device, the size of a deck of cards, that he calls M-Power.

Khaitan built and launched about a hundred M-Power units while he was still in school. His idea—design solutions that cater to consumers who require only small amounts of energy—garnered a win at the annual Big Ideas@Berkeley competition and the support of the Blum Center. Soon, other accolades followed. By 2010, Dickinson, a fellow EECS student, joined the project as chief technology officer, and Gram Power was officially born. The team also started working with EECS professor Eric Brewer and his Technology and Infrastructure for Emerging Regions (TIER) group.

Brewer is well-known for his contributions to Internet architecture, but he also spends his time creating innovative information and communications technology for developing economies. For years, through his work with TIER, Brewer has been advocating for a more formalized development engineering trajectory that combines technical training with an understanding of development from a social science perspective.

"Engineers are problem-solvers," says Brewer. "But we need information to solve problems, and getting that information involves quite a process of discovery."

The intersection of technology and economics is where Khaitan and Dickinson found themselves when they returned to India as freshly minted graduates in 2011. While they were away, completing their degrees and further developing the M-Power technology, some of their consumers received connections to the Indian grid through government programs. The new access to grid-level electricity, although erratic and unstable, quickly improved their quality of life and fueled a greater demand for energy than M-Power could meet.

"The trend that we've noticed is that people's standard of living is increasing pretty rapidly after they have access to power," says Khaitan. "When we set up the system, they opted only to operate a light or two in their homes. But within a couple of weeks they ended up getting access to televisions, fans, coolers and small buttermilk machines."

After doing more market research and advancing the technology further, Gram Power altered course. "We started to develop the idea of prepaid microgrids; to get the cellular phone model that has revolutionized telecommunications in most of the developing world into the energy sector," Khaitan says.

Prepaid cell phone follow a model used for fast-moving consumer goods, like toothpaste or a can of soda, not the typical utility with fixed costs and monthly bills. This means that people with a low or irregular income can become consumers. The shift creates an off-the-charts demand curve for cell phone service purchased in small amounts.

In late 2011, the Gram Power team won another competition, and this one was big. They were selected by NASA, from 10 clean-tech start-ups from around the world, as an idea with tremendous promise. Their success put them on the radar of USAID and angel funders. Soon after the nod from NASA, they secured the first round of seed funding to continue research and development.

The result is Gram Power's current microgrid. It is powered by centralized solar panels and has an AC inverter, a battery storage array and a smart meter attached to each user's home. Besides being clean and reliable, the microgrid allows consumers to purchase small amounts of energy from a local entrepreneur who uses a wireless system that Khaitan calls an "energy wallet" to reload the meter.

Gram Power consumers get direct feedback from the meters. They can plug in devices, like an incandescent light bulb, and the meter will tell them how much energy the light draws. They can then

Berkeley Engineers **Yashraj Khaitan** and **Jacob Dickinson**, pictured here beside Gram Power's first microgrid solar array outside Rajasthan, India.

compare that to alternatives, like a compact fluorescent bulb. The prepaid model and feedback about decisions offer consumers tools for conserving energy, unlike other energy grids that often charge a flat fee, stripping the incentive to save. As users start to conserve, Khaitan says, "We ourselves are surprised by the number of connections we are able to provide with the amount of power we can generate."

The smart grid is also connected wirelessly to a remote monitoring system, so Khaitan can detect attempts at energy theft or technical problems from his office in Jaipur. As with M-Power, users connected to the microgrid can tailor their energy decisions based on their weekly cash flow and scale their use accordingly.

Khaitan had plans to return to Berkeley this fall to finish his master's degree and continue on with a Ph.D., but because of Gram Power's rapid growth, he has decided to stay in India and run the company full time. His connections to the university, however, are still close. Khaitan participates in regular meetings with Brewer, TIER, the Blum Center and the Center for Effective Global Action (CEGA). They figure out how Berkeley's development economists can make use of data collected from Gram Power's engineering project. The information has a range of benefits.

"This is a model project," says Temina Madon, CEGA's executive director, a research hub for development economists. "We are building in randomized pricing experiments to the deployment of new smart grids. As we learn how people make decisions about power consumption, the technology can be redesigned. We can change the metering systems, the payment plans and the plant's generation and storage capacity. So we can help inform refinements to the technology using social science."

At the same time, the collaborators are seeking to partner with USAID to start a new center on campus, which would create a development engineering Ph.D. track and career path. Gram Power is one of several projects that offer a concrete example of what the new hybrid model of engineering and development economics would look like. "Together, I think we have a lot of promise to create solutions for development that go beyond widgets or gadgets," says Madon.

In the meantime, Gram Power continues building microgrids in Rajasthan. By summer's end, Khaitan and Dickinson were connecting the remaining households at their first test site to their grid. Now, about 30 households, or 200 people, have clean and reliable electricity.

Given the context of India's recent epic infrastructure failure and blackout, what started as a simple beta test for Gram Power's new technology has suddenly become a metaphor for a larger proof of concept—smart infrastructure, on a different scale, as a way forward for India and elsewhere. Khaitan is already working with India's Smart Grid Forum, a public-private partnership.

"A lot of the guidelines they have for the next 15 or 20 years are systems we have implemented on a micro scale in our microgrid," says Khaitan. "But we plan on getting all of these systems on the main grid as well." BE

THE ANATOMY OF A MICROGRID

SOLAR POWER
In one of the village's household compounds, a centralized solar array collects the sun's energy and converts it to DC electricity.

CENTRALIZED STORAGE
Batteries store the excess solar DC energy and supply users with energy at night and during peak usage.

MONITORING SYSTEM
The inverter converts DC electricity from solar panels and batteries to AC electricity, which makes it compatible with household appliances. A wireless connection allows Gram Power to detect energy theft or abnormalities and collect data on consumer behavior and consumption patterns.

SMART METER
Each household has a meter that draws energy from the central monitoring system. The meter also keeps track of the amount of prepaid electricity the consumer has remaining, and provides data on the amount of energy a plugged-in appliance is using.

2010+

Christopher Ategeka (B.S.'11 ME) was awarded Berkeley's graduate student award for civic engagement this year. He is the founder and director of CA Bikes Uganda, an organization that builds bicycles and wheelchairs for orphans, people with HIV and others in Uganda.

Richard Fisher (B.S.'10 CEE) and **Ryan Whipple** (B.S.'10 CEE) won the Delta Alliance Young Professionals Award for a pilot project to transform the San Joaquin Delta. The pair was one of three winning teams out of 53 from 29 countries. Their project originated as a capstone project for a systems course under the direction of civil engineering professor Robert Bea. Fisher and Whipple presented their project at the Rio+20 United Nations Summit for Sustainable Development in Rio de Janeiro, Brazil.

David Litwak (B.S.'10 EECS) is the founder of Mozio, a comprehensive travel-planning search tool. When trying to find the best way to visit his brother in New York last fall, Litwak discovered how difficult it was to book a trip from start to finish, and he decided to combine his passions for travel and technology to help fellow travelers. Mozio, he hopes, will soon assist travelers in booking trips from doorstep to destination with ease.

2000+

Audrey Fischer (B.S.'08 IEOR) took a year off from a job at Goldman Sachs to travel around South America and Europe in 2010. Upon her return, Fischer felt out of touch with friends and family, and was inspired to create a website that made it easy to send high-quality, handcrafted cards. This site evolved into Gramberry, a company that enables customers to order environmentally friendly cards to be sent out with personalized messages composed on vintage typewriters.

Aryk Grosz (B.S.'06 IEOR) and **Andrew Laffoon** (B.S.'05 IEOR) are co-founders of Mixbook, an online photo-sharing site that allows users to collaborate on photo projects. After many rejections from venture capitalists, the two persuaded the co-founders of Art.com to invest. Earlier, the pair had created a Facebook app named Photobooks.

Mahil Keval (B.S.'09 ME), in collaboration with fellow alumnus Jacob Howard (B.A.'08 Mathematics), launched Knockout Design, a company dedicated to building mobile applications for the construction industry. After the development of the iPad, Keval saw a huge opportunity for improvement in managing "punch lists" (construction tasks to be completed before a project is turned

Belle W. Y. Wei (Ph.D.'87 EECS), formerly dean of engineering at San Jose State University, is the new provost and vice president for academic affairs at California State University, Chico. She is also chair of the diversity committee of the American Society for Engineering Education and a member of the executive board of ASEE's engineering deans council. Earlier in 2012, Wei was invited to the White House for the 10,000 Engineers Initiative.

PHOTO COURTESY SAN JOSE STATE UNIVERSITY

Maker's ed.

Parents like **Tony DeRose** (Ph.D.'85 CS), at right, are all too familiar with the difficulty of finding something engaging for their children to do with their hands. "When my son grew out of Legos at about eight years old, we realized there wasn't much for him to graduate into," DeRose says.

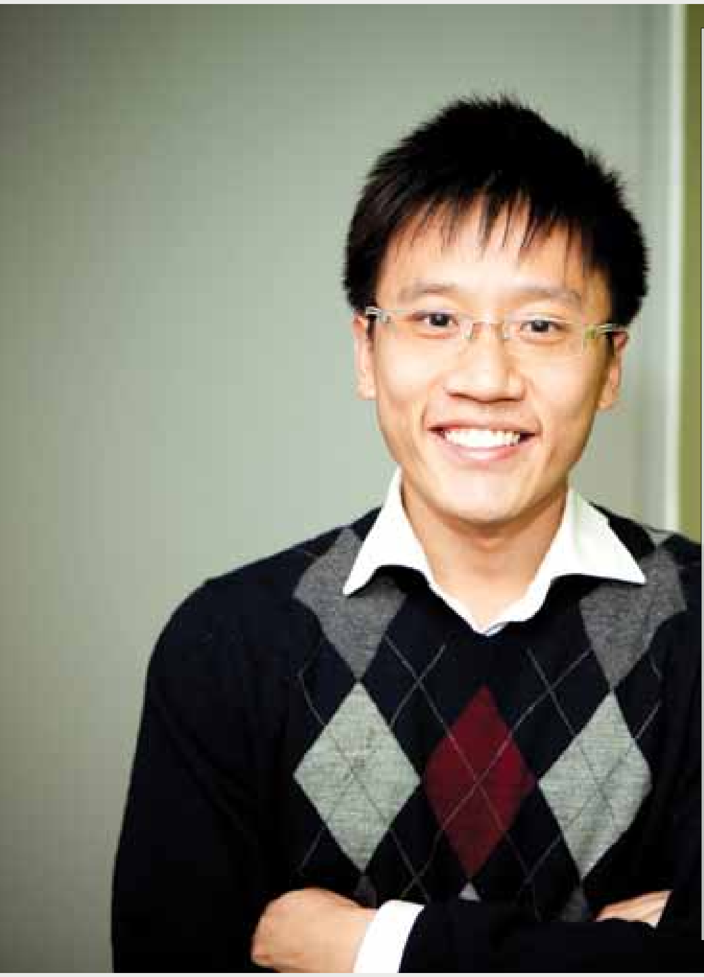
That's when DeRose began working on projects with his son in their garage. Most of the projects went unfinished until they discovered the Bay Area Maker Faire, "the world's largest DIY festival," held each spring. Their first exhibit at the fair was a multi-touch computer display, similar to a giant iPad, in 2008.

From there, DeRose and his son were hooked. DeRose, a senior scientist and research group leader at Pixar Animation Studios, wanted to bring the Maker Faire to more students. In collaboration with the Exploratorium, San Francisco's hands-on science museum, DeRose co-founded the Young Makers program in 2010. The program expanded with Young Makers clubs at schools or in parent-run garages and workshops. In its first year, 20 clubs with about 100 young makers participated, and around 40 teams exhibited at the Maker Faire. Projects ranged from kinetic horses and hovercrafts to animatronic fire-breathing dragons.

Makers are people "who are always wondering how things work, taking things apart, who really like to work with their hands in everything from knitting to robotics," says DeRose. "The most important thing we're helping to develop in these kids is the ability to learn on their own—to take an idea from conception to completion."

STORY BY SHWETA DOSHI • PHOTO COURTESY TONY DEROSE

SEND YOUR CLASS NOTES to **berkeleyengineer@coe.berkeley.edu**, submit online at **coe.berkeley.edu/classnotes** or mail to *Berkeley Engineer*, UC Berkeley College of Engineering, McLaughlin Hall #1704, Berkeley, CA 94720-1704.



Picture-perfect translation

Never mind the labyrinthine streets, chaotic traffic and unfamiliar food: If you talk to many foreign travelers to China, they'll tell you the most challenging part of the journey is the language barrier. And with thousands of symbols making up the Chinese script, deciphering a street sign, menu or train ticket can be an onerous—if not impossible—task for tourists.

But recent graduate **Chun Ming Chin** (M.Eng.'12 EECS) and his team at Translate Abroad have created a solution to this problem: a mobile app that makes translating Chinese characters as simple as taking a photo. Their app, Waigo, allows iPhone users to point the camera at Chinese text and see it translated instantly into English.

As a graduate student in the inaugural class of Berkeley's new master of engineering program, Chin wanted to deepen his understanding of computer vision technology, and create what he calls "a wow moment" for his app. Chin enlisted classmates to create an algorithm to improve the program's ability to read and translate characters.

In March, the team's app won third place and $20,000 in the 2012 Made for China Competition, a contest for young entrepreneurs developing products for the Chinese market.

Shortly thereafter, Translate Abroad released their first consumer-ready app, currently available for download at the Apple store. The technology developed at Berkeley will be rolled out in a later version of the product.

STORY BY JULIANNA FLEMING • PHOTO BY PRESTON DAVIS

over to its owner), which led to the development of their first app, Speed Punch. Keval is now focused solely on the expansion of Knockout Designs and SpeedPunch.

Nikit Kumar (B.S.'09 BioE) began graduate studies in a Ph.D. program in biological and biomedical science at Yale University this fall, after several years spent researching at the UCSF Medical Center.

Eul-Bum Lee (Ph.D.'00 CEE), an associate researcher and co-principal investigator in the Institute of Transportation Studies at Berkeley, has focused on researching and implementing innovative methods for transportation infrastructure rehabilitation. Along with a team of three others, Lee has developed a systematic cost-estimation modeling process for transportation management plans that automatically estimates costs for highway projects.

Brian S. Loo (B.S.'09 IEOR), a member of the creative team at Walt Disney Imagineering, creates interactive experiences and supports logistical planning for the design and construction of Disney venues around the world. He is working on the expansion of the Magic Kingdom for Walt Disney World in Florida, the expansion of Hong Kong Disneyland and on Disney's newest park in Shanghai. "I always dreamed about designing rides for Disney, and I can't believe I'm doing it now," says Loo.

Seongchan Moon (B.S.'07 EECS) is enrolled in the MBA program at the University of Michigan.

Ryan Panchadsaram (B.S.'07 IEOR) was named a Presidential Innovation Fellow for the Blue Button Program, a new White House initiative. He also won first place in the international visualization challenge co-sponsored by Google and *The Guardian*. Now a resident of San Francisco, Panchadsaram has worked with Microsoft, Salesforce.com and the MIT Media Lab spin-off, Ginger.io.

Priyanka Reddy (B.S.'09, M.S.'10 EECS) and fellow Berkeley alumna Jennifer Toney (B.A.'95 Economics, MBA '08) directed their shared passion for applying technology to solve social problems to a new venture, WeMakeItSafer. The company helps thousands of companies and consumers each day avoid product-related injuries and deaths by alerting consumers to recalled products.

Keith Suda-Cederquist (B.S.'02 ME/MSE) is the founder of a start-up company called Collaborate i/o. Its mission is to leverage communications technology to make the lives of fellow engineers easier. Their first product, TelePresence for Engineers, is a videoconferencing system designed for troubleshooting technical problems at remote locations, such as manufacturing floors and customer sites.

Kevin Wang (B.S.'02 EECS) went from Berkeley to Harvard to study education. When he began work as a high school teacher in Seattle, Wang was appalled at the state of computer science education, and discovered that the problem was not a lack of curriculum but a shortage of teachers. In 2009, Wang founded Technology Education and Literacy in Schools (TEALS), a Seattle-based grassroots organization that recruits high-tech professionals passionate about digital literacy to teach computer science in high schools across the metropolitan region.

1980+

Ashar Aziz (M.S.'85 CS) is the CEO of FireEye, a company he founded in 2005 that detects and prevents attacks from cyber-criminals. A UC Regents Fellow, Aziz spent 12 years at Sun Microsystems working in networking, security and operating systems before starting Terraspring, a datacenter automation and virtualization company.

Stephen Keehn (M.S.'82 CEE) is a coastal engineer in Florida.

Barbara Simons (Ph.D.'81 CS), the first woman to receive the college's Distinguished Engineering Alumni Award in 2005, has co-authored a book entitled *Broken Ballots: Will Your Vote Count?* In it, Simons argues against using computer-based voting systems exclusively, claiming that a paper trail is necessary for secure voting. Simons was recently interviewed about electronic voting on the *Charlie Rose* show.

1970+

Charles H. Ballard (M.S.'74 EECS) has retired from the nuclear industry after 40 years. His book, *A Leadership Vacuum,* which addresses trends in American business that favor managerial techniques and practices over leadership, was published in 2009. Ballard was also recently elected president of his local school board.

Steven A. Frank (B.S.'73 CEE) reports that he went back home to California's central coast on the day he graduated and got a job with the county as a construction engineer. Over the course of a 33-year career, he built bridges, highways and water and sewage treatment plants, and then retired with a six-digit pension. "Life is good," says Frank.

Masuo Okada (Ph.D.'78 MSE) retired last March from Tohoku University in Japan as a faculty member and is now the president of Hachinohe National College of Technology, also in Japan.

Ilesanmi "Ade" Adesida (M.S.'75, Ph.D.'79 EECS) has been chosen as provost of the University of Illinois. Born in Nigeria, Adesida has made UI his home for the last 25 years, most recently as dean of the college of engineering. Since 2001, Adesida has been a director of the Center for Nanoscale Science and Technology. Adesida is also the chair of the National Science Foundation's engineering advisory committee.

PHOTO L. BRIAN STAUFFER/UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

1960+

George Iwanaga (B.S.'62 ME) earned a master's degree at USC and began working for the Aerospace Corporation. In the early 1990s, he began investigating the viability of an Antarctic ground research site, which over the decades grew into a crusade. On December 5, 2011, the McMurdo Station research center on Ross Island, Antarctica was officially dedicated and named "GIGS" for the George Iwanaga Ground Station, which receives and transmits global environmental, terrestrial and space weather data to users around the world.

Katta G. Murty (M.S.'66, Ph.D.'68 IEOR) is emeritus professor of industrial and operations engineering at the University of Michigan. Murty was recognized by the American Society for Engineering Education with the Meriam-Wiley distinguished author award for his latest book, *Optimization for Decision Making: Linear and Quadratic Models* (Springer 2012) and for seven other textbooks he has authored.

Antonie Stroeve (B.S.'64 ME) reports that he was supposed to graduate with the rest of the Class of '64, but was six credits short, so was still at Berkeley for the fall of 1964. "The Free Speech Movement, etc., etc., very interesting," recalls Stroeve. He retired from Motorola Satcom in Chandler, Arizona after a 35-year career in aerospace—including the launching of 95 satellites from the U.S., Russia and China for the Iridium Project.

1950+

Elihu I. Druckman (B.S.'50 ME), after working in the military products business, started a machine-tool company with a fellow engineer and spent 35 years building advanced metal working machines. Druckman obtained several patents and then sold the company upon his retirement in 1986. He is now 88 years old, and all five of his children received degrees from the University of California.

Building green motorcycles

Most of the things motorcycle makers call character, like throaty pipes, are really just covering up byproducts of internal combustion—and masking energy lost during power production. In contrast, electric motorcycles are stealthy and quiet, a trait not lost on riders.

"If you get on these electric motorcycles the first thing you notice is a magic carpet ride feel," says **Abe Askenazi,** B.S.'92, M.S.'94 ME. "It's almost like flying. You don't hear all of the drama of power production, you are just doing it."

As a student at Berkeley, Askenazi started in electrical engineering but missed the constant tinkering with machines that defined his childhood. So he switched to mechanical engineering, bought a Harley and started studying with professor Albert Pisano. For his master's thesis, he created a new mathematical model for single-track vehicle dynamics.

After working for 15 years with Buell Motorcycle Company in Wisconsin, Askenazi got a call from a start-up back in California that wanted to build electric motorcycles.

"It seemed like a good fit," says Askenazi, now head of engineering at Zero Motorcycles in Santa Cruz. "Even during my time at Berkeley, another side passion of mine was environmentalism." Currently electric motorcycles reduce overall emissions by 90 percent. That number will likely improve. "As the grid gets cleaner, electric vehicle emissions will get cleaner," Askenazi says.

STORY BY DANIEL MCGLYNN • PHOTO COURTESY ZERO MOTORCYCLES

Sterling Higgins (B.S.'50 CEE) served on a submarine in the Pacific Ocean in WWII. He also worked with the Atomic Energy Commission in the Pacific Islands investigating the impact of atomic blasts. Then he became an Internal Revenue Service agent, and retired in 1986. Higgins has traveled to all seven continents, visiting more than 60 different countries.

Anthony Johnson (B.S.'59 IEOR) retired with the rank of colonel from his post as director of logistics at Fort Ord on the Monterey Peninsula. His responsibilities included maintaining a wide variety of aviation equipment. Johnson has taught leadership and business at Chapman University and Hanwell Community College near Monterey, CA. This year, Johnson received a community service award from the city of Monterey.

C.D. "Dan" Mote, Jr. (B.S.'59, M.S.'60, Ph.D.'63 ME), past president of the University of Maryland, was recommended by the National Academy of Engineering (NAE) 2013 nominating committee to stand as the sole candidate for the NAE presidency. Mote served on the Berkeley faculty for 31 years and served as vice chancellor for university relations.

Balraj Sehgal (M.S.'57, Ph.D.'61 NE) is the author of *Nuclear Safety in Light Water Reactors: Severe Accident Phenomenology* (2012), a textbook designed for graduate students. The book addresses such disasters as the Fukushima nuclear plant accident in Japan in 2011.

Sven Thoolen (B.S.'51 IEOR), a retired vice president of industrial engineering at Matson Navigation Company, has moved to a retirement home in Pleasanton, CA near his daughter, Karla.

1940+

Louis E. Scott (B.S.'44 ME) spent three years in the South Pacific during WWII, five years as a petroleum engineer and more than 35 years in international marketing. An avid sailor, Scott has sailed around the world and has played the world's top 100 golf courses. He has been married for 70 years and has seven great-grandchildren.

Sam H. Zutler (B.S.'49 ME) retired 28 years ago after 35 years at Dow Chemical. After retirement, he taught at Fresno State for three years before embarking on two trips with Global Volunteers. In Poland, Zutler taught English to teenagers; in China, he served as a consultant in human relations. He reports: "I'm fine for an 89-year-old."

Farewell

Philip Brown, Jr. (B.S.'44 ME) died on April 9. Brown was a member of Alpha Delta Phi and in Navy ROTC. He attended the U.S. Naval Academy, received specialized sweeper training and served on the *U.S.S. Hobson* during the WWII assault on Okinawa. Brown began a career at Otis Elevator as a draftsman and worked his way up to executive vice president for the U.S. far west and Pacific basin regions. He and his wife of 67 years, Dorothy, raised four children.

Benjamin Buzzo (B.S.'42 ME) died on July 27. After graduating from Berkeley, Buzzo entered the U.S. Army and served as an officer in Europe during WWII, taking part in the Normandy invasion on D-Day and the Battle of the Bulge. After the war, Buzzo began a career as a petroleum engineer and worked in the U.S. and internationally. Buzzo and his wife, Marylin, were married for 63 years and raised four children.

Gee-Minn ("Jimmy") Chang (M.S.'86 MSE) died on March 6. Chang obtained his B.S. from National Tsing-Hua University in Taiwan before coming to Berkeley, where he worked in the Microlab and at Lawrence Berkeley National Laboratory. He was a semiconductor process engineer at Integrated Device Technology (IDT) in San Jose. In 2000, Chang returned to the Microlab as a senior development engineer until his death. Chang and his wife of 27 years, Edna, raised two daughters.

William Godden died on April 6 at the age of 88. A civil engineering professor at Berkeley, Godden served as associate dean of the college from 1964 to 1991. During WWII, Godden worked on a team of six engineers designing military bridges in Europe and North Africa. He received his Ph.D. from Queen's University in Belfast and also served on the faculty there. Godden and his wife of 54 years, Anna, raised four children.

Frank Alwyn Martin (B.S.'48 ME) died December 6, 2011, in Ashland, OR. Born in Los Angeles in 1922, Frank served in the U.S. Army Air Forces during WWII. He was stationed in Roswell, NM, where he worked on the Norden bombsight. Martin then worked for Lockheed Aircraft until his retirement in 1980. Martin and his wife of 60 years, Jeanne, raised four children and spent their empty nest years traveling the world. Martin fought Parkinson's disease for 12 years and died two months short of his 90th birthday.

Douglas C. Moorhouse (B.S.'50 CE) died on March 14 at the age of 86. After serving in WWII, Moorhouse worked his way up to president and CEO of Woodward-Clyde, a leading consulting engineering firm. Moorhouse was nominated to the National Academy of Engineering. After his retirement, he built a vineyard and house in Alexander Valley. He and his wife, Dorothy, raised two children.

James Murakami (B.S.'52 ME) died on April 28. Murakami grew up in Sonoma County; after Pearl Harbor, he and his family were incarcerated first in Merced, CA and then in Amache, CO for three years. Murakami served in the military before graduating from Berkeley. He was the national president of the Japanese American Citizens League and was instrumental in passing redress legislation requiring the U.S. government to apologize for the incarceration of 120,000 Japanese Americans in WWII. Murakami and his wife of 59 years raised two children.

Scott Shoaf (B.S.'63, M.S.'71 CE) died on May 3. He was appointed deputy director of the department of public works and received a commendation from San Francisco mayor Art Agnos for leadership during the Loma Prieta earthquake in 1989. Shoaf and his wife, Rebecca, were married for 30 years.

Robert Lee Vance, Jr. (B.S.'54 CE) died on March 1. He was a member of the Chi Psi fraternity at Cal, and throughout his life he remained an avid Cal football booster. He worked for the California Department of Transportation as a project manager before joining C.K. Moseman Construction. In the 1990s, Vance founded RLV Engineering. He worked on highway and bridge projects throughout the Bay Area and in Los Angeles and Honolulu.

Arthur Fong (B.S.'43 EE) died on March 17 at the age of 92. The son of a grocer in Sacramento, Fong decided to forgo the family business and instead attended UCLA, and then Berkeley. Three years after graduation, he was recruited by William Hewlett to join Hewlett-Packard, at the time a company of only about 100 people. In the 1960s, Fong's designs accounted for about a quarter of all HP's revenue, bringing in a total of $55 million. Throughout his career, Fong received awards and recognition from HP, Berkeley Engineering and IEEE. Fong retired from HP in 1995. He and his wife, Mary, were married for 69 years and together raised four children.

PHOTO COURTESY HEWLETT-PACKARD

Still driving innovation

IEOR researchers study man-machine interactions in the Human Factors Laboratory in this photo, circa 1964. The researchers connected instruments to this car-on-road simulator to see how the driver's decisions in different situations affected the car's directional and speed control. The goal of the research was to create better automobile design parameters to minimize the risk of accidents.

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