

BREAKTHROUGHS

UC BERKELEY COLLEGE OF NATURAL RESOURCES • FALL 2017

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RECORD-BREAKING

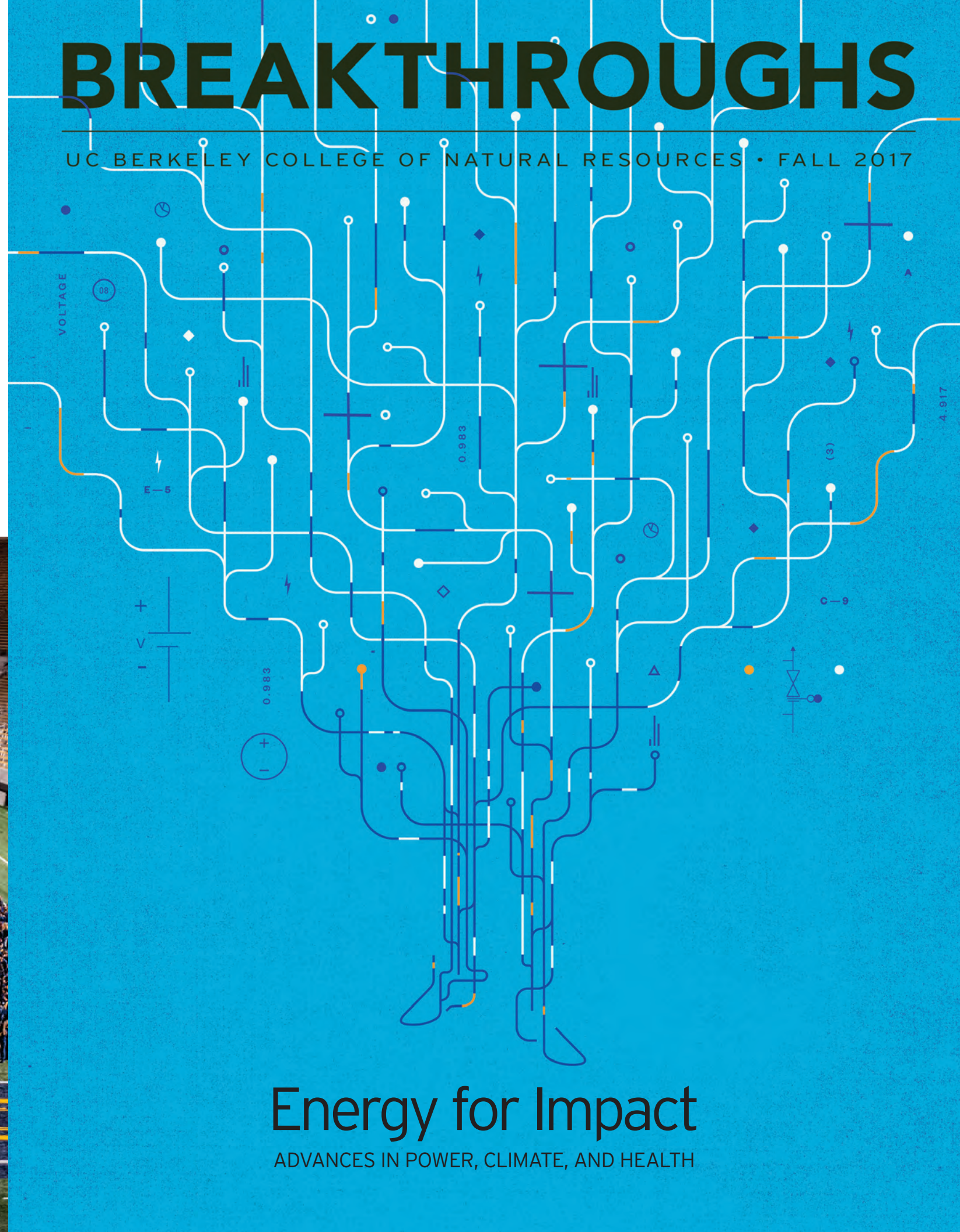
During Golden Bear Orientation on August 15, two judges from Guinness World Records certified that UC Berkeley had broken the world record for the largest human letter. Cal's C was composed of 7,196 incoming students, surpassing the previous record of 4,223 people. Go, Bears!

PHOTO: Keegan Houser



Energy for Impact

ADVANCES IN POWER, CLIMATE, AND HEALTH





We welcomed more than 600 first-year and transfer students to the College of Natural Resources this fall—double the size of our incoming class a decade ago. This rising enrollment in CNR majors reflects students’ desire to positively affect the world around them. Indeed, CNR is a place where both undergraduate and graduate students can begin to make change even as they prepare for careers across diverse fields. The enthusiasm and curiosity they bring to campus energizes us all.

In this issue of *Breakthroughs*, we cover student start-ups, faculty research, alumni impact, and more, bringing you stories of “energy” in many forms: Sustainable approaches to generating, storing, and distributing power around the world. Metabolic therapies to invigorate the fight against obesity. Global partnerships to accelerate policy for a clean-energy economy. Access to better food, to fuel our bodies and promote health.

We also announce the launch of a campaign to revitalize the CNR teaching kitchen—a space that has fostered our successful nutritional sciences programs and continues to support many groups in the growing “food ecosystem” on campus. We hope you’ll consider getting involved.

January 2018 will mark the start of a yearlong celebration of UC Berkeley’s sesquicentennial. With our roots in the College of Agriculture—the first college established with the University of California charter of 1868—this is truly CNR’s 150th anniversary as well. Watch for updates, events, and special stories in the new year.

I welcome your feedback at gilliss@berkeley.edu.

J. Keith Gilliss

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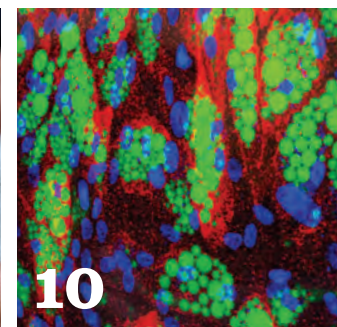
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FALL 2017



BREAKTHROUGHS



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ONLINE

CNR Student Spotlights
Our new series of interviews features stellar students from across the College’s many fields of study.
Go to nature.berkeley.edu/student-spotlights

COVER: Illustration by Mike McQuade

PHOTO: Elena Zhukova

Mapping the Costs of Climate Change



A new study co-led by two UC Berkeley researchers predicts that if climate change continues unmitigated through the end of the century, the poorest third of U.S. counties will likely lose up to 20 percent of their incomes, and regions such as the Pacific Northwest and New England will gain economically over the southern and Gulf states.

The research concludes that for every 1-degree-Fahrenheit increase in global temperatures, the U.S. economy stands to lose about 0.7 percent of its gross domestic product.

Published June 29 in the journal *Science*, the analysis was led by **Solomon Hsiang**, a professor in the Goldman School of Public Policy, and **James Rising**, a postdoctoral researcher in the Energy and Resources Group (ERG).

Their study combined 116 forecasts and numerous economic analyses developed by scientists around the world to assess costs and benefits of unmitigated climate change for crime, agriculture, energy, labor, coastal communities, and mortality.

Rising and Hsiang say that the study results can be useful to everyone from policy makers and public utility officials to farmers and law enforcement officials, as well as those in the tourist industry and disaster relief organizations.

— ADAPTED FROM AN ARTICLE BY KATHLEEN MACLAY

KEY FINDINGS

- Rising mean sea levels linked to stronger, more frequent tropical cyclones will amplify storm tide heights and extend floodplains, worsening problems for low-lying coastal cities and inflicting direct economic damages on them.
- Agricultural yields in the Midwest will decline dramatically with rising global mean surface temperatures.
- Annual national mortality rates will rise by roughly five deaths per 100,000 people for each 1-degree-Celsius (1.8-degrees-Fahrenheit) increase in temperature.
- Owing to more hot days, electricity demands will increase for all regions except the Rockies and the Pacific Northwest.
- For each additional degree of rising global mean surface temperature, the number of hours worked will decline by about 0.11 percent for workers who are not generally exposed to outdoor temperatures and by 0.53 percent for high-risk, outdoor workers in sectors like agriculture, construction, manufacturing, and mining.
- Property crimes will increase in the Northeast as the number of cold days decreases. Meanwhile, violent crime rates will increase across the country by about 0.9 percent per each additional degree Celsius in global mean surface temperature.

CANNABIS CROP EXPANSION THREATENS WILDLIFE HABITATS

Planting cannabis for commercial production in remote locations creates forest fragmentation, stream modification, soil erosion, and landslides. Without land-use policies to limit its environmental footprint, the impacts of cannabis farming could get worse, according to a new study published in *Frontiers in Ecology and the Environment*.

“To mitigate the anticipated environmental impacts, now is the time for policy makers and land-use planners to set regulations to manage the spatial pattern of cannabis expansion, before crop production becomes established,” said co-author **Van Butsic**, a Cooperative Extension specialist in the Department of Environmental Science, Policy, and Management (ESPM).

Cannabis, as either a medicinal or a recreational drug, is now legal in more than 30 U.S. states and several other countries. In California, where medicinal marijuana has been legal since 1996, voters approved the sale and possession of one ounce of marijuana per person for recreational use in November of last year. As a result, cannabis production is ramping up.

Earlier studies have shown that cannabis production causes environmental damage, including the rodenti-

cide poisoning of forest mammals and the dewatering of streams due to improper irrigation.

In this study, Butsic, ESPM assistant professor **Ian Wang**, and Jacob Brenner of Ithaca College compared the effects of cannabis cultivation in Humboldt County from 2000 to 2013 with those of timber harvests during the same period. Based on the size, shape, and placement of the cannabis grows within 62 randomly selected watersheds, they quantified the grows’ impacts relative to those of timber harvests.

“We found that although timber has greater landscape impacts overall, cannabis causes far greater changes in key metrics on a per-unit-area basis,” Butsic said.

The cannabis grows resulted in 1.5 times more forest loss and 2.5 times greater fragmentation of the landscape, breaking up large, contiguous forests into smaller patches and reducing wildlife habitats.

Current California law caps the size of outdoor cannabis production at one acre per parcel, to prohibit the development of industrial-scale cannabis operations outdoors. An unintended consequence of this law may be smaller, dispersed cannabis grows that edge out wildlife.

— ADAPTED FROM AN ARTICLE BY PAMELA KAN-RICE

FACULTY HONORS ★★★★★



ESPM professor **Mary Firestone** was elected to the National

Academy of Sciences in May. Firestone’s research examines the fundamental understanding of soil microbial ecology and its applications to issues such as climate change, sustainability, and biodegradation.



Plant and microbial biology professor **N. Louise Glass** was named a fellow of the

Mycological Society of America in July. Glass is a leading researcher in the molecular genetics of *Neurospora*, including the genetics of mating, non-self recognition, and lignocellulose decomposition.

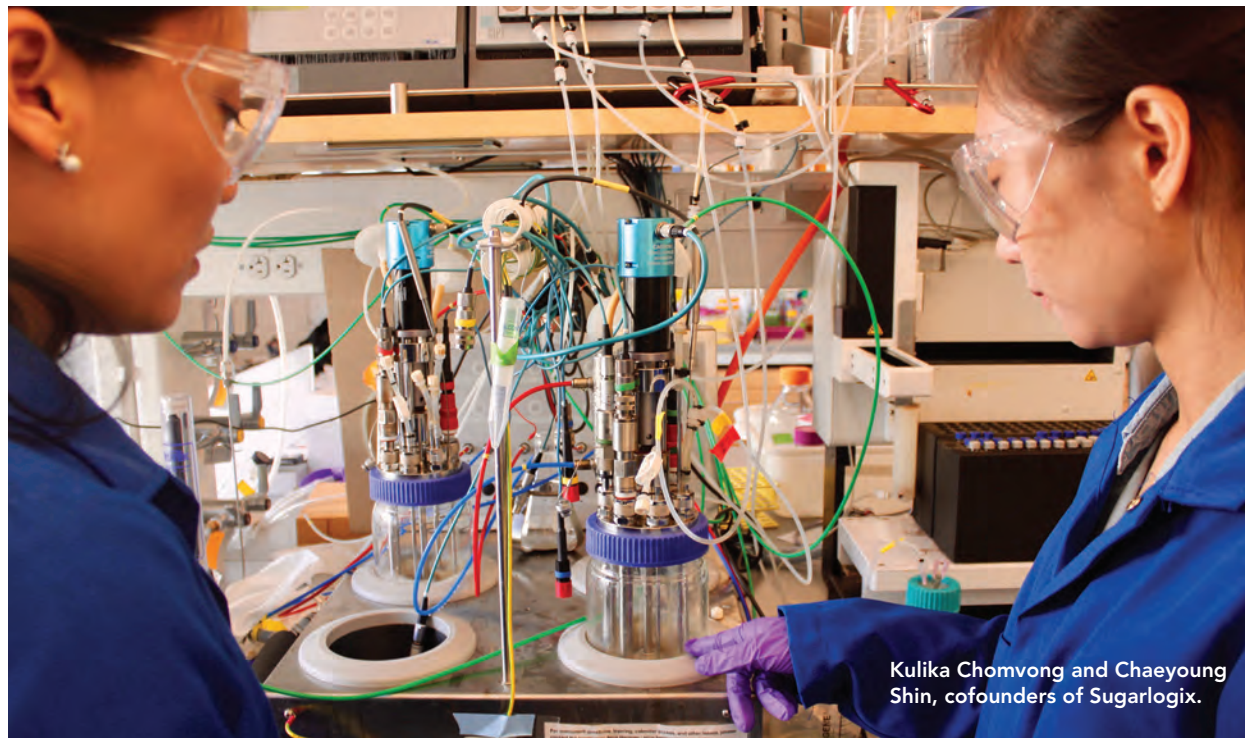


Also in July, **Susan Hubbard** and **Margaret Torn** were

elected fellows of the American Geophysical Union. Hubbard is an adjunct ESPM professor and the associate lab director of the Earth and Environmental Sciences Area at the Lawrence Berkeley National Laboratory (Berkeley Lab). Torn is an adjunct ERG associate professor and a senior scientist in Berkeley Lab’s Earth and Environmental Sciences Area.

ENGINEERING

A Sugar That's Good for You



Kulika Chomvong and Chaeyoung Shin, cofounders of Sugarlogix.

Kulika Chomvong and **Chaeyoung Shin** want the world to eat more sugar. The two are cofounders of Sugarlogix, a start-up cultivating prebiotic sugars. “We make healthier sugars for healthier products,” said Chomvong, PhD '16 Plant and Microbial Biology. “We want to make sugars that are worth getting addicted to.”

The duo met on campus at the Energy Biosciences Institute while working at separate ends of the same problem. Chomvong was engineering yeast suitable for the production of fuel from cellulose, while Shin—a chemical engineering doctoral student—was refining the biofuel fermentation process itself. After graduating in 2016, the two pivoted to the production of prebiotic sugars.

Many people are familiar with probiotics, live cultures of “good” gut bacteria found in foods like yogurt and kombucha. In contrast, prebiotic sugars—also called prebiotics—are nondigestible compounds that promote the growth of intestinal microflora. Probiotics are living bacteria, whereas prebiotics are the nonliving chemical compounds on which intestinal flora feed.

“What we’re doing is re-creating the food for good gut bacteria,” said Chomvong, and the result could be a positive

impact on gut health. While anyone can benefit from a healthier gut, Chomvong is optimistic that prebiotics would most benefit individuals with depleted levels of gut bacteria, such as those who have recently taken antibiotics.

Currently, Sugarlogix is focusing on how prebiotics could help infants, by culturing human milk oligosaccharides, or HMO. Compounds similar to HMO—called galactooligosaccharides, or GOS—occur naturally in the milk of other mammals and have been used as an additive in infant formula for years. A study co-published by the National Center for Biotechnology Information and the National Institutes of Health found that infants given formula supplemented with GOS showed gut health consistent with that of breast-fed infants. Chomvong and Shin believe they would see similar if not superior results for infant formula supplemented with HMO.

Although prebiotics can’t replace sweeteners, as an additive to infant formula they could lead to healthier babies. And as Sugarlogix develops prebiotics for a wider audience, Chomvong and Shin hope its products can someday promote healthy intestinal flora in adults, too.

— ADAPTED FROM AN ARTICLE BY CIRRUS WOOD IN *BERKELEYSIDE*

India's Rising Suicide Rate Linked to Climate Change

Climate change has already caused more than 59,000 suicides in India over the last 30 years, according to estimates in a study published in *Proceedings of the National Academy of Sciences* in July. Research suggests that failing harvests that push farmers into poverty are likely the key culprits.

Tamma Carleton, a doctoral candidate in the Department of Agricultural and Resource Economics, discovered that warming by 1 degree Celsius (1.8 degrees Fahrenheit) on a single given day during India’s agricultural growing season leads to roughly 65 suicides across the country whenever that day’s temperature is above 20 degrees Celsius (68 degrees Fahrenheit). Warming by 5 degrees Celsius under the same temperature conditions has five times that effect.

Heat drives crop loss, Carleton contends, which can cause ripple effects throughout the Indian economy as poor harvests drive up food prices, shrink agricultural jobs, and deplete household savings. The study demonstrates that warming—forecast to reach 3 degrees Celsius by 2050—is already taking a toll on Indian society.

Using methods that she developed in a previous paper, published in the journal *Science*, Carleton projects that the suicide rate will only rise as temperatures continue to warm.

Debate about solutions to the country’s high and rising suicide rate, which has nearly doubled since 1980 and claims more than 130,000 lives each year, is contentious and has centered on lowering economic risks for farmers. In response, in 2016 the Indian government established a \$1.3 billion crop insurance plan aimed at reducing the suicide rate—but it is unknown if that will be effective or sufficient.

Carleton said she hopes her work will help people better understand the human costs of climate change, as well as inform suicide prevention policy in India and other developing countries. “The tragedy is unfolding today. This is not just a problem for future generations. This is our problem, right now,” she said. “The right policies could save thousands.”

— ADAPTED FROM AN ARTICLE BY KATHLEEN MACLAY

SUBJECT: Why I Do Science

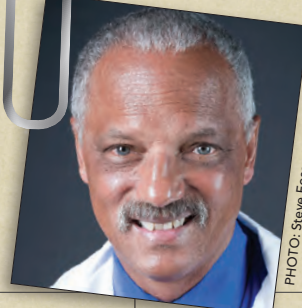


PHOTO: Steve Fossum

ENTRY BY:
Vernard Lewis

ENTRY #:
016

My first memories of insects were in Fresno when I was in kindergarten, and involved chasing grasshoppers and ants. Except for several speed bumps of playing high school sports and almost going to medical school, I devoted most of my adult life to the study of insects. I was trained at UC Berkeley when it was the number-one entomology department in the nation. As a professional, I’m known as an urban entomologist specializing in termites.

My grandfather was the person who first instilled my love of nature, and it was my grandmother who taught me discipline and the value of education. Being the eldest of 10 children in Minneapolis taught me responsibility, how to share, and negotiating skills. In a low-income family, nothing comes easily or can be taken for granted.

Even though I always had a passion for insects, it didn’t always show in my grades; in high school I was told that I wasn’t good enough to go to college. However, with \$300 in my wallet, a one-way ticket to San Francisco, and a belief in myself, I wagered on my own success. After three degrees from Berkeley, a 27-year academic and research career, and being inducted into the *Pest Management Professional* Hall of Fame in 2016, I think I won the wager!

I’m probably most proud of creating and naming the Villa Termiti. This two-car-garage-size structure was built in 1993 and was the first of its kind to test termite detection and control methods. I’m also proud of being the first African American entomologist with an academic title at Cal.

Recently retired, **Vernard Lewis** continues his academic and outreach activities as an emeritus Cooperative Extension specialist in the Department of Environmental Science, Policy, and Management. He also serves as a member of the department’s Equity, Inclusion, and Diversity Committee.



How Big Is Your Own Carbon Footprint?

Worldwide, countries are working hard to reduce their greenhouse gas emissions. But what does your own state's carbon footprint look like? What about your city's footprint? Your household's?

The CoolClimate Network, founded by Energy and Resources Group (ERG) researcher **Chris Jones** and professor **Dan Kammen**, helps answer those questions. It created the first—and still most highly rated—carbon footprint calculator, which is tailored to each U.S. state, city, and household. Based at UC Berkeley, the network is a consortium of universities, businesses, governments, and nonprofit organizations that's developing policies and programs to motivate people and organizations to take climate action.

Jones developed the first comprehensive carbon footprint calculator in 2003 for his master's project in ERG. By 2007, the calculator's capabilities included benchmarking according to zip codes, which enabled it to compare cities and individual households.

CoolClimate has also launched innovative behavioral change programs and policy tools that are accelerating the transition to a clean-energy economy. Its competition software offers a gamified online platform that motivates participants to form teams and reduce their collective footprints. In 2015, CoolClimate's

Cool Campus Challenge, in partnership with all 10 UC campuses, engaged 20,000 UC staff, students, and faculty to inspire the UC community to be climate neutral by the year 2025. A new round of the challenge is being planned for 2018.

Additionally, an online planning tool maps future household carbon footprints at the neighborhood scale, based on policy scenarios. And CoolClimate's tools provide data and analytics to help hundreds of other research efforts and programs. Jones is now scaling the calculator internationally, replicating it for other countries. "It's really taking off right now," he said. "Once you know your own carbon footprint, it ranks recommendations and encourages pledges for behavioral change."

The network is funded by a tiered partnership program that costs between \$10,000 and \$60,000 per year, and CoolClimate has recently formed partnerships with the Nature Conservancy, the Leonardo DiCaprio Foundation, and the government of Ontario, Canada.

"CoolClimate has demonstrated how behavioral science research, tools, and programs can quickly scale up climate solutions in California," said Jones. "We're excited to expand this model as a complement to national and international climate policy."

— KIRSTEN MICKELWAIT

ONE MEGAWATT CLOSER TO CARBON NEUTRALITY

Working toward the goal of becoming a carbon-neutral campus, UC Berkeley is now producing one megawatt of solar power per year—enough to power 164 homes on average, according to the Solar Energy Industries Association.

Solar panels have been installed recently at five locations on campus: the Martin Luther King Jr. Student Union, Eshleman Hall, the Recreational Sports Facility (RSF) field house, University Village, and Jacobs Hall. At University Village—the largest of the sites—the solar carport system generates 20 percent of the electricity needed to power the whole village, while at the RSF the panels generate about one-third of the necessary energy. Online power dashboards for these two sites allow users to track power generation in real time and learn about the corresponding environmental benefits.

Falcons Choose On-Campus Housing

Once on the brink of extinction, peregrine falcons—the world's fastest animals—have made a remarkable comeback and have begun moving from their customary habitats on cliff faces into urban areas, laying their eggs on skyscrapers and other tall buildings.

After a pair of peregrine falcons nested on the second balcony of the Campanile, two chicks hatched in late May. Volunteers—including **Doug Bell**, PhD '12 Zoology, of the East Bay Regional Park District—banded the chicks, in order to allow researchers to study their movement.

Mary Malec, a volunteer raptor-nest monitor for the park district, organized a group of eight volunteers to be on "fledge-watch" throughout the week that the chicks were likely to start flying. The volunteers took shifts and were ready to help if necessary. "Fledglings fly well, but land badly," Malec said. Named Fiat and Lux via a UC Berkeley Facebook poll, the fledglings took their first flight off the 307-foot bell tower in July. Sadly, Lux died a week later after flying into a window on the 10th floor of Evans Hall.



PHOTO: Mary Malec

Fiat has since taken flight and left campus, which is typical behavior for adolescent raptors. Since Fiat's departure, four other peregrines have flown into the area, but were chased off by the peregrine couple that have claimed the Campanile as their home. Malec thinks the outsiders were house hunting. "This is a great territory," she said. "They'll have to defend it."

— ADAPTED FROM AN ARTICLE BY ANNE BRICE



METABOLIC RESEARCH ACROSS THE BAY

More than 100 million Americans are now diabetic or prediabetic, according to the Mayo Clinic. Many of the researchers in the Department of Nutritional Sciences and Toxicology (NST) study what drives diabetes and other metabolic diseases and are working to answer some new questions: How do vitamins, hormones, and aging affect metabolism? What metabolic alterations underlie the development and growth of cancer cells? How can we create healthy fat tissues to combat obesity-related diseases?

The need for continued research in these areas was a catalyst for a new collaboration between NST's metabolic biology graduate program and the Diabetes Center at the University of California, San Francisco (UCSF). Currently, metabolic biology graduate students complete three lab rotations with NST faculty before joining one lab for the remainder of their doctoral research. Starting this fall, they'll also have the opportunity to work with five faculty at UCSF, including the Diabetes Center's director, Matthias Hebrok.

"The expertise in diabetes research at Berkeley and UCSF is highly complementary," said professor and NST chair **Andreas Stahl**, "so I expect many exciting projects and discoveries to emerge as the two units grow closer in research and education."

— MACKENZIE SMITH

ON THE GROUND

Research on the Future of Energy

INTEGRATING RENEWABLE ENERGY INTO THE GRID

Duncan Callaway, an ERG associate professor, leads a Department of Energy-funded effort to improve the way rooftop solar and electric vehicles are integrated into the grid. His lab studies how to reliably and cost-effectively operate the grid utilizing rapidly changing technologies such as rooftop solar panels, electric vehicles, wind turbines, and battery storage.

CHARTING THE POLITICS OF ENERGY INNOVATION

Jonas Meckling, an assistant professor in the Department of Environmental Science, Policy, and Management, studies climate and clean-energy policy and the political forces that drive it. His current research examines carbon regulation, innovation in solar power and electric vehicles, and China's role in global renewable energy trade.

At the College of Natural Resources, researchers are investigating ways to meet the world's energy needs through renewable-electricity access, clean-power storage solutions, and more.



DOCUMENTING GRID ACCESS IN TANZANIA

Veronica Jacome, a doctoral student in the Energy and Resources Group (ERG), investigates the relationship between unreliable electricity, the physical properties of the electric grid, and how people access power. Working in Tanzanian communities that face intermittent and unstable electricity services, Jacome gathers information through both qualitative and quantitative methods—speaking with community members, surveying households, and monitoring electricity at transformer and household levels.

TRACKING VEHICLE-EMISSIONS POLICIES

Agricultural and resource economics (ARE) assistant professor **James Sallee** studies energy, environmental, and tax policies, with a focus on evaluating policies aimed at mitigating greenhouse gas emissions in the transportation sector. A recent study that he co-authored revealed that European cars emit dramatically more carbon dioxide than their official ratings suggest.

EXPLORING BIOENERGY THROUGH FUNGI

Plant and microbial biology professor **N. Louise Glass** studies the mechanisms of plant biomass deconstruction and their implications for the production of biofuels and specialty chemicals. Utilizing genetics, genomics, and biochemical tools, her lab focuses on fungal enzyme-secretion pathways and fungal regulatory networks to understand possible applications of fungi to bioenergy.

INCENTIVIZING SMARTER ENERGY CONSUMPTION

ARE professor **Meredith Fowle** and her co-authors in a recent study demonstrate how a small nudge can influence individual consumer decisions that add up to big social impacts. When an electric utility defaulted consumers into a time-varying electricity-pricing program, participation dramatically increased. All participants, including those defaulted into the program, significantly reduced their electricity consumption during critical periods when supply costs are typically highest.

ANALYZING PATHWAYS TO LOW-COST ELECTRICITY

ERG PhD student **Noah Kittner** studies the environmental impacts of new storage systems and the potential for storage technologies to contribute to low-carbon and low-cost electricity. A recent study he co-authored with ERG professor **Dan Kammen**, published in *Nature Energy*, analyzed the rapidly falling cost of lithium-ion battery technologies and how these storage methods can be utilized in the transition toward solar and wind electricity on the grid.

Architects of

Metabolism

Andreas Stahl's campus collaborations in fighting obesity with fat

By Nate Seltenrich

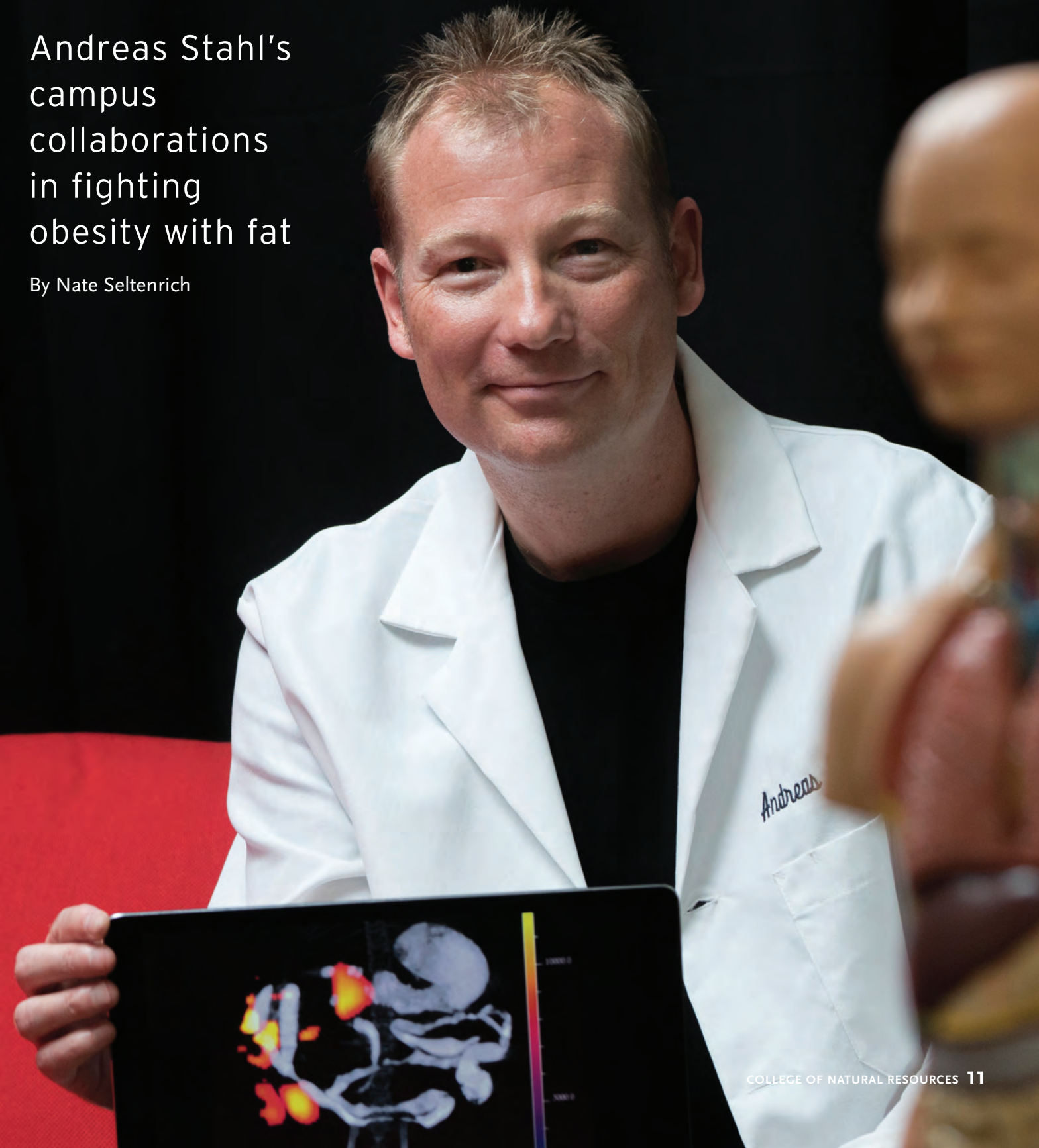


PHOTO: Jim Block

If 17 seasons of *The Biggest Loser* have taught us anything, it's that keeping the pounds off can be harder than losing them in the first place. A long-term National Institutes of Health (NIH) study of 14 of the reality show's eighth-season contestants, for example, found that in the six years following that competition, all but one regained weight—and four ended up heavier than before the competition. Even more interesting: All but two contestants exhibited slower metabolisms than they had before the show, burning hundreds fewer calories per day than a typical man or woman of their size.

More than one-third of adults in the United States and 10 percent of people worldwide are considered to be obese. But it's the potential complications of obesity—including type 2 diabetes, heart disease and stroke, fatty liver disease, and some cancers—that most concern Professor **Andreas Stahl**. “Combating obesity is a huge problem, and in particular the chronic diseases associated with it have placed a large strain on our health care system,” says Stahl, who is chair of the Department of Nutritional Sciences and Toxicology. “These diseases are very expensive to treat, and there can be very drastic consequences.”

The NIH findings lend credence to Stahl's belief that for many obese individuals, diet and exercise alone aren't enough—and may in fact be quite unlikely to work. “I think there need to be behavioral interventions in parallel with other approaches,” says Stahl. Approaches, that is, like using tissue engineering and “metabolic therapy” to fire up one of the body's most effective calorie-burning engines: brown fat.

Up until eight years ago, scientists thought that brown fat existed only in babies, where it plays an important role in generating lifesaving heat. Now we know that

adults can have it too, and through cutting-edge research and collaborations with colleagues in the colleges of chemistry and engineering, Stahl is working hard to harness its power in the fight against obesity. His goal: to develop a safe, easy, injectable treatment that can generate new brown fat in a patient's body and begin to slowly, steadily burn off calories.

IN SEARCH OF THE METABOLIC “SINK”

When we talk about excess fat in adults, we're typically referring to “white” fat, present in large quantities even in healthy individuals. It's essential to our survival in its own way, storing energy and working as an insulator, cushion, and endocrine organ. The problem comes when we consume more calories than we burn and white fat begins to accumulate in places it shouldn't, like the liver. This can lead to fatty liver disease, which affects roughly 10 percent of children and a quarter of adults nationwide and contributes to diabetes, liver failure, and increased risk of liver cancers.

Bypassing this chain of events would require finding another way of storing or consuming excess fatty acids. “We need a location where we can put it safely,” Stahl says. And that's what brown fat is: a sort of “metabolic sink” that generates heat while it's burning calories.

By introducing the proper signal and cellular “environment” into the body, Stahl believes, we can recruit a specific, relatively abundant type of stem cell; instruct it to become brown fat instead of white fat; and proceed to radiate away excess calories as heat.

SNIFFING OUT STEM CELLS

This may sound impossibly futuristic, but in fact more than half the work is already done. Stahl; his colleague **Kevin Healy**, a professor of bioengineering and materials science; and seven other collaborators, including five more from



“You need copper to fight obesity. If you don’t have enough copper, you can’t burn fat well.” — Chris Chang

PHOTO: Michael Barnes

UC Berkeley, described in a November 2015 research paper their development of a gel-like substance with the right properties to turn stem cells into brown fat cells. The researchers also demonstrated that their subcutaneously injected implant—a mix of stem cells and an in situ-forming hydrogel—accomplished the end goal of reducing weight gain and blood glucose levels in mice.

The next step, of course, is to extend this technology to humans. “It’s a high-priority project, and I think it has a big social need,” Healy says. But developing the technology for real-world use will require another big advance. Instead of extracting white fat from a subject in order to obtain stem cells that will then be reinjected, Stahl envisions introducing an additional chemical signal into the implant that will actively “recruit” the desired stem cells, summoning them from nearby areas to enter the gel-like matrix, where they will convert to brown fat.

“It’s like a dog sniffing out a scent trail and going toward where the scent is the strongest. Cells can do that with chemicals as well,” Stahl explains. “What we’re working on right now is how to attract the stem cells into the matrix and still be able to turn them into brown fat after they have arrived.”

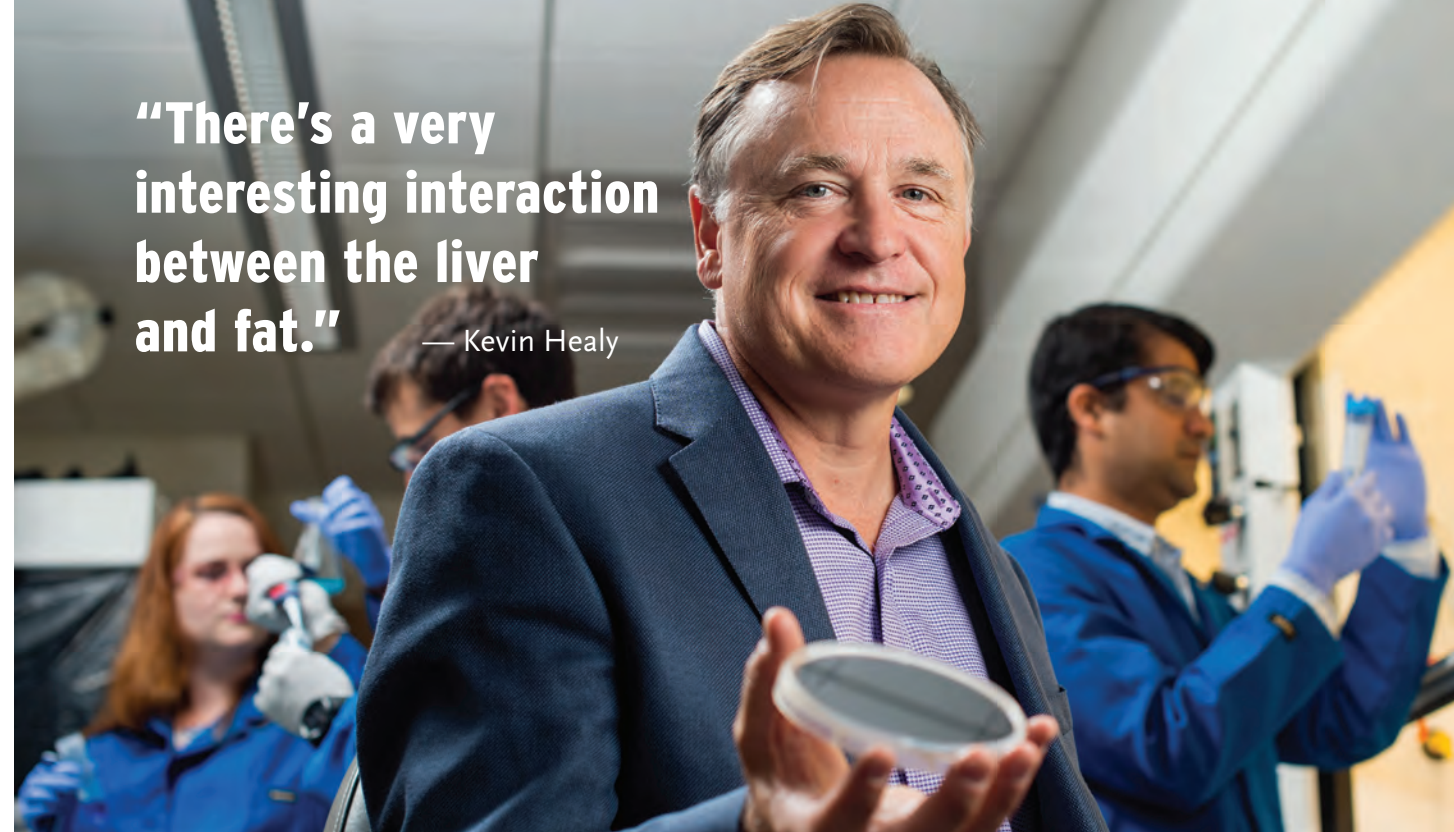
TRACKING COPPER WITH BIOLUMINESCENCE

It’s a pressing question, but far from the only one occupying Stahl’s mind. A recent collaboration

with chemistry professor **Chris Chang** and other Berkeley researchers not only led to an obesity-related breakthrough of its own but also laid the groundwork for more progress on brown fat. First, using a novel technique developed by Chang’s lab to track copper inside a live mouse with the help of firefly-derived bioluminescence, the researchers showed that diet-induced fatty liver disease is associated with copper deficiency in the liver.

“It shows you need copper to fight obesity,” Chang says. “If you don’t have enough copper, you can’t burn fat well. That potentially can lead to fat storage, weight gain, and glucose intolerance.” Building on this work, he and Stahl are now attempting to apply a similar bioluminescent marker to brown fat. “We’re really keen on imaging not only where that type of fat is locally in the body, but how active it is under different situations,” Chang says. Achieving this goal could be a big step in the journey from lab to real world for Stahl’s brown fat implant.

Stahl and his team aren’t the only ones seeking to tap the power of brown fat, but they’re certainly at the forefront, driven by a desire to reduce obesity’s huge burden on our society. “We’re trying to tap into this mechanism,” Stahl says. “We want to change the equation where we reduce white fat by expanding brown fat”—not simply to make people skinnier, like so many reality-show contestants, but to lower glucose levels, blood lipid levels, and the amount of calories in circulation, he says. “Those are the things that lead to detrimental effects.” **31**



“There’s a very interesting interaction between the liver and fat.” — Kevin Healy

PHOTO: Noah Berger

FAT ON A CHIP

Andreas Stahl’s mission to beat obesity has generated important insights into brown fat biology and nutrient imaging. But it doesn’t end there. Another line of research—with bioengineering colleague **Kevin Healy**—resulted in a breakthrough earlier this year and a powerful new tool for research into fat and metabolism.

Stahl, Healy, and their collaborators fit a biologically active, fully functional sample of human white fat—which accounts for one-fourth of the body weight of a typical healthy adult—onto a silicon chip measuring less than one millimeter squared.

This “fat on a chip” device—more technically known as a “microfluidic system incorporating white adipose tissue”—is designed to play at least two important roles in the lab. By replicating the in vivo (“within the living”) experimental model without the use of test animals, it can serve as a test bed for investigating fat-related diseases such as obesity and type 2 diabetes. It can also act as an efficient and highly accurate screening tool for assessing drug effects on white adipose tissue function.

The device stems from earlier work by Healy on other innovative “organ on a chip” systems. In 2015, his lab developed the “heart on a chip”—around 5,000 heart-tissue cells arranged on a chip, beating

with the regularity of a human heart—and more recently it did the same for the liver, though that work has not yet been published.

Together with the fat chip, Healy says, these systems form an ideal “minimal metabolic unit” for researching human disease and evaluating drugs with metabolic activity. “There’s a very interesting interaction between the liver and fat,” he says. “This might allow us to look into things associated with high-fat diets, such as diabetes and other imbalances in the metabolic system.”

What’s more, Stahl says, these systems allow researchers to safely test cells taken from specific individuals, opening up new lines of inquiry into mechanisms behind metabolic effects tied to age, race, and other factors. “Humans are genetically diverse, and often people with different backgrounds and ethnicities have different responses to the same drug,” he says.

Healy and Stahl are already working on brown fat on a chip, another step toward their ultimate goal of assembling a complete “multi-organ microfluidic device” that could reveal wonders about the inner workings of human metabolism on a personalized basis. “We want to create the best ‘miniaturized’ human that we can within these different devices,” Stahl says.

—NS

International Adventures in Clean Energy

Like the intrepid fictional professor Indiana Jones, Daniel Kammen cuts a swashbuckling figure. As a trained pilot, he once flew medical supplies to remote areas of Kenya, ferrying patients back to Nairobi for treatment. Today, the 55-year-old globe-trotting energy and climate scientist and environmental policy wonk straddles two different yet distinguished worlds.

Fresh off a yearlong stint as a U.S. State Department science envoy, Kammen—a professor of energy and director of the Renewable and Appropriate Energy Laboratory (RAEL)—admits he was discouraged by the Trump administration’s withdrawal from the Paris climate accord, which he views as the United States ceding its environmental leadership to nations such as China.

Yet he remains optimistic that the momentum for clean energy will continue to swell, especially with leadership from the Golden State. “California is truly ground zero for innovating on science and climate change technology and policies,” he says in his Barrows Hall office—tall, trim, and clad in a gray “I ♥ Science” T-shirt.

Astronomers vs. astronauts

At UC Berkeley, Kammen holds appointments in the College of Natural Resources’ Energy and Resources Group (ERG), which he now chairs; the Goldman School of Public Policy; and the Department of Nuclear Engineering. In 20 years, the number of students signing up for his Energy and Society class has grown tenfold, from about 35 students for the course’s first semester to more than 300.

Beyond academia, Kammen serves as an advocate for worldwide recognition of human-made climate change and wider use of renewable energy to combat it. In 2007, he shared a Nobel Peace Prize as a contributor to a report for the Intergovernmental Panel on Climate Change. (Berkeley Nobelists traditionally win a much-coveted campus parking spot. But in a fitting green twist,

Professor Daniel Kammen combines science with environmental policy in the quest for sustainable power

By Tom Levy



Kammen and the other Berkeley contributors requested that their prize be honored with a bike rack near the Free Speech Movement Café.)

International luminaries have sought his battery-technology expertise. And then there’s his enduring connection to Africa, where he married his wife, Dele, a pediatric radiologist, in her ancestral Nigerian village. The couple has two teenage daughters, whom he has nudged into attending NASA Space Camp and traveling to Kenya and Borneo.

Insight into his own fascination with both science and policy came to him, he says, after watching *Jurassic Park III*. In that film, another fictional professor, Alan Grant, says that exploring the unknowns of outer space attracts two kinds of people: astronomers, who study the unknown from the comfort and safety of their observatories, and astronauts, who immerse themselves in the unknown, leaving comfort and safety behind.

“What I do now, the science and policy of energy, feels like a mixture of astronomer and astronaut,” says Kammen. “There’s the basic science story, understanding innovation in renewable energy technology—that’s the astronomer. And then there’s the rough-and-tumble world of energy policy, and that feels more like astronaut.”

Translating science into policy

Born in Cambridge, Massachusetts, and raised in Ithaca, New York, he is the son of Pulitzer Prize-winning historian Michael Kammen. But history was not the younger Kammen’s calling. Instead, he studied undergraduate physics at Cornell University, noted for physicist-activists like Hans Bethe, who led the Manhattan Project’s theory division. There, Kammen was mentored by other physicist-activists, like David Lee, an expert on how economic development, agriculture, and the environment interact, and Kurt Gottfried, a co-founder of the Union of Concerned Scientists.

Kammen began channeling his inner astronaut as a Harvard University doctoral candidate in physics, spreading

PHOTO: ELENA ZHUKOVA

the word about renewable energy technology in several developing countries and forging lifelong connections with energy scientists and policy makers. “I followed a path I didn’t know was a path at the time,” says Kammen, who earned his PhD in 1988. “And that was the physicist-activist path.”

First as a postdoc at Caltech and then again back at Harvard, he traveled to Nicaragua—with support from Berkeley-based NGO techNICA—to research and publish papers about the Sandinista government’s pioneering solar and wind energy efforts. He also connected with Bill Lankford, who had developed a solar oven design he was sharing with Nicaraguan villagers. But village women, who did most of the family cooking, wanted larger ovens and didn’t want ovens made by men. As the women dissected and improved the designs and then built and shared their own ovens, the two scientists observed “appropriate technology” in action.

Kammen’s first teaching job was at the Woodrow Wilson School of Public and International Affairs at Princeton University, where he also collaborated with the physicist-led Center for Energy and Environmental Studies (CEES). He continued his research—on biomass as an energy source,



GLOBAL ENERGY CONNECTIONS
 Daniel Kammen is pictured (clockwise from upper left) with Berkeley professor of physics and former California energy commissioner Art Rosenfeld in 2013; with Virgin Group founder Sir Richard Branson in 2006; with former California governor Arnold Schwarzenegger at the Paris COP21 summit; in South Sudan with a soldier/guide at a mini-grid project site near the Ugandan border; with then-secretary of state John Kerry in 2016; at a solar installation in Ouarzazate, Morocco; with Representative Jackie Speier at a 2017 town hall meeting in San Francisco; with then-U.S. ambassador to Morocco Dwight Bush in 2016.

“Kenya and Morocco are quite different but, like California, they’re very much on the leading edge of the clean-energy transition on their continent.”

cookstoves suitable for use in East Africa, and what could be learned about technology innovation by tracking patents. Gradually he developed a vision for building a research community around appropriate and alternative energy.

“All those types of projects—not only on the science of clean energy, but on translating science into policy—led me to Berkeley,” says Kammen. “Back then, the CEES group at Princeton and the Energy and Resources Group at Berkeley were two of the very few places doing interdisciplinary science.”

From Silicon Valley to the Silicon Desert

When famed physicist-activist John Holdren left Berkeley’s ERG faculty for Harvard in 1998, Kammen was hired as an associate professor. “Holdren was one of the physicists in the same tradition I was in,” says Kammen. “In fact, he was one of the people who inspired me to do this kind of thing.” During Barack Obama’s presidency, Holdren became the longest-serving science envoy ever.

Kammen, too, took a turn in Washington, in 2010, as the first chief technical specialist for renewable energy and energy efficiency at the World Bank.

In the last year of Obama’s term, Secretary of State John Kerry named Kammen a science envoy, one of several asked to leverage their knowledge and networks toward sustained collaborative international science efforts. Kammen was assigned to increase renewable energy capacity in Africa and the Middle East.

In the Middle East, Kammen focused his science envoy work on Jordan; in Africa, on Kenya and Morocco, which he calls “the Californias of Africa.” “Kenya and Morocco are quite different but, like California, they’re very much on the leading edge of the clean-energy transition on their continent,” says Kammen. “What made Morocco and Kenya leaders was choosing early on to emphasize diversity in their energy mix, just as California has done.”

Morocco and California are of similar size, population, climate, and geography, and each possesses coastal areas as well as sizable mountain and desert regions. Each has one of the planet’s largest solar power facilities—Morocco’s at Ouarzazate and California’s at Ivanpah. And each has set aggressive 2030 climate targets, says Kammen: Morocco to reach 52 percent renewable energy, intentionally topping California’s 50 percent goal.

Kammen has been assisting Morocco’s efforts to emulate California’s example of encouraging powerfully productive academic-tech partnerships. Morocco’s goal: a “Silicon Desert” connecting young science researchers with budding local tech companies helping to build out the country’s renewable energy grid.

Influenced by the rising use of big data in the United States, and Berkeley’s own data sciences initiative, Kammen partnered with Morocco’s premier science institution. The School of Data Science at École Nationale Supérieure d’Informatique et d’Analyse des Systèmes parallels Berkeley courses and workshops on using big data, smartphones, apps, and connecting telecoms to efficiently nurture clean-energy growth and the smart management of water resources. “We’re working on a proposal right now to train young entrepreneurs in Morocco, largely by having them interact with Silicon Valley companies and universities,” says Kammen.

Nation-sized solutions

In Kenya, Kammen’s deep network of friends and contacts helped him to dive into furthering the nation’s goal of growing its renewable energy grid. “Kenya is the China of Africa,” Kammen says, with economic



Kammen meets with the dean and students in the School of Data Science at École Nationale Supérieure d'Informatique et d'Analyse des Systèmes in Rabat, Morocco.

PHOTO: Courtesy of U.S. embassy, Rabat

and infrastructure growth but also a lingering issue of off-grid energy-access challenges. So Kammen's RAEI team cranked up research and collaborations with an open-source energy-modeling package called SWITCH (solar and wind integrated with transmission and conventional power), a big-data tool for looking at largescale—nation-sized—climate change solutions.

Using SWITCH as the simulation platform, the lab's team members marry systems modeling with detailed explorations of new theories to understand the speed of energy innovation and adoption. For example, they look at patent-application activity and gauge the effects of changing economic and financial activity. Other

measurable factors fed into SWITCH include the rapidly decreasing price of solar panels; accelerating efforts to replace heavy, rigid solar panels by bringing lightweight, flexible panels to market; and massive new investment in battery research.

Kammen's team has also built SWITCH models for other African nations, South American countries, western U.S. states, and elsewhere. Its largest effort to date, a model for China, ties in with that nation's aim to peak its carbon emissions in 2030, with steady reductions thereafter. Kammen plans to visit China three times in the next five months to work on U.S. partnerships with its research community and to see

how to get ideas suggested by SWITCH modeling put into practice.

The economic juggernaut has a tradition, like California, of learning from small-scale pilot programs. China just finished a five-province carbon-pricing test. And because its powerful central government, unlike the U.S. government, can avoid years-long policy-change debates, Kammen says, the country plans to go national with carbon pricing this year.

In August, Kammen regretfully resigned from his science envoy position in a letter responding to President Donald Trump's "attacks on core values of the United States." The letter went viral on Twitter, with more than 100,000 likes and 40,000 retweets in 24 hours. But Kammen's global collaborations will continue. On the horizon for him, in November, are the United Nations Climate Change Conference in Bonn, Germany, and a meeting at the Vatican possibly including a face-to-face with Pope Francis.

Solar-powered batteries for the stars

Perhaps one of the most tantalizing new dishes on Kammen's upcoming research menu is his lab's work on battery technology. Cheap storage of sun-generated energy could give the world access to reliable baseload solar power, even when the sun isn't shining. It's today's energy-rainbow pot of gold.

But the physics of battery-efficiency limitation are ugly. Lithium-ions may be the battery du jour, found in mobile phones, laptop computers, and soon perhaps huge arrays like Tesla Powerwalls. But like other commonly used rechargeables, such as lead-acid batteries in cars, they eventually lose their ability to hold a charge.

In 2004, a phone call from Virgin Group magnate Richard Branson led Kammen to pursue an

alternative. Branson wanted a renewable energy system with a supersized battery able to run his entire private Caribbean island. Price was no object. Kammen's lab began looking at "flow" battery technology: two tanks of diffuse sulfuric acid separated by a membrane. In this battery, which behaves more like a fuel cell, physics minimizes the charge-holding problem.

Kammen's team did some preliminary work, but didn't build Branson's entire project. Shortly afterward, a representative of the Marlon Brando estate called. He also wanted a renewable energy system with a backup battery, to power the late actor's private South Pacific island. Now a Kammen lab-built flow battery, possibly the world's second largest, powers the island of Tetiaroa in French Polynesia.

"Flow batteries started out as a luxury good," says Kammen, who flew to Tetiaroa in August to evaluate the power system's performance and to work with the UC Berkeley-run Richard B. Gump South Pacific Research Station on neighboring Moorea. "But now research labs are looking at ways to miniaturize them, to build everything from a flow battery for your home or business to a tiny battery that could run your phone or laptop for several weeks."

These days Kammen spends more time building relationships, managing, and conducting diplomacy than doing physics. So the scientist in him gets a big charge watching the battery world show as much interest in chemistry and physics as the solar world once did.

"This is feeling increasingly far from my physics roots, but this is where the clean-energy world takes you," says Kammen. Even without Indiana Jones's renowned sable fedora, he gives off an air of confidence that more adventures and discoveries are yet to come. **31**

AN ENVIRONMENTAL WIN IN BORNEO

China and Southeast Asia, now among the world's hottest economic regions, have drawn **Daniel Kammen's** attention for some time. The latter region is also where his collaboration with indigenous environmental activists, in Malaysian Borneo, scored a major victory in 2016.

"I caught the Borneo bug early, and it has held tight to me ever since," says Kammen, describing a 1985 trek he and his brother took across the poorly mapped Indonesian portion of the densely forested island.

Three decades on, deforestation has made much of Borneo unrecognizable. Vast swaths of native forest have been clear-cut for palm plantations, displacing whole communities of indigenous people.

Kammen returned to Malaysian Borneo in 2007 to research fossil-fuel alternatives for a group of NGOs battling a 300-megawatt coal-fired power plant in Sabah State. Four years later, their win stopped the coal plant in favor of electricity from natural gas and renewables.

That victory led to a request for assistance from activists in Sarawak, Malaysia's poorest and most rural state. Officials had proposed building 12 massive hydropower dams and

two coal-fired generating plants—with a combined capacity of 9,380 megawatts—to attract factory investment and fuel manufacturing.

The first of the 12 hydropower projects—the 2,400-megawatt Bakun dam, Asia's largest outside China—was completed in 2012. It flooded thousands of acres, displacing about 10,000 people in Sarawak. In 2013, the 944-megawatt Murum dam went online, and plans for the 1,200-megawatt Baram dam were waiting in the wings.

The research Kammen co-led showed that it was unlikely that Malaysia would ever need this much electricity. It also identified appropriately sized, ecologically friendly power alternatives. Local indigenous people and other environmental activists had fought the dams and coal plants for years. Together they stopped the Baram dam, and native land-ownership rights were reinstated. There is no funding for the other proposed dams now, but Malaysian activists continue to work against them.

"This remarkable turnaround victory demonstrated the importance of local community activism, along with doing and communicating the best science," Kammen wrote. — TL



FOUNDER OF THE MODERN SALAD

BS 1956 SOIL SCIENCE

JIM LUGG

From studying dirt clods to revolutionizing how we buy our produce, Jim Lugg’s career in agriculture has earned him a reputation as one of the inventors of the modern salad. He credits the College of Natural Resources as the place where he learned to analyze problems and find practical solutions.

By Molly Oleson | Photos by Jim Block

In 1963, when Lugg, an agriculture scientist, was hired as director of research by Bruce Church Incorporated—one of the largest U.S. lettuce producers at the time—the company hoped that he could help solve its soil and water problems. But Lugg soon discovered that the company’s difficulties weren’t as much about soil and water as they were about post-harvest issues.

Looking for ways to better preserve crops’ freshness during shipment, Lugg turned to Whirlpool Corporation, which had come up with a new system for storing apples and pears. “It was just about managing carbon dioxide and oxygen,” he explains. “I thought, ‘They do it in warehouses—if we could do it in transportation, it would be a home run.’”

Out of a partnership between Bruce Church and Whirlpool, a corporation named TransFresh was born in 1966, and Lugg became its president. “The mission was to use these different gas mixtures of oxygen and CO₂ in transportation vehicles,” Lugg says. Extensive research and experimentation led to modified atmospheres in refrigerated shipping containers and railcars that greatly extended the shelf life of whatever perishables were inside.

“Our refrigerated-shipping business grew into a very large operation, because people wanted a lot of California fruits and vegetables,” Lugg says. Business expanded to Florida, Chile, New Zealand, and Europe, and the company’s atmospheric pallets for fresh produce maintained a grip on the market until competitors appeared around 2000.

But after interviewing retailers’ customers about their experiences with the company’s produce, Lugg discovered that a lot of the lettuce that was being purchased and not used right away was being thrown out. That led to another big idea.

The birth of salad kits

The company decided to cut and wash the lettuce, then package it with the same oxygen-and-CO₂ mixture as in the shipping containers. “We were trying to make the bag’s film differentially permeable to oxygen and carbon dioxide so that we’d let enough oxygen in to keep the lettuce alive and let enough CO₂ out so that we didn’t spoil the lettuce with an off flavor,” Lugg says.

By the 1980s, Lugg and his team—made up of microbiologists, post-harvest physiologists, nutritionists, and others—had succeeded. In 1989, they introduced the Fresh Express Family Classic garden salad blend, the first retail packaged salad sold nationwide.

“It was extremely exciting,” Lugg says of the innovative and rapidly growing business, “because we knew what the customer wanted. But until then, you couldn’t go into a store and buy packaged lettuce in the produce section.”

From there, the company rolled out salad kits and other blends (Caesar Supreme being the big hit) and built plants around the country to process lettuce and other products to go into the “magic gas” bagged mixes.

“We thought it was convenience,” Lugg says of the salad blends’ popularity among consumers at the time. “Today, I’m a believer

“We knew what the customer wanted. But until then, you couldn’t go into a store and buy packaged lettuce.”

in not only its convenience but its health. You can’t get enough organic ground today to grow the organic crops that the market wants. People are just concerned about eating more healthily.” Fresh Express currently offers 13 organic products. Innovations in agricultural technology will continue to emerge, he says, including crop-management and microbe-mapping projects, as well as the mechanical harvesting of strawberries.

Learning how to think

Lugg, who lives in Salinas, California, served on the CNR Advisory Board for 14 years, including 3 years as chair. “I wanted to give something back to the College, and it was a way I could do that,” he says. Retired since 2009, he still occasionally consults for companies, and helps mentor CNR students.

Looking back on a successful career that has included being presented with the E.E. “Gene” Harden Award for Lifetime Achievement in Central Coast Agriculture, serving on the board of the Center for Produce Safety, and securing \$2 million for *E. coli* research, Lugg says that he always viewed his role as motivational, encouraging his team to “figure out how to do something bigger and better next time.”

He gives Cal complete credit for providing him with the knowledge he needed. “One of the things that I valued most of anything out of my college training there was learning how to think,” says Lugg, who, as a student, wanted to work in the area of reducing clods in agricultural fields. “It wasn’t about the soil physics, chemistry, or fertility as much as it was about learning how to analyze problems, and then choosing the best possible solution.”



Reducing dirt clods was Jim Lugg’s first focus as a CNR student.

Q&A

Cal Future Forum Offers Solutions for a Healthier Planet

Photography by Elena Zhukova



California is playing an increasingly proactive role in understanding our global impact and finding solutions to ensure a vibrant future. In fact, we lead the nation—and the world—in developing a clean-energy economy, lessening the effects of climate change, and promoting green businesses. And the solutions being developed at UC Berkeley are already being used globally. At the Cal Future Forum, held on campus last May, more than a dozen researchers from Berkeley and the Lawrence Berkeley National Laboratory shared their findings on the condition of the planet, offering a better understanding of the challenges we face. Here we provide a glimpse with excerpts from a few of the presentations made by CNR faculty.

How do we verify compliance with our hard-won climate treaties?

Inez Fung

Climate Scientist
Professor, Environmental Science, Policy, and Management (ESPM)

Although U.S. participation is uncertain, through the Paris Agreement, countries around the world have pledged to rein in greenhouse gas emissions enough to maintain global temperatures at just 2 degrees Celsius above preindustrial levels. A very ambitious emissions-reductions schedule is needed. Since country emissions are self-reported, we have a challenge: How can we confirm that countries are maintaining their pledges and encourage them to do even better?

As a climate modeler, I'm part of an international scientific team developing the detection skills of the Orbiting Carbon Observatory 2 (OCO-2), a satellite launched in 2014 by NASA's Jet Propulsion Laboratory. OCO-2 gathers around 100,000 detailed measurements of Earth's carbon around the globe every day, allowing us to answer important questions about where CO₂ in the atmosphere is coming from and where it's going.

The first picture we got from the satellite after it launched from Vandenberg Air Force Base in California was very exciting to me, because we could clearly see that Pasadena, an urban part of LA, has a much higher CO₂ concentration than



Inez Fung is on the team working with NASA's Orbiting Carbon Observatory 2.



Rosemary Gillespie studies ecosystems of insects and spiders to understand ecosystem function on a global scale.

the nearby nonurban areas. Since the launch of the satellite, my research group has developed powerful mathematical-analysis tools that use the satellite data to help us determine if actual emissions match a country's pledged target.

In the future, OCO-3, a follow-on to OCO-2, is scheduled to continue spaceborne observations of atmospheric CO₂ from the International Space Station. And last year, NASA announced plans for the Geostationary Carbon Cycle Observatory, which will provide continuous daytime observations of CO₂ over Asia and the eastern Pacific. All of these Earth-observing satellites will contribute to treaty verification and help us monitor the health of the planet.

How do we maintain local and regional biodiversity in the face of increasing global connectivity?

Rosemary Gillespie
Insect Ecologist
Professor, ESPM

People in general have a fascination with diversity, novelty, and rarity. The development and preservation of the diversity of life around us requires one key ingredient: isolation. Yet when we travel, we unknowingly ferry plants, insects, and sometimes larger critters from one locale to another. In our

globalized world, no place is truly isolated anymore. We're basically putting biodiversity in a blender and seeing what comes out. Sometimes what come out are forests, once humming with bird and insect diversity, now hushed by intruders—non-native tree species smothering all the natives.

What can we do? We can't stop people from traveling, or get rid of the species that have traveled and are now firmly established in new sites. Instead, we need to embrace novelty and figure out what creates a functional system in this new reality, on both local and global scales. Of course, all this is very complex.

One approach is to look at simple systems—like small, isolated islands—that can serve as microcosms for under-

standing ecosystem function on a global scale. We're currently studying entire ecosystems of insects and spiders across the islands of Hawaii—measuring their diversity, their abundance, and interactions between organisms—to see how they change over space and time. We learn what makes a community more stable and resistant to intrusive species, and what part of the community is more vulnerable. We take the pulse of the system.

By measuring more patterns of species diversity in ecosystems that differ in age and human impact, we can start to understand what features of a natural community provide stability in the face of intrusions driven by climate change and other threats from our own species.



What is the future of farming?

Claire Kremen
Conservation Biologist
Professor, ESPM

Our planet is incredibly productive; it produces ample food for all the people of the world. And yet, 800 million people are chronically hungry, another billion people are malnourished, and two billion people are overweight or obese. What's more, the way we farm takes an increasing toll on the environment. Farming contributes a third of the world's greenhouse gas emissions and uses 70 percent of our total freshwater resources. It's a major contributor to tropical deforestation and biodiversity loss and has caused large areas of fertile land to become desert wasteland.

We must find better ways to produce enough food now and into the future without killing our planet. Having studied pollination for over 20 years, I know that healthy wild bee populations are a key element. Bees improve the pollination of three-quarters of the world's crops, but their populations are suffering from a variety of threats, including our current farming practices, which rely heavily on monoculture farming. My research group has demonstrated how a more diversified approach to farming can allow wild bees to thrive while also preserving biodiversity and maintaining healthy crop yields.

Diversified farming systems incorporate non-crop vegetation like hedgerows around the perimeters of our crop fields, multiple crop types within fields instead of a single crop type, and natural habitat patches and grazing lands nearby. Together, these practices support healthy and abundant pollinator communities that in turn provide crop pollination. There is also growing evidence that diversified farming systems offer other benefits, such as more fertile soils and natural pest control, which can reduce overuse of fertilizers and harmful pesticides.



Claire Kremen is looking at how more diversified farming can preserve biodiversity and produce healthier crop yields.



Justin Brashares examines how human-wildlife interactions can have far-reaching impacts.

How do biodiversity loss and social conflict affect human health?

Justin Brashares
Ecologist and Wildlife Biologist
Professor, ESPM

The fishing industry is on the front lines of the human response to environmental change. Fish are the primary source of animal protein for two billion people on Earth, and the fishing industry provides 11 to 13 percent of all jobs in the world. But two-thirds of global fisheries are overexploited and unsustainable, and fishers must work longer and travel farther to achieve the same yields they saw 10 or 20 years ago. The search for cheap labor to address these demands has had enormous social consequences as human trafficking and forced child labor have become embedded in the industry.

Another consequence of our depleted fisheries is an increase in fish prices, which has led to great global demand for alternative sources of wild meat, ranging from crickets to snakes to elephants and more. Since 2005, my research group has tracked the transport and sale of more than 230,000 wildlife products coming out of Africa and into markets around the world.

In our work, we have focused on how the wildlife trade has impacted large carnivores, because these species play critical roles in ecological systems: Reduced populations of carnivores usually result in ballooning populations of the species they once contained—like baboons, coyotes, and raccoons—and that can impact humans tremendously. For example, in rural Mozambique and many other parts of Africa, millions of young children are taken out of school to guard fields of maize from baboon raids.

As we continue to study and learn how a changing environment impacts human society both around the world and in California, we're able to identify potential levers of change. For example, police enforcement or policy changes have generally been unsuccessful at getting children out of slavery in the fishing industry. Our research shows that such efforts must start by working toward more sustainable local fisheries. Or, school lunch programs, a popular approach supported by development agencies to get kids into school in many areas of Africa, may be more effective if they are paired with efforts to restore healthy ecological communities that naturally regulate crop pests. **31**

Find videos of these and other presentations from the Cal Future Forum at vcresearch.berkeley.edu/energy/highlights.

A FLOURISHING Food Ecosystem

From organic agriculture to product development, CNR students are following their passions to make a difference on campus and to discover potential careers in nutrition, food design, and environmental science.

By Kirsten Mickelwait



Hailey Zhou



Brianna Caspersen



Carolyn Hsieh

Hailey Zhou

Senior, Nutritional Sciences–Dietetics
Co-Founder, FoodInno Club

Hailey Zhou wants to work “at the intersection of food and health.” She may already be there: She’s been active in several campus initiatives that explore the future of food design and development.

In February 2016, Zhou—who first came to the United States from Shenzhen, China, in 2012 to attend high school—became co-founder and president of the **FoodInno Club** at Berkeley. It’s an offshoot of the Berkeley-Stanford collaboration the

FoodInno Institute. The club’s “food innovation hackathons” enable students to bring a millennial’s-eye view to local food companies, while also providing them with networking opportunities in their chosen fields.

“A food hackathon is a one-day event linking students’ creativity with the challenges that local food businesses face by ‘hacking’ business model solutions,” Zhou explains. Previous hackathons have included such local companies as TCHO Chocolate, Odwalla (Coca-Cola), House Kombucha, and Wrecking Ball Coffee Roasters. To date, FoodInno has also taught five student-run **DeCal classes**, including Food Design Thinking, Coffee & Wine, and Fermentation 101.

On Cal Day in spring 2016, Zhou wandered by a table promoting the **Millet Project**, and she has since become involved with that group, leading event outreach, business partnerships, social media, and product development efforts. Started by researchers in the Department of Plant and Microbial Biology, the project has set a long-term goal of developing a line of millet-based products. “Millet is an ancient grain I grew up eating in China, so I was curious,” she explains. “It’s not native to the U.S., but it’s great for drought areas like California.”

Zhou is also a co-founder of **FEEDx**—a collaborative conference on the future of food put on by Berkeley, UC Davis, and Stanford, begun in May 2016 and modeled after the TEDx series. In addition, she has worked as a **sports nutrition intern** for Cal Athletics and a **social media intern** for the undergraduate course Eat. Think. Design., offered through the School of Public Health.

Brianna Caspersen

Senior, Conservation and Resource Studies
Administrative Manager, Student Organic Garden Association

Brianna Caspersen came to Berkeley specifically to study nutritional sciences, but her interest quickly turned to the study of food systems. After taking a DeCal course offered by the **Student Organic Garden Association (SOGA)**, she became the garden’s summer operations apprentice. And once she got her hands in the soil, she began spending up to 20 hours a week not only growing her own food but also becoming involved with activism, community building, educational programming, and food justice issues.

The Student Organic Garden was founded in 1971 to promote a sustainable campus food system, and today it occupies a quarter acre on the Oxford Tract. Entirely student-run, each year it offers hundreds of students from across campus the chance to apply sustainable-agriculture theories in the field—and much of the resulting produce goes to the UC Berkeley Food Pantry.

The plot comprises a variety of annual and perennial crops, a small orchard, and both medicinal and edible herb gardens. The gardeners practice agroecological techniques and permaculture design principles.

Caspersen hopes to pursue a career in urban design using an environmental science lens. Her SOGA experience reminds her “how fortunate I am to fully engage with my food, from planting and nurturing it to harvesting and eating it,” she says.

Carolyn Hsieh

Senior, Nutritional Sciences–Dietetics
Operations Manager, UC Berkeley Food Pantry

When Carolyn Hsieh began her studies in nutritional sciences, she hadn’t even heard of the term “food insecurity.” Now, as operations manager for the **UC Berkeley Food Pantry**, she knows how close it hits to home. Food scarcity among Cal students is all too common—as they prioritize expenses like tuition, high rents, and transportation, there’s often not enough left over for food. Student visits to the pantry in spring 2017 totaled more than 5,600, representing at least 1,500 unique students.

Founded in 2014, the pantry offers a variety of healthy foods, all approved by the campus dietician. Its partners include Cal Dining, the Alameda County Community Food Bank, the Berkeley Student Food Collective, several campus gardens, and local businesses. With their Cal IDs, students can pick five items at a time, free of charge. The pantry is also working on several new initiatives, including mobile pop-up pantries and late-night events.

After graduation, Hsieh hopes to become a registered dietician, with a possible master’s degree in public health. Her work at the UC Berkeley Food Pantry has “definitely deepened my interest in social service and food assistance programs,” she says. “These issues are affecting the people I sit next to in class every day.”

PHOTOS (from left): Ariel Yue, Julie Gipple, Rose Liu

MORE ELEMENTS OF THE EDIBLE ECOSYSTEM

Through a new UC Berkeley “foodscape map” and other online resources, the **Berkeley Food Institute** highlights food-related activities on campus, including teaching, student and faculty research, student organizations, administrative decisions and initiatives, and dining services and procurement. Here’s a sampling:

- Food Science and Tech at Cal
- Berkeley Student Food Collective grocery store
- Student Nutrition Advocacy Club (SNAC)
- Personal Food Security and Wellness course
- Food Equity, Entrepreneurship, and Development (FEED)
- CNR’s food systems minor
- Food and Agriculture Policy Group



VISUALIZATION: Robert Backer

An architectural rendering of the vision for an updated Cal Teaching Kitchen.

IT ALL BEGINS IN THE KITCHEN

A teaching space to serve the whole campus

To become registered dietitian nutritionists (RDNs), dietetics students must pursue a rigorous program of education, get accepted into highly competitive internships, and pass registration exams. But before all that, they need a more fundamental skill: They must learn how to cook.

In the College of Natural Resources, the Cal Teaching Kitchen is the laboratory in which future dietitians are prepared for careers that will help us understand and prevent chronic disease, promote healthy communities, and further metabolic research and education. Now CNR is launching a fundraising campaign to bring its kitchen up to par with its exceptional program.

UC Berkeley is the birthplace of nutrition studies, having offered the first courses on the subject in the early 1900s. Our faculty continue to be active in practice, serving as professional role models, and Berkeley researchers are at the leading edge of metabolic health and related fields. The dietetics program offers a rigorous, science-based curriculum and many opportunities for student research. And the campus is now part of the Teaching Kitchen Collaborative, launched by the Culinary Institute of America and the Harvard T.H. Chan School of Public Health.

Beyond the dietetics program, the teaching kitchen is used by graduate and undergraduate student groups, campus health services, Cal Athletics, and staff wellness programs. Students from all disciplines can take Personal Food Security and Wellness (NUSCTX 20), a popular course offering instruction in how to prepare healthy meals on tight budgets. Launched in spring 2016, this class is now more necessary than ever, as a recent study showed that 57 percent of Cal students struggle to find sufficient or healthy food.

Berkeley's dietetics students are achieving a remarkable 99 percent pass rate on the Commission on Dietetic Registration's mandatory exam. These are the future nutritionists who will help us combat the obesity epidemic and associated

chronic diseases like diabetes, heart disease, and high blood pressure. They'll play an integral role in the well-being of our nation, promoting healthy food to better fuel our bodies.

"The food science course and accompanying lab was one of my favorite classes and sparked an interest in the biology and chemistry of food," says **Brittney Dietz**, PhD '16, Nutritional Sciences and Toxicology. "I was able to apply the knowledge and techniques I used in my medical research to experiments that unveiled the science of what we eat."

Unlike CNR's acclaimed program, however, the teaching kitchen is woefully out-of-date. Built in 1953, the facility still largely relies on older equipment. It's too small to accommodate its roughly 2,200 student visits each year. And its split kitchen-classroom footprint limits the potential for growth.

The fundraising campaign seeks to remedy all that. Plans call for a new open kitchen-classroom layout that will feature individual and ADA-compliant cooking stations for each student group; added counter space; an instructor station; and state-of-the-art equipment like gas ranges, energy-efficient appliances, and a commercial-grade dishwasher. An adjacent patio will feature a culinary garden.

"Graduates of our program are at the forefront of translating the science of nutrition into real-life applications," says **Mikelle McCoin**, director of the Didactic Program in Dietetics. "The new Cal Teaching Kitchen will serve as a valuable laboratory to train the food educators of the future."

— KIRSTEN MICKELWAIT

SAVE THE DATE: Visit the Cal Teaching Kitchen, in Morgan Hall, at our open house on April 20, 2018. Enjoy healthy snacks prepared by our students, tour the kitchen, and learn more about our vision for its future.

White Sands Predator | Photo by Clay Noss

A western diamondback rattlesnake (*Crotalus atrox*) on the edge of the dune field in White Sands National Monument, New Mexico. **Clay Noss**, a PhD candidate in the Department of Environmental Science, Policy, and Management, researches the role that predators—which have profound impacts in many natural systems—may play in deserts like this one. Whereas three lizard species are found throughout White Sands and the surrounding Chihuahuan Desert, lizard predators are absent from the heart of the dune field. By comparing the ecologies of lizards that overlap with predators and those that have escaped predation, Noss hopes to clarify our understanding of desert predator-prey interactions.



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