College of Engineering
University of California, Berkeley
Fall 2020
Volume 18

Safe to drink
Removing arsenic from water

Meeting the moment
Researchers take on COVID-19

Berkeley ENGINEER

The Transformer

A material's unusual properties inspire next-gen technologies

Engineering heroes

There's no question that 2020 is an unprecedented year of challenges. The public health and economic crises resulting from COVID-19 continue to persist, compounding the issues of racial injustice and inequity in our society. At the same time, we're experiencing a changing climate that has brought extreme weather events and one of the most destructive wildfire seasons for the western United States.

In times like these, the importance of our mission has never been more clear. Our future tomorrow is being shaped by Berkeley engineers today.

In times like these, the importance of our mission has never been more clear.

As you'll read in this issue of the magazine, many of our faculty and their research teams quickly pivoted their work to help combat the pandemic. Unsung heroes among us include instructors and staff who have worked tirelessly to maintain the high quality of our education programs while enhancing their accessibility. Our students also have demonstrated grit and compassion in finding new ways to stay connected and to support each other while sheltering in place.

In the midst of these challenges, there is hope for a healthier and more sustainable world. Our faculty are advancing the frontiers of science and technology, many as part of new research centers funded by the U.S. National Science Foundation. These include centers that will accelerate technologies for the preservation of biological systems, speed the development of quantum computers, probe mathematical and scientific foundations of deep learning and use artificial intelligence to improve food production processes.

We're also moving toward a more equitable society, which requires a diversity of perspectives and ideas. This year, we welcomed our most ethnically diverse cohort of new students in decades, and we also saw the diversity of our faculty increase to historically high levels, due to concerted efforts to eliminate bias in admissions and hiring processes. To fully unlock our individual and collective potential for positive impact, we are actively fostering a more inclusive culture that values and leverages diversity.

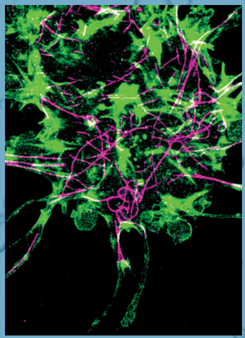
I hope that you will be inspired, as I am, by all of the heroic people within the College of Engineering who are working together to ensure a brighter future for all. *Fiat Lux — and Go BEARS!*

—*Tsu-Jae King Liu*
DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING

Adam Lau

in this issue

BerkeleyENGINEER FALL 2020



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> COVER PHOTO: **Materials science and engineering professor Junqiao Wu, photographed with a thermographic camera in Hearst Memorial Mining Building. Instead of detecting visible light, thermographic cameras typically detect radiation in the long-infrared range of the electromagnetic spectrum (roughly 9,000–14,000 nanometers or 9–14 μm), making it possible to see one's environment through tiny changes in temperature.**

PHOTO BY **ADAM LAU**

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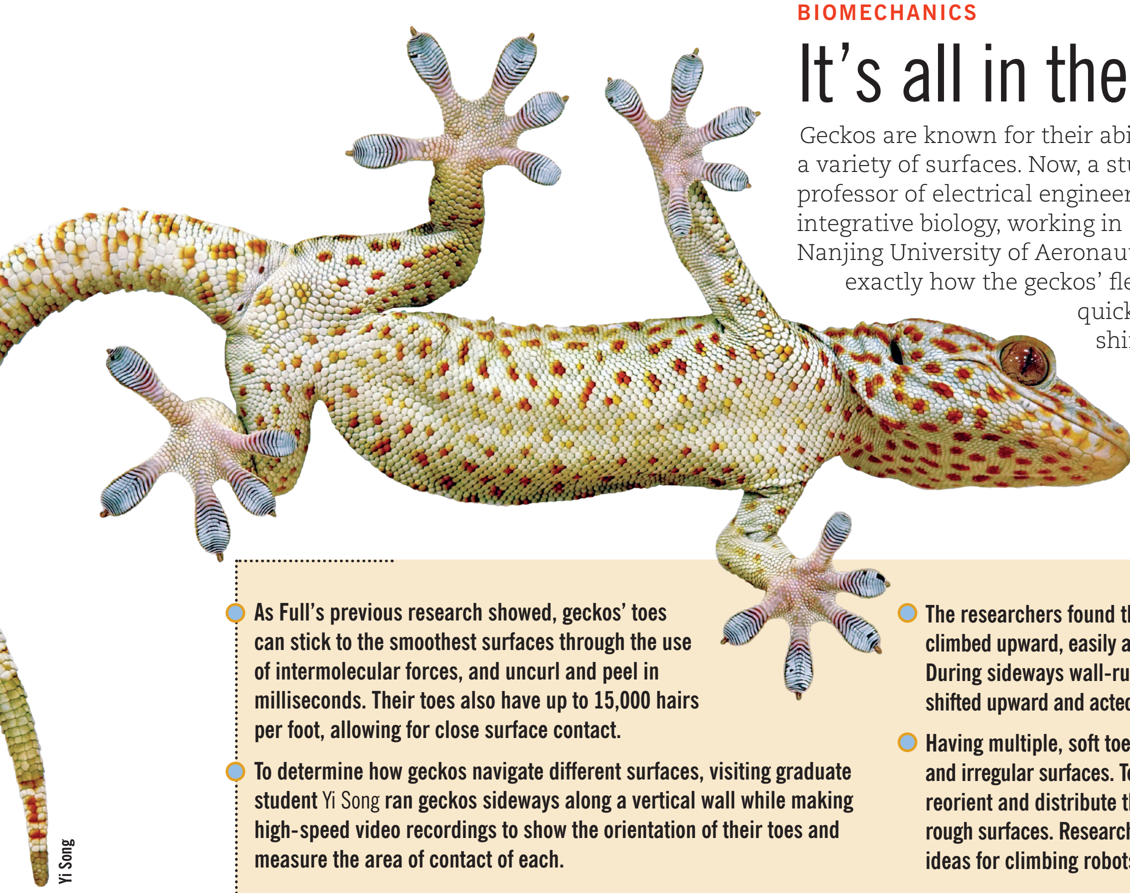
BIOMECHANICS

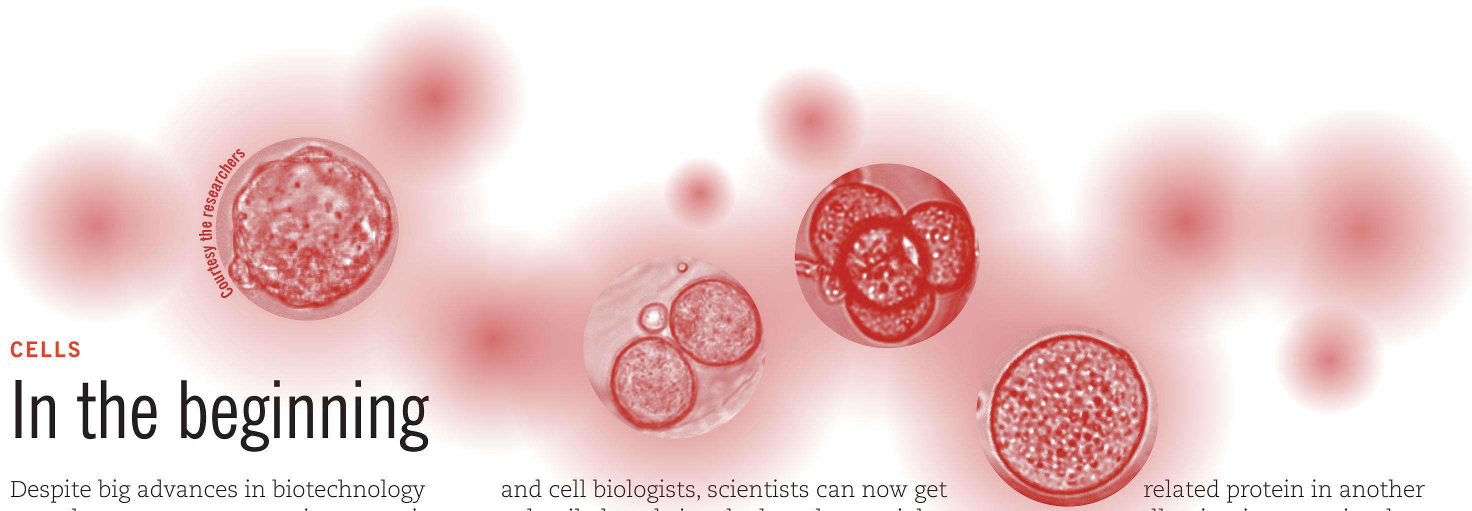
It's all in the toes

Geckos are known for their ability to nimbly scale walls and climb a variety of surfaces. Now, a study from a team led by **Robert Full,** professor of electrical engineering and computer sciences and of integrative biology, working in collaboration with researchers from Nanjing University of Aeronautics and Astronautics, has determined exactly how the geckos' flexible, hairy toes allow them to make quick adjustments that accommodate shifting weight and slippery surfaces.



Yi Song

- As Full's previous research showed, geckos' toes can stick to the smoothest surfaces through the use of intermolecular forces, and uncurl and peel in milliseconds. Their toes also have up to 15,000 hairs per foot, allowing for close surface contact.
- To determine how geckos navigate different surfaces, visiting graduate student Yi Song ran geckos sideways along a vertical wall while making high-speed video recordings to show the orientation of their toes and measure the area of contact of each.
- The researchers found that geckos ran sideways just as fast as they climbed upward, easily and quickly realigning their toes against gravity. During sideways wall-running, the toes of the front and hind top feet shifted upward and acted just like toes of the front feet during climbing.
- Having multiple, soft toes allowed geckos to navigate slippery areas and irregular surfaces. Toes that still had contact with the surface would reorient and distribute the load, while the softness let them conform to rough surfaces. Researchers say these findings could lead to new design ideas for climbing robots.



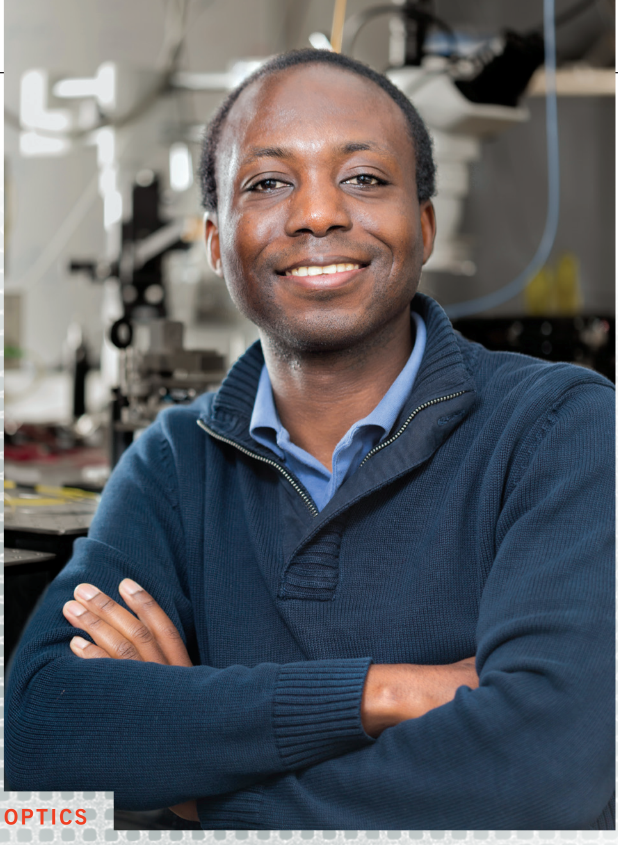
Courtesy the researchers

CELLS

In the beginning

Despite big advances in biotechnology over the years, many questions remain on the first stages of fertilization and early development, when a single cell zygote develops into a complex, multicellular embryo. During this crucial period, researchers don't have much biological material to work with, and examining the direct relationship between RNA, proteins and cells is a difficult task. But thanks to research by bioengineering professor **Amy E. Herr** and a team of engineers and cell biologists, scientists can now get a detailed, real-time look at the crucial period when genetic molecules like RNA instruct cells on what proteins to form.

To observe what's happening with RNA and corresponding proteins at the same time and in the same cell, the researchers designed microfluidic chips to scrutinize and process single cells from mice, using microwells stippled into tiny gel pallets. So instead of watching an RNA molecule in one cell and then moving onto the related protein in another cell, scientists can simultaneously measure both substances at any given stage of the embryo and in that same cell. Such levels of precision could reduce the cost and number of research animals needed in developmental biology. The new technology could also help scientists better understand assisted reproduction technologies like in vitro fertilization, as well as lead to improved cancer treatments.



David Baillot/UC San Diego

OPTICS

Game-changing metalens

The size and weight of optical lenses have presented significant obstacles in the effort to miniaturize optoelectronics and other devices. But researchers led by **Boubacar Kanté,** associate professor of electrical engineering and computer sciences, have created an ultrathin, flat optical metalens whose performance rivals that of bulkier, traditional lenses on the market — and could lead to game-changing advances in solar energy, virtual reality and medical imaging.

Traditional lenses are usually made with bulk materials and curved surfaces to bend and focus incoming light waves. Such lenses are able to capture 65–75% of the incident light but are heavy and susceptible to chromatic aberrations. Flat lenses — which use engineered designs and metamaterials to bend light — can manipulate light at subwavelength scales and overcome chromatic aberrations, but only in a very narrow band of light. And going flat has often meant sacrificing performance: previous metalenses delivered lower efficiencies of 20–40% in lenses measuring 600–800 nanometers thick.

To improve light-capturing capabilities, the researchers used electron-beam lithography to shape a fishnet pattern onto a titanium dioxide wafer. To mimic the curvature of a traditional lens, they used a gradient in which smaller holes were formed in the center and larger ones were positioned around the edges. Their fishnet-achromatic-metalens, measuring 350-nanometers thick, was able to capture 70% of incoming light in frequencies ranging from 640 nanometers (reddish-orange light) to 1200 nanometers (infrared light). Light entering the fishnet metalens within that broad octave band of wavelengths can be focused at a single point on the other side of the lens.

CANCER RESEARCH

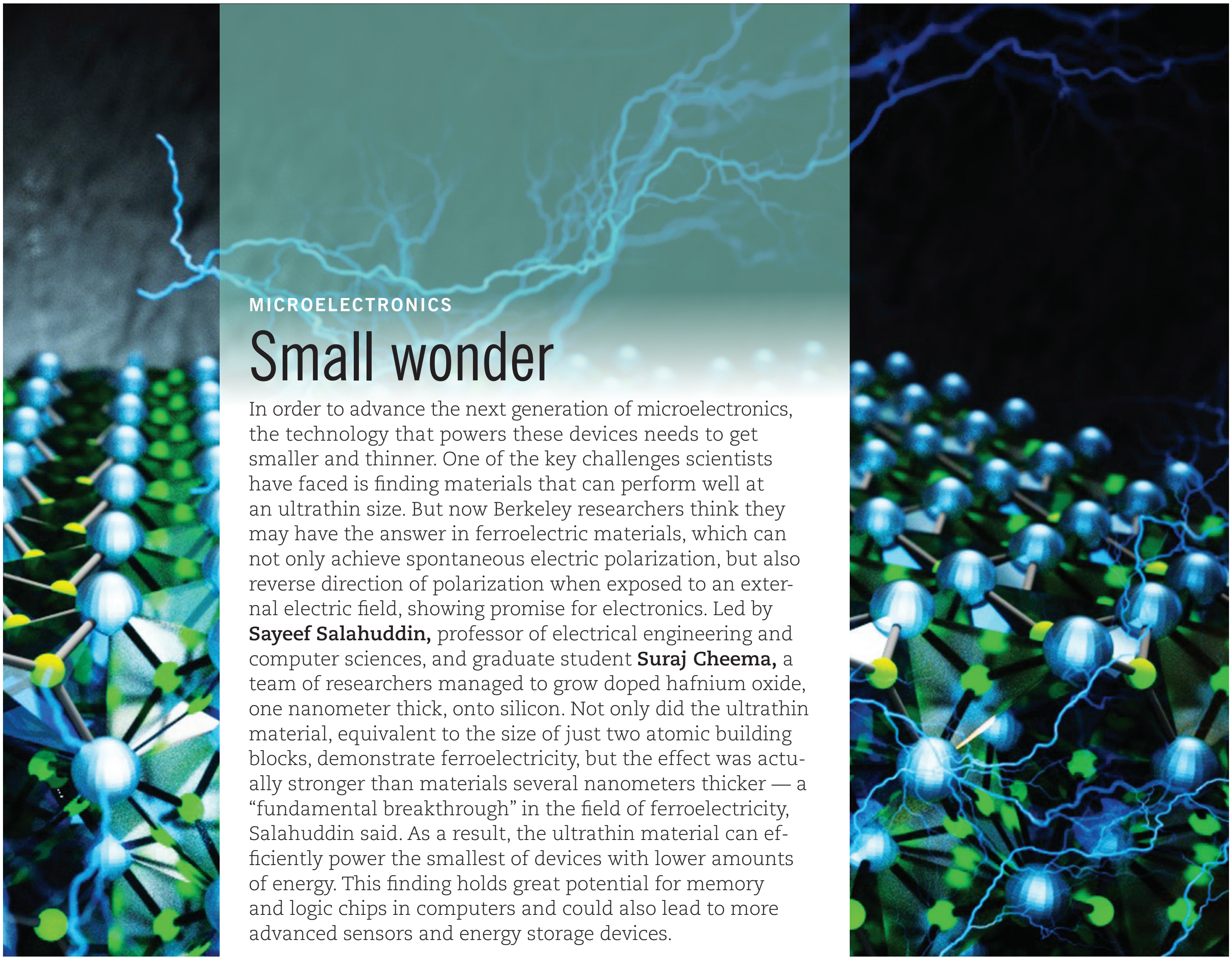
The way it moves

The average patient survival rate for glioblastoma, an aggressive type of brain cancer, is about 15 months. Because many affected cells can evade surgery and become resistant to radiation and chemotherapy, learning how and why these cells are so invasive is an important step toward understanding how to stop the invasion itself — and ultimately to finding a cure. Now, new research led by **Sanjay Kumar,** professor of bioengineering and of chemical and biomolecular engineering, has shed light on how tumor cells adhere to and move through brain tissue.

Every tissue in our bodies consists of cells and material that surrounds those cells; this "extracellular matrix" keeps our tissue from falling apart. In our brains, that relevant material is hyaluronic acid (HA). Previous studies used a synthetic polymer material to mimic brain tissue, but Kumar's team replaced the polymer with the brain's own HA. Upon doing so, the team observed that a specialized HA-binding cell surface receptor called CD44 allows tumor cells to form very long microtentacles, establishing a foothold that the cells can use to pull themselves forward and shimmy through the tissue — much like a rock climber grabs ahold of a crevice to advance on the rock face.

Graduate student and study lead author **Kayla Wolf** recognized that such structures had been seen before, just in a different context. Circulating tumor cells, which have detached from a primary tumor and entered the bloodstream, use microtentacles to attach to blood vessel walls and metastasize. Additionally, the research team identified several proteins involved in the process, some of which turned out to be enriched in highly aggressive tumors and could be further explored as disease biomarkers or drug targets.

Courtesy the researchers



Courtesy the researchers

MICROELECTRONICS

Small wonder

In order to advance the next generation of microelectronics, the technology that powers these devices needs to get smaller and thinner. One of the key challenges scientists have faced is finding materials that can perform well at an ultrathin size. But now Berkeley researchers think they may have the answer in ferroelectric materials, which can not only achieve spontaneous electric polarization, but also reverse direction of polarization when exposed to an external electric field, showing promise for electronics. Led by **Sayeef Salahuddin,** professor of electrical engineering and computer sciences, and graduate student **Suraj Cheema,** a team of researchers managed to grow doped hafnium oxide, one nanometer thick, onto silicon. Not only did the ultrathin material, equivalent to the size of just two atomic building blocks, demonstrate ferroelectricity, but the effect was actually stronger than materials several nanometers thicker — a "fundamental breakthrough" in the field of ferroelectricity, Salahuddin said. As a result, the ultrathin material can efficiently power the smallest of devices with lower amounts of energy. This finding holds great potential for memory and logic chips in computers and could also lead to more advanced sensors and energy storage devices.

HEALTH

Young again

Aging is inevitable, but one of the keys to mitigating the physical decline that comes with growing older may be found in blood. A team led by bioengineers **Irina Conboy** and **Michael Conboy** has found that diluting the blood plasma of older mice has rejuvenating effects on the body. In the study, the researchers replaced half of the blood plasma of mice with a saline solution containing 5% albumin, which simply replaced protein lost when the original blood plasma was removed but did not have young or old properties on its own. In doing so, they observed improved function of the brain, liver and muscle in the older mice; performing the same procedure on young mice had no detrimental effects on their health.

This discovery establishes the benefits of removing age-elevated, and potentially harmful, factors in old blood — opening the door to new therapies in humans. Currently, the composition of human blood plasma can be altered through therapeutic plasma exchange, or plasmapheresis, which is used to treat a variety of autoimmune diseases. The research team is now working to develop a modified plasma exchange that could be used to improve the overall health of older people and not only treat but also prevent age-associated diseases in humans.

Q+A on Women in Engineering

Fiona Doyle is the Donald H. McLaughlin Professor Emerita of Mineral Engineering and special adviser to the dean. During her 36 years at UC Berkeley, she also filled leadership roles across campus, including as dean of the Graduate Division and chair of the Academic Senate. In recognition of the 150th anniversary of the admission of women to Berkeley, we talked with Doyle about her experiences as a woman at Berkeley Engineering.

Matt Beardsley

How did you first become interested in engineering as a career?

Always interested in math and science, I pursued my first degree in metallurgy and materials science as a science at the University of Cambridge. I never thought, "I'm going to be an engineer." I followed my passions, and my graduate degrees in metallurgy from Imperial College, London happened to be classed as engineering.

Students think that their choice of major will define the rest of their lives. I advise them just to follow their interests — they'll find their direction and be successful. When combined with technical expertise, having a broader background can lead to more creative problem-solving. It's a much happier way to live your life — and it's seriously important to be happy.

You were the third female faculty member hired by the College of Engineering back in 1983, and the first in your department. What was that experience like?

I was only 26 years old, younger than many of the graduate students. I would get two reactions. In the corridors, people thought I was a student. In the office, they assumed that I was Professor Doyle's secretary. The assumptions and gender stereotypes were annoying, but overall, I was incredibly lucky. Colleagues might have been oblivious to gender issues, but I never felt they were biased against me. Gender bias often arises in situations when men feel threatened, and because I was so junior, I don't think people were remotely threatened by me. My response was: I'll show them by doing better than the men.

Elizabeth Bragg, the first woman to receive an engineering degree from an American university, graduated from Berkeley in 1876. But it was nearly 100 years before the college's first female faculty member, Susan Graham, was hired in 1973. Can you shed any light on why you think it took so long?

Even longer, because Susan Graham was initially hired into computer science in Letters & Science. In addition to few women pursuing research in engineering, I think that, after World War II, the emphasis was on hiring returned servicemen, with women expected to stay home. Across the university there were also many distinguished female researchers, married to male professors, who were every bit as important to the scientific contributions as their husbands but never got real credit.

The real transformation began with Dean Karl Pister, who was determined to enhance the diversity of the college across the board and emphasized hiring women. He took a ridiculous chance on me — I was appointed on April 1, 1983, a week before defending my Ph.D. But within five years, I proved that I was worthy of tenure.

Do you have any particular advice for young women considering an engineering course of study or career?

Be yourself. Don't compare yourself to the male stereotypes — many stereotypical feminine traits are incredibly useful. Women are often better at multitasking and social intelligence, which can prove invaluable when working with teams. When I started my teaching career, I used to have to watch out for the women in my classes, ensuring they wouldn't just be appointed the team note taker. By the turn of the millennium, I started to notice that the smart guys would purposely join a team with a woman. A lot of the social stuff associated with teamwork would run more smoothly.

Overall, I'd say: Don't feel shy about asking questions. You're smart, you'll learn what you need to learn. And you'll bring so much to the table that you'll eventually be immensely successful.

This year marks the 150th anniversary of the University of California's 1870 resolution: **"That young ladies be admitted into the University on equal terms in all respects with young men."** The act came just two years after the university's founding; six years later, Berkeley Engineering had its first female graduate. Today, our female faculty, students and alumni are at the cutting edge of our work: holding tenured positions, serving as mentors, leading groundbreaking research and founding innovative startups.

Find their stories at **https://engineering.berkeley.edu/about/150-years-of-women-in-engineering/**

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

Berkeley Engineering

Just weeks after COVID-19 first grabbed headlines, Berkeley Engineering researchers had pivoted their research to help test, treat and heal the growing numbers of patients. Many of our engineering makerspaces — like the Jacobs Institute for Design Innovation and the CITRIS Invention Lab — remained open and operating even during the initial shutdown to allow researchers to make products and prototypes. Here are just a few examples of how Berkeley engineers answered the call.

BREATHING NEW PURPOSE INTO SLEEP APNEA MACHINES

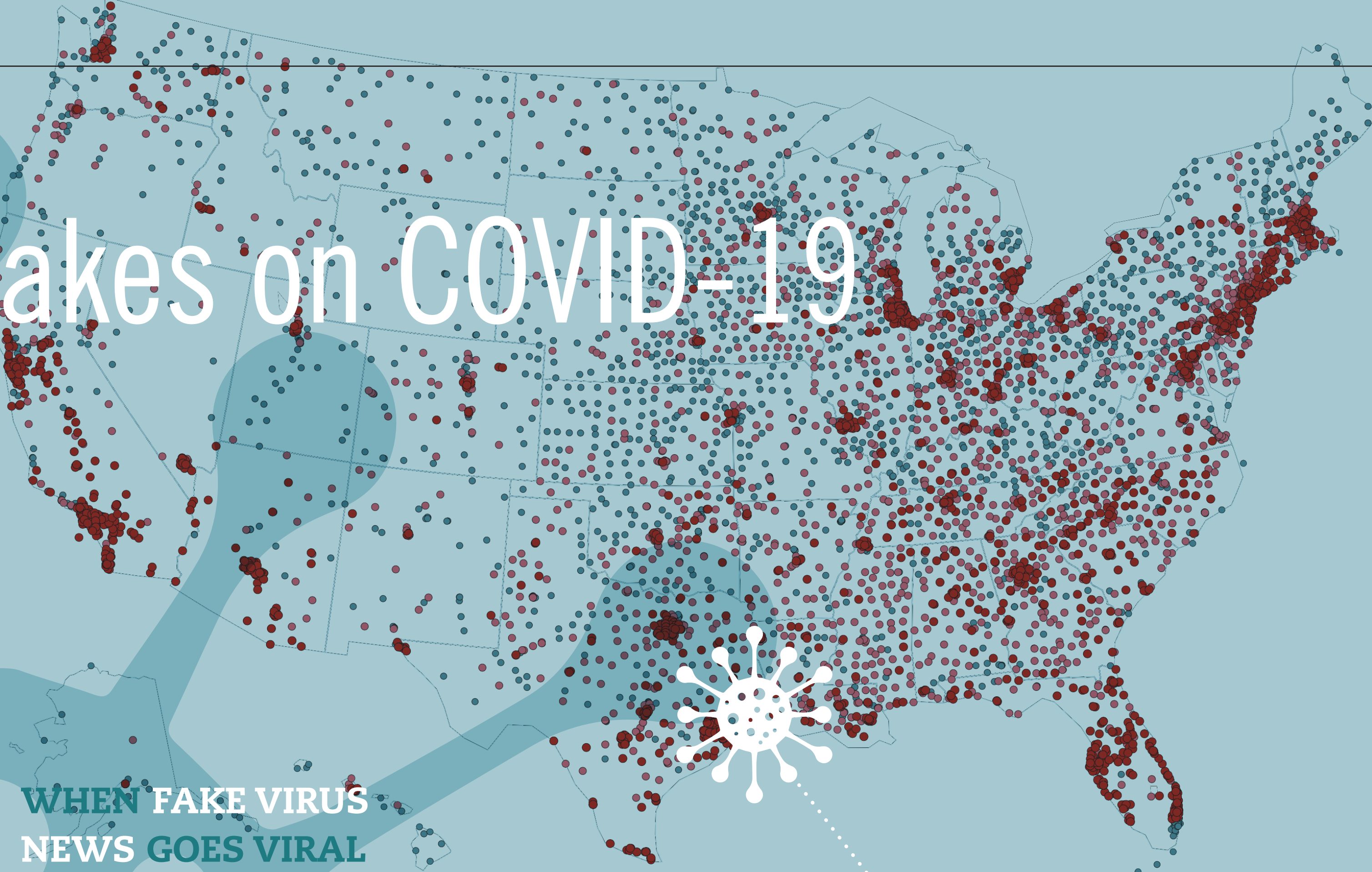
As the coronavirus began spreading across the United States, it became clear that there would soon be a high demand for respiratory devices. That's when **Bryan Martel** (B.S.'86, M.S.'89 ME) got the idea to convert consumer sleep apnea devices to help COVID-19 patients with mild to moderate respiratory symptoms, saving ventilators for ICU patients. Dean **Tsu-Jae King Liu** connected him with associate professor of mechanical engineering **Grace O'Connell,** who quickly formed a team of student volunteers to launch the PreVENT project. The team developed designs with the help of Martel, **Ajay Dharia** (B.S.'04 BioE) and the late **Bertram Lubin.** After partnering with a UCSF clinical team — led by **Aenor Sawyer** and including **Brian Daniel, David Harrison** and **Michael Matthay** — the design was further refined and tested on a lung simulator. The collaboration resulted in a low-cost noninvasive ventilation system that can benefit many patients with acute infectious respiratory illnesses. The converted device uses a special face mask and a two-HEPA filter system to safely deliver oxygenated air without risking aerosolization and virus spread. Because these sleep apnea machines have already been approved by the FDA to help increase oxygen flow, and the parts used to adapt the machine are also FDA-approved, the modified machines can be deployed quickly. Access to ventilatory support has since increased in the United States, so the PreVENT respiratory devices are now being provided to other countries — including Ecuador and Malawi — that are facing shortages.


Grace O'Connell

HOW WASTEWATER CAN PROVIDE CLUES

Testing, tracing and tracking — for months, we've been hearing about the need for these measures to help contain the pandemic, but they've largely been focused on individual testing and hospital admissions. Such data can't detect trends in the virus's spread among the greater population, including people who are asymptomatic. **Kara Nelson,** professor of civil and environmental engineering, has been trying to change that. She is leading a multidisciplinary group of researchers who are working with Bay Area wastewater agencies and public health officials to develop a regional monitoring effort that accurately tracks COVID-19 in the Bay Area. By measuring levels of the SARS-CoV-2 virus in wastewater, Nelson's team will track the virus among many thousands of people by testing a sample from a single collection station. The results will provide insight into trends in viral prevalence, determine which strains of the virus are present in a given community and identify new strains that are being introduced from other regions due to increased contact and travel. Health authorities and decision-makers will pair wastewater analysis with clinical data to provide a more complete picture that can inform efforts to control the spread of COVID-19. The detection of new strains will also help identify novel pathogens that may threaten to cause future epidemics.

takes on COVID-19



WHEN FAKE VIRUS NEWS GOES VIRAL

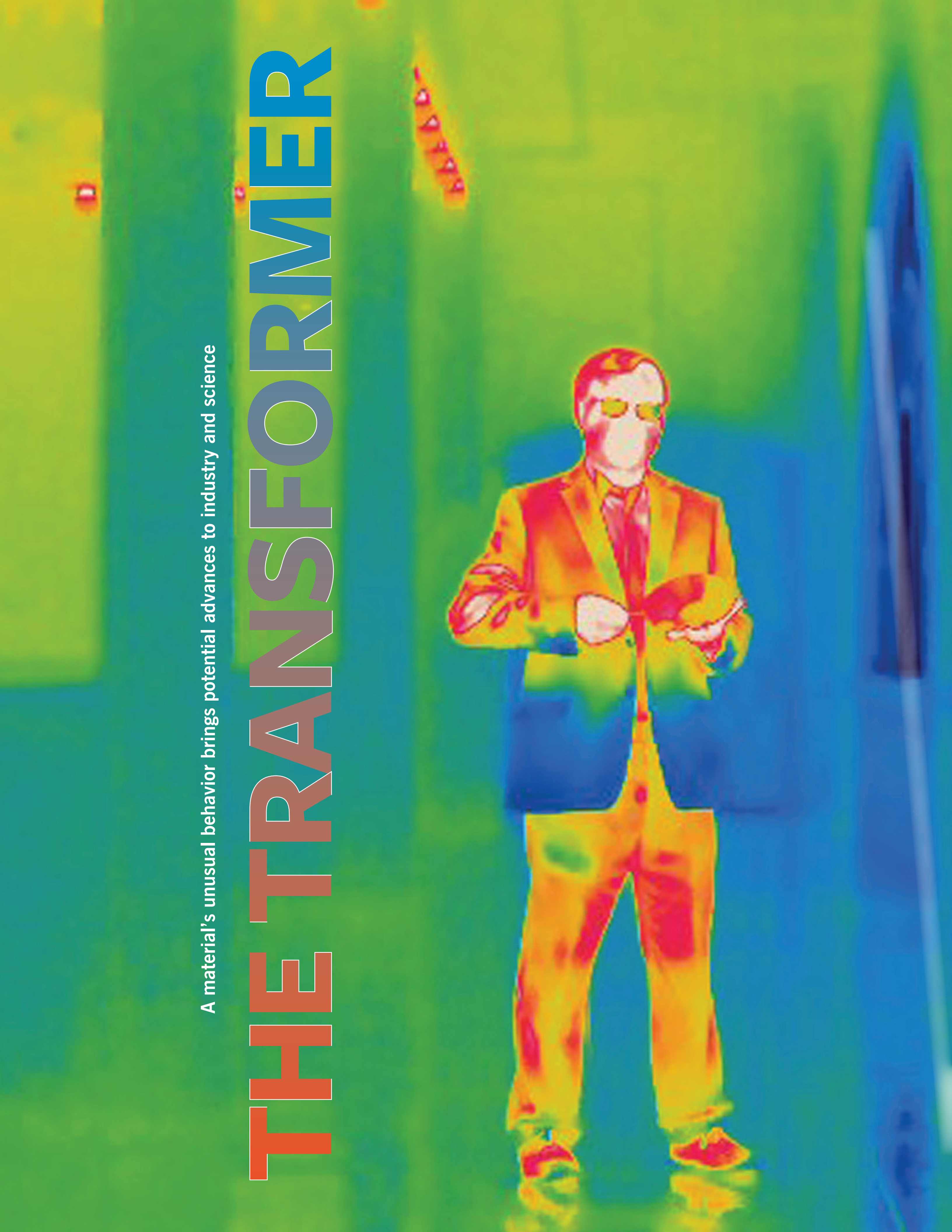
Misinformation via social media? We're familiar with the dangers. But false news about the coronavirus pandemic could actually lead to increases in death. Just ask **Hany Farid,** professor of electrical engineering and computer sciences and at the School of Information, who conducts research on how to spot fake news, images and videos. Farid's team launched a major survey of more than 3,000 people in the United States, Western Europe, South America, Northern Africa and the Middle East to determine how far COVID-19 misinformation has penetrated the global population. Preliminary survey information suggests that a vast majority of people believe that humans deliberately created the virus, even though scientists confirm the pathogen occurred naturally. Other myths posit that Black people are immune to the virus, the Chinese military deliberately engineered COVID-19 and drinking bleach can stop its spread. Farid and his team are trying to develop a "vaccine" to quickly counter the misinformation before it can do serious damage. They're working with the university's Human Rights Center to identify people and institutions who can quickly and credibly push back against misinformation, and they hope to develop strategies on stopping fake news about COVID-19 before it settles into people's minds.

TESTING THE TESTS

Antibody testing for COVID-19 helps us understand who has been exposed to the coronavirus, how our immune systems respond and how the pandemic is spreading. But are some tests working better than others? This past spring, a collaboration between UC Berkeley and UCSF evaluated some of the more than 120 antibody test kits to provide the performance data needed to decide which tests to employ and to understand how reliable the results are. **Patrick Hsu,** assistant professor of bioengineering at Berkeley, led the effort with **Alex Marson,** associate professor of microbiology and immunology at UCSF; **Caryn Bern,** professor of epidemiology and biostatistics at UCSF; and **Jeffrey Whitman,** a clinical fellow in pathology at UCSF and a resident in laboratory medicine. In head-to-head comparisons of a dozen tests against roughly 300 patient blood samples, the researchers found that many performed reasonably well, especially two weeks or more after infection, when antibody levels begin to peak. But many other tests had false positive rates that may have exceeded the proportion of people who have been infected in some communities. The resulting paper, now published in Nature Biotechnology, is one of the first systematic studies of COVID-19 rapid antibody tests.

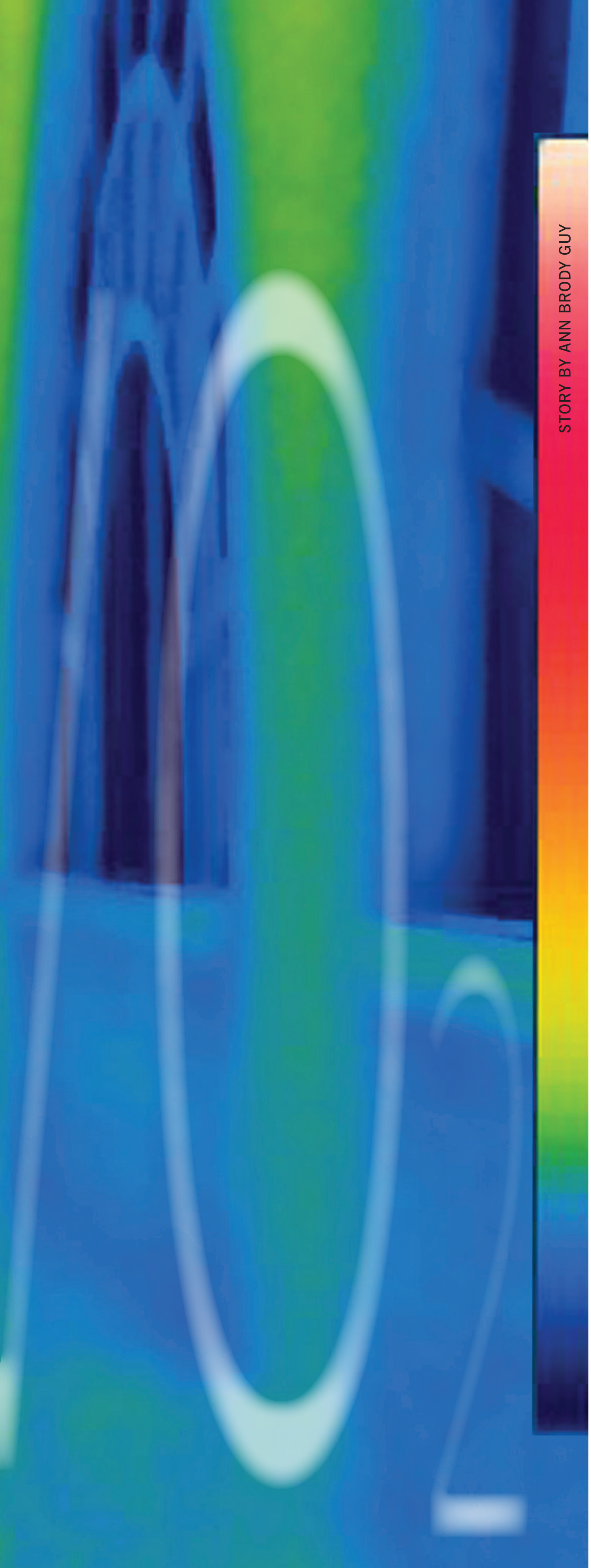
VISUALIZING COVID'S SPREAD IN REAL TIME

As the virus has taken hold across the country, it has become critical to have real-time tracking of infections and deaths to forecast the pandemic's spread and severity for individual counties. **Bin Yu,** professor of electrical engineering and computer sciences and of statistics, and her lab have developed interpretable models that are updated daily and have curated the data to predict the trajectory of COVID-19-related deaths. Their website, covidseverity.com, gives access to those predictions in the form of interactive visualizations. They have also created a web page for hospital-level prediction, where users can upload data for a specific hospital and download prediction results for it. The uploaded data is only temporarily used for prediction and is not collected for future use.



THE TRANSFORMER

A material's unusual behavior brings potential advances to industry and science



STORY BY ANN BRODY GUY

Adam Lau

To anyone unfamiliar with the world of chemical compounds, vanadium dioxide sounds like something that the "Star Trek: Enterprise" crew might have to battle a few aliens to get their hands on. But this oxygen-infused variant of the chemical element vanadium is indeed real and has a notable characteristic: It can change from an insulator to a metal.

Whether we learned about phase change as kids eagerly waiting for popsicles to freeze or watching a science teacher turning a liquid to gas with a dramatic poof, most of us understand the concept: when a material changes from one physical state to another – usually solid, liquid or gas – without altering its chemical make-up. Water, for example, is H_2O whether it's in a liquid or a solid state.

Vanadium dioxide's phase change lacks the visual flair of turning to ice or gas, but it is much more novel: It toggles between conducting and not conducting electricity. When heated to 152 degrees Fahrenheit — about the temperature of a hot cup of tea just starting to cool down — the dark, solid material changes from blocking the movement of electricity to letting it flow.

Materials science professor Junqiao Wu has been working with the compound, VO_2, for a decade, at first probing its unusual physical properties. But a few years ago, he began developing real-world technologies with the metal.

"I started thinking, this phase transition is unique — it must have some new applications," he says.

He bundled several related research projects into an entry for the Bakar Prize, a 2020 addition to UC Berkeley's Bakar Fellows program, which provides robust support for a faculty member to move commercially promising work beyond the lab and into the market.

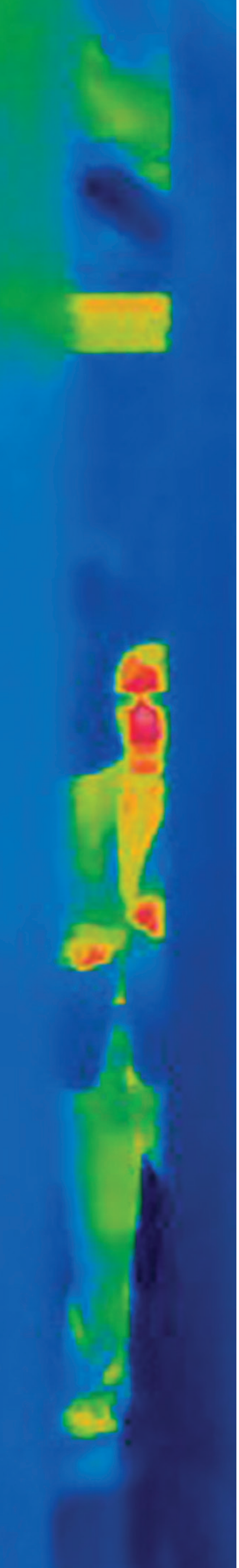
Wu won the prize's inaugural award — a generous $225,000 financial infusion to his lab. As a result, three applications of vanadium dioxide are in various stages of development and hold potential for exciting advances in biomedical, engineering, energy and military technologies.

FROM COOLING TO WARMING

Wu got one of his inspirations by looking up. He'd noticed a roofing technology called radiative cooling that's been on the rise in recent years. The coating, marketed as shingles and panels by a few startups, radiates infrared heat waves off of a building and out into the atmosphere, keeping buildings cool without using any energy.

While that may be effective for perpetually hot climates such as equatorial regions, Wu says, "Whenever I'd see that technology, I would ask myself, what about in winter? Your roof will continue to do the same thing — take the heat energy and radiate it out. That's not what you want to be doing in winter, right?" He notes that by "winter," he means any significant cooldown, like the Bay Area's fog-chilled nights.

Vanadium dioxide, he thought, with its novel temperature-driven phase transition, could enable a technology that radiates heat off of buildings when



ambient temperatures are warm, and then, when the temperature drops, changes to a non-radiative state to keep heat in.

To create this smart, all-weather roofing material — he calls it temperature-adaptive radiative coating, or TARC — Wu and his team developed vanadium dioxide into an ultra-thin film. On a balcony at his Berkeley Hills home, the team monitored the experiment continuously over several days. In warm temperatures, the small, TARC-covered panels radiated heat efficiently, and when temperatures cooled down to below 70 Fahrenheit, the panels switched off the radiative cooling, allowing the space underneath them to warm up.

How, exactly, does the material know when to make the switch? The secret sauce is tungsten, a dense metal common in metal alloys. Infusing, or "doping," the vanadium dioxide with tiny amounts of tungsten — just 1–3% — creates a built-in thermostat, effectively programming the material to enter its phase transition at a desirable threshold, such as 50 or 60 degrees Fahrenheit.

Wu's team — which included postdoctoral researchers Kechao Tang, now a faculty member at China's Peking University, and Kaichen Dong, together with Wu's students — designed and analyzed the experiment. The film they produced is just a tiny fraction of a micrometer thick, much thinner than a human hair.

Naturally, working at that scale is complex. The researchers compress mixed powders, Dong explains, then hit them with a high-powered laser, causing clusters of atoms to fly out and form a film on a glass positioned above the powders. "That's why we call it 'growing the material' — because if you look at this piece of glass, you can see the thickness increase as more and more material lands on it," he says. Transferring the resulting film onto cellophane tape causes the rigid material to take on the tape's flexible characteristics.

In addition to the Berkeley Hills experiment, the team used year-round weather databases to run simulations of their film's performance in typical weather conditions for cities around the world. "We proved that our device would save a lot of energy in temperate-zone cities like Chicago, Boston and New York," Wu says. The team submitted their results for publication this fall.

The road to commercialization is still a long one. Dong, who also spent two years as a visiting student in the Wu lab, notes that to produce the film at a manufacturing scale, the team must re-optimize all their measurements. "We're starting again at the design stage to ensure the manufactured materials will achieve the same performance level as the grown material," he says. "We're working as both scientists and engineers."

TURNING UP THE HEAT

Wu's lab is also growing a different tungsten-doped vanadium dioxide film to improve a well-known technology: thermography. Infrared cameras read temperature variations across an object to create those glowing red, orange and green thermal images often associated with night vision goggles. They measure infrared energy, the invisible wavelengths that objects radiate when they have any measurable temperature. In addition to some medical scans, thermography is used to check electronics for faulty connections and to scan buildings for hidden structural problems.

However, as those nebulous images suggest, the technology is not very precise; its usefulness has been limited by its low resolution. Higher sensitivity readings would help make more meaningful, even critical distinctions between similar points in a scan.

"People in manufacturing or industry spend a lot of money to improve infrared cameras," Wu says, but his team flips that approach. "Instead of improving the camera, we coat the surface of the thing we're imaging." Placing his ultra-thin smart film over an object sensitizes its surface radiation, allowing the camera to image it more efficiently.

The resulting image is 15 times more sensitive to small temperature variations on the surface compared to currently available thermography methods. "If you want to improve the sensitivity of a camera by 15 times, that's a lot more expensive and a lot bulkier," Wu says. With his smart film method, "Using the same camera, you will see a lot more."

Like the roof coating, the smart film, called thermal imaging sensitizer, is tape-based, so it can go on almost any solid surface. Currently, the team can make only smaller pieces, but they are exploring how to cover larger areas by spraying it onto the surface of a building or bridge, for example, to enhance safety inspections with infrared imaging.

"We're trying to come up with a new way to apply nanoparticle film over a large area without the need for complicated high-energy lasers," says Dong. "A spray will allow us to add a thin layer of nanoparticles directly onto the target area," adding sensitivity to make tiny, sub-surface cracks or structural flaws visible with an ordinary infrared camera.

A study with mice also has demonstrated the vanadium dioxide film's potential usefulness in early cancer detection. Wu's team took smart-film-enhanced thermal images of mice with cancer and detected tumors where existing technology — optical imaging and standard thermography — did not. Two days later, the other technologies corroborated the location of the tumors the vanadium dioxide film had found earlier. Four days after the earliest findings, the tumors were large enough that bumps could be visually observed. The work will be published in the journal Science Advances this year.

Wu expects the technology will have the largest impact in the early detection of breast cancer, where tumors are close to the skin's surface, accessible to thermography. His team will also research comparable biomedical applications such as vascular conditions and skin cancer.

HIDDEN IN PLAIN SIGHT

For another application, instead of increasing the visibility of objects in thermal scanning, Wu hides them. Thermal camouflage technologies — evading the detection of night vision goggles, for example — already exist, conjuring spy-versus-spy covert operations with obvious appeal for military and other surveillance and counter-surveillance applications. But they're still clumsy, require energy input to work and have rigid, cumbersome structures. They also have glitches — when a hidden object's temperature changes, it becomes momentarily visible while the devices adjust.

The vanadium dioxide-based system is "power-free, monolithic and mechanically flexible," according to a paper published in Advanced Materials in July, and continues to work even when the target object's temperature surges.

But Wu's team went further than camouflage. They created a way to fool infrared cameras into "seeing" a thermal image that's different from what the camera is actually measuring. In a spirited party trick, researchers made a "Cal" logo appear on a thermographic image, indicating completely different temperature settings than the real temperatures of the C, A and L actually being imaged.

"The decoy would not only passively conceal the real thermal activity of the object from an infrared camera, but also intentionally fool the camera with a counterfeit infrared image," the paper says. Put more simply, it's a total fake out.

While the decoy findings suggest Hollywood-inspired technology — for example, making a 98.6 Fahrenheit reading for a human appear more like a tree — Wu confesses that mainly he set out just to test a theory about manipulating infrared waves.

"We were just curious," he says with a playful smile.

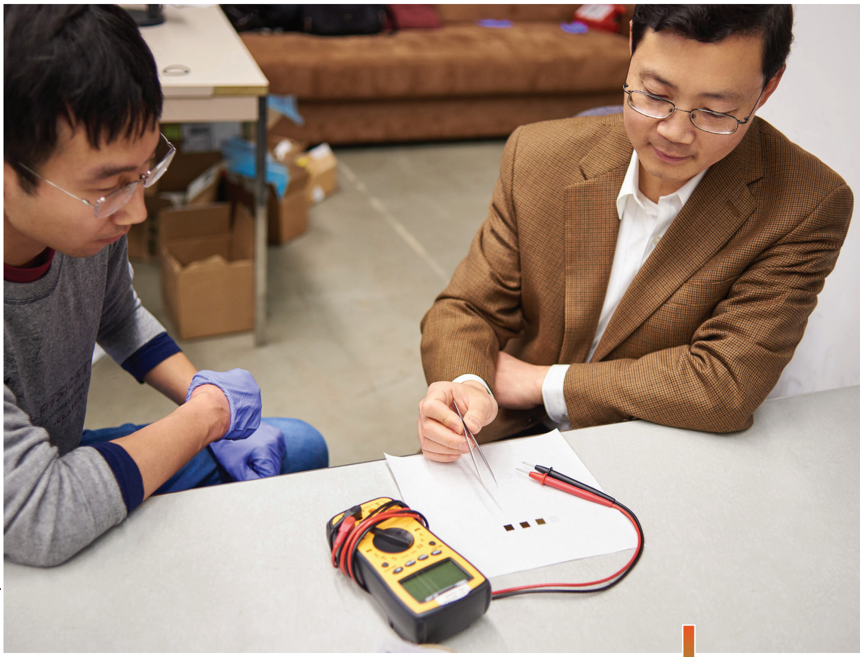
ONWARD AND INWARD

To commercialize the Bakar work, Wu and his students — with help from Berkeley's innovation ecosystem, including Skydeck and CITRIS Foundry — have launched the startup DeepRed Technologies. Much of the company's current effort is focused on scaling up, but the lab is exploring scaling down, so to speak: Wu is conceiving of a way to use his signal-amplifying smart film at the cellular scale.

By putting the film onto a clear base — a substrate — and placing cells on top, "You can probably use an infrared camera to look up through the bottom and see individual cells," he says. And not just the form of the cells, he adds, but possibly their interactions and even slight temperature differences, down to a thousandth of degree Centigrade.

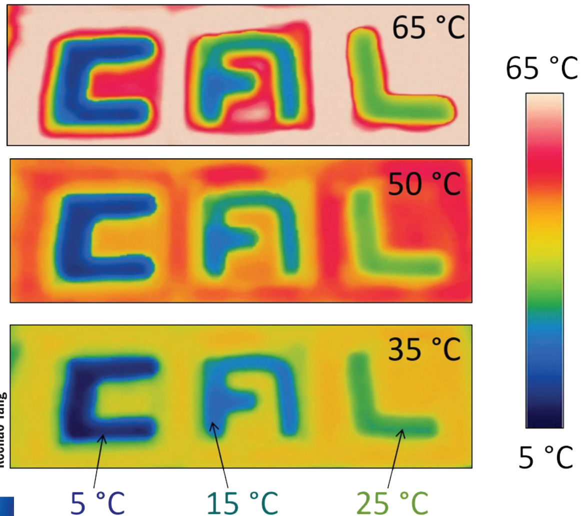
As far as he knows, no one's taken the temperature of individual cells before. If his ideas bear fruit, they have the potential to open up whole new areas of biological and medical inquiry.

"All of a cell's biological and metabolic activities probably will reflect onto their local temperature," Wu says. "If we can amplify that, so that you can see it with a regular infrared camera, that would be wonderful, right?" BE



Mark Joseph Hanson

Kechao Tang and Junqiao Wu examine samples of ultra-thin vanadium dioxide films that switch automatically between conducting heat and insulating against it.



Kechao Tang

New technology can fool infrared cameras into perceiving a thermal image that is different from what the camera is actually measuring. Here, the letters C-A-L appear cool even when the real temperatures are hot.

Safe to drink

SOLVING THE ARSENIC PROBLEM IN GROUNDWATER

Dana Hernandez/Gadgil Lab

Adam Lau

Top: Joyashree Roy, left, economics professor at Jadavpur University, Kolkata, a key research partner in the ECAR research, watches a teacher collect treated water at a school outside Kolkata, India.

Bottom: Postdoctoral researcher Siva Bandaru assembles an ACAIE unit.

STORY BY NATE SELTENRICH

Every day in Bangladesh and neighboring West Bengal, India, tens of millions of people drink water containing deadly levels of arsenic. Although awareness of the problem dates to the early 1990s — and in 2000 the World Health Organization named it the largest mass poisoning in human history — no large-scale solution yet exists. The largely poor, historically marginalized people living in this region have no choice but to drink the toxic water.

And it's not just a problem in Southeast Asia. Communities in South America, Alaska and California's Central Valley also have contaminated groundwater, putting residents' health at risk. Long-term exposure to arsenic through drinking water, even at low levels, can have dire consequences. The list of potential health effects includes internal cancers, cardiovascular disease, skin lesions and disfigurement and, among young people, impaired cognitive development.

Ashok Gadgil, professor of civil and environmental engineering, desperately wants to help. He has found an affordable, scalable way to remove arsenic from water that his track record suggests just might work. Across five decades at UC Berkeley and Lawrence Berkeley National Laboratory, he has cultivated an uncommonly broad humanitarian perspective in his work as an engineer — one that wields innovation and design to address serious challenges affecting human health and well-being, particularly among the poor. "The central point of our work is to bring science to solve real problems on a societal scale," he says.

In the 1980s, Gadgil developed patents for solar heaters and even moved to India for five years to deploy them — but was ultimately foiled by politics and bureaucracy. In the 1990s, he invented a technology that uses ultraviolet light to disinfect water, killing disease-causing pathogens like cholera. Today, it is widely used by WaterHealth International to provide purified drinking water to nearly 30 million people throughout India and Africa.

Then, in the early 2000s, Gadgil began researching safer wood-burning cookstoves for residents of developing nations, particularly displaced women at refugee camps in Darfur, Sudan. Because wood is scarce in the region, women would trade food rations for fuel or venture far from the camps to source wood, leaving them vulnerable to assault. Having more efficient stoves that reduced woodfuel demands would help these women and protect them from violence. Ultimately, Gadgil led the design and development of the Berkeley-Darfur Stove and co-founded the nonprofit Potential Energy to oversee the manufacture and distribution of the stoves in Darfur refugee camps and, more recently, Uganda. To date, more than 50,000 stoves have been distributed.

Affordable, effective, community-scaled

When his lab's research on stoves ended earlier this year, Gadgil found himself with a singular focus on another class of technologies he first began exploring in 2005: low-cost arsenic removal from contaminated groundwater. For afflicted communities, this should come as good news.

A naturally occurring element, arsenic is widespread in the earth's crust. Depending on geology, aquifer depth and other factors, it can dissolve from certain rock formations and accumulate in groundwater. By drinking water from wells that access this water, people can be exposed to harmful levels of the highly toxic metalloid.

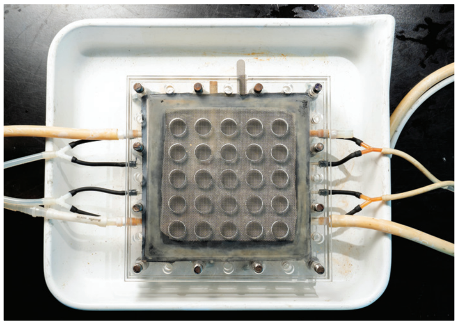
But removing arsenic is notoriously difficult and expensive. While treatment may be within reach for larger, well-funded water systems, with existing technologies it is typically not feasible for small, rural and low-income communities. That's why Gadgil has worked for more than 15 years to develop affordable, effective, community-scale arsenic removal technologies.

Most significantly, a technology his research group began working on in 2005 — called ElectroChemical Arsenic Remediation (ECAR) — has operated successfully since 2016 at a rural high school outside the West Bengal capital of Kolkata, India. Installed inside a large converted classroom, the system treats water drawn from a nearby well to remove arsenic levels from a dangerously high 250 parts per billion (ppb) all the way down to 3 ppb, well below the World Health Organization's recommended standard of 10 ppb.

The technology builds upon a common process known as electrocoagulation, in which an electric current is passed through water to precipitate dissolved and suspended solids. At the India ECAR plant, a total of 32 one-meter-by-one-meter steel plates, submerged in two large tanks holding up to 1,400 liters each, are electrified with about 10 volts of DC power to rapidly release a particular kind of rust from the steel plates. Arsenic in the water naturally binds to the iron oxides in this rust, and together the denser particles sink to the bottom for easy extraction.

It takes about 100 minutes for each tank or reactor to clean 1,000 liters, says Siva Bandaru (Ph.D.'20 CEE), a postdoctoral

Adam Lau



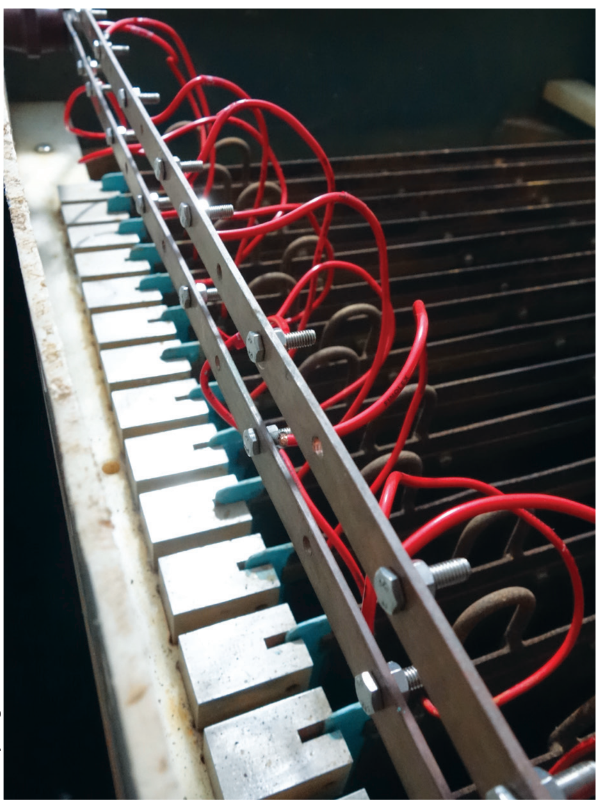
Adam Lau

Top: Ashok Gadgil, professor of civil and environmental engineering.

Left: An ACAIE unit, with electrical cables and connectors removed for clarity. Untreated water enters from the tubes on the left, passing between iron and air-diffusion carbon electrodes, with filtered water exiting the tubes on the right.

Adam Lau

Ashok Gadgil and Ph.D. student Dana Hernandez, right, test new technology at Gadgil's lab.



Courtesy Gadgil Lab

ECAR technology works to remove arsenic from well water at a rural high school outside of Kolkata, India. Electrified steel plates, submerged in a tank of water, release rust in a controlled manner. The rust naturally transforms and captures arsenic, sinking to the tank bottom for easy extraction.

researcher in Gadgil's lab who helped develop the system. Operated for profit by an Indian licensee, the plant provides up to 10,000 liters per day of safe drinking water to the school, for free, and to about 3,000 members of the surrounding community, for less than 1 cent per liter. It generates surprisingly little waste — about one-third of a cup of sludge per person per year — which Gadgil's Indian partners are looking to incorporate into concrete bricks for safe immobilization.

California's hidden water crisis

Almost 300 public water systems in California deliver water containing high levels of arsenic. For geological reasons, most of these are concentrated in the state's Central Valley, where the challenge is compounded by familiar risk factors including poverty, political under-representation and air and water pollution tied to the valley's intensive agricultural use. Here, in the fertile center in one of the largest states in one of the wealthiest nations on the planet, another arsenic crisis quietly plays out every day.

About 95 miles northwest of Bakersfield in the South Valley lies a small town called Allensworth. Little known now, it has a rich history dating to the early 20th century and holds the honor of being the first California town established by Black Americans. Like many towns in the valley, it sits on groundwater contaminated with unsafe levels of arsenic. Also like many neighboring communities, it lacks the funding and expertise to remove the arsenic, leaving its 500 or so residents reliant on costly bottled water.

When Gadgil learned about the town's predicament — and that its current leadership was actively seeking ways to solve the water problem and revive the economy — he thought he might have a solution.

Water demands and labor costs are far higher in California than in rural India or Bangladesh. So rather than trying to shoehorn ECAR into a situation vastly different from that for which it was designed — one in which ease of use and availability of materials are paramount — Gadgil and his research team realized they needed something faster and more powerful.

The result was a pair of advanced arsenic-removal technologies based on the ECAR platform called Air-diffusion Cathode Assisted Iron Electrocoagulation (ACAIE) and Fe/iron Electrocoagulation with External Oxidizer (FOX).

In ACAIE, the iron cathode is replaced with an air cathode that takes in oxygen from the air and releases hydrogen peroxide into the water. In water, hydrogen peroxide reacts with iron ions thousands of times faster than dissolved oxygen does in ECAR. ACAIE takes up a tenth as much space as ECAR to treat the same volume of water — and does so in four-hundredths of the time, Bandaru says.

FOX also relies on hydrogen peroxide, either from an ACAIE cathode or other external source. It further speeds up reaction times in water with low salt content or conductivity by replacing the iron plates, typically spaced 2.5 to 3 centimeters apart, with paired iron sheets sandwiching a thin plastic mesh, reducing the distance between them to just a few millimeters.

In the summer of 2019, a one-week test of the two new technologies in Allensworth served as a successful proof of concept and could potentially point toward an arsenic-free future for the town. Graduate student researcher Sara Glade led the charge, designing and implementing the trial.

"Sara [and her team] proved with very careful experiments that we can remove arsenic from their groundwater in Allensworth, reliably and inexpensively," Gadgil says. "What we did in India and Bangladesh could work in Allensworth.… We are satisfied that it will work perfectly well."

"Another door opens"

Despite the success of the trial, which was locally funded with Glade's support, the community or state will still need to come up with the money to install a permanent, properly sized treatment plant. Gadgil estimates this could run between $500,000 and $750,000. Because this will be the first demonstration project, this includes the cost of detailed monitoring, verification and rectifying unexpected problems that might emerge during the scale-up. So the project in Allensworth remains on hold.

"When one door closes, another door opens," Gadgil says — 45 miles to the north, to be precise. With a population of around 26,000, Lemoore is much larger than Allensworth. Some of its residents already have access to safe tap water. Yet the Central Union Elementary School, which is in a rural, unincorporated region of Lemoore and operates its own water system, does not.

At this school, groundwater is used only to water the lawn, and all water fountains have been turned off. Instead, the school purchases five-gallon bottles of drinking water that are placed on water-dispensing stands throughout the campus.

In 2019, Gadgil received a $900,000 grant in collaboration with Berkeley's School of Public Health to fund a three-year effort to further evaluate ACAIE technology. "If successful," Gadgil wrote in the grant application, "this project will bring us closer to solving the arsenic crisis in rural California."

Central Union Elementary was the perfect test case. As in Allensworth, its leaders were eager to find a solution to their arsenic problem. The Berkeley team began working closely with the school last year to create both a small treatment facility in a vacant classroom and complementary modules in STEM curriculums at different grade levels, which will teach children about water safety and treatment. If successful, the treatment facility will provide safe water to the school at no cost once installed, mirroring the project in India.

Progress was interrupted by the COVID-19 epidemic in March, and while work on the treatment units has since resumed at a slow and careful pace in Berkeley, the field trial itself won't begin until after restrictions on travel and other activities are lifted. Meanwhile, curriculum development and student engagement continues — with remote learning as a new twist, says Winston Tseng, associate professor of research with the School of Public Health, who is leading the project's outreach and education components.

Tseng and his team of two graduate students, two undergraduates and one other faculty member also actively consult with Central Union parents, teachers and school administrators, and with the local Tachi-Yokut Tribe, whose children represent a significant proportion of the student body.

"They continue to support the work to pilot this new innovative technology at the school," said Tseng. "They appreciate that UC Berkeley cares about this rural community and Central Union. We're building this relationship."

Bandaru, who also worked on the Allensworth trial and is now involved in the Lemoore project, says he thinks ACAIE's improved speed and efficiency will allow it to eventually overtake its predecessor. "From a technology point of view, it's flawless," said Bandaru, who is also training a delegation from the Philippines on the technology. "I think it'll scale up more rapidly than ECAR."

If the plant in Lemoore works as well as the team hopes, it could provide a foundation for deploying ACAIE not only throughout California's Central Valley but also back in India and Bangladesh, bringing the work of Gadgil's lab full-circle — and showcasing its commitment to real-world solutions, not specific technologies. BE

Mechanical engineering professor **Alice Agogino** (M.S.'78 ME) was named one of the top 10 women in the robotics industry by Analytics Insight for her research on squishy robots at the Berkeley Emergent Space Tensegrities Lab. She was also the winner of the 2020 WITI@ UC Athena Award in Academic Leadership.

The American Chemical Society has selected **Paul Alivisatos,** professor of materials science and engineering and of chemistry, as the recipient of the 2021 Priestley Medal, the society's highest honor.

Electrical engineering and computer sciences professors **Murat Arcak, Kameshwar Poolla** and **Claire Tomlin** (Ph.D.'98 EECS) have been named 2020 Fellows of the International Federation of Automatic Control.

Adda Athanasopoulos-Zekkos (M.S.'04, Ph.D.'08 CE), assistant professor of civil and environmental engineering, has received the 2020 TC203 Young Researcher Award. She was also elected president of the U.S. Universities Council on Geotechnical Education and Research.

Andrea Goldsmith (B.S.'86, M.S.'91, Ph.D.'94 EECS), dean of the School of Engineering and Applied Science and an electrical engineering professor at Princeton University, became the first woman to receive the Marconi Prize, the highest honor in telecommunications research. Her research interests are in information theory, communication theory and signal processing and their application to wireless communications, interconnected systems and neuroscience. Goldsmith holds 29 patents; co-founded two companies, Plume and Quantenna; and is a member of the National Academy of Engineering and the American Academy of Arts and Sciences. She is donating the $100,000 award back to the Marconi Society to start an endowment for technology and diversity initiatives.

PHOTO BY ADRIEL OLMOS

Popular Mechanics has named **Ruzena Bajcsy,** professor of electrical engineering and computer sciences, as one of 37 women who "upended science, tech and engineering for the better." She also won the 2020 NCWIT Pioneer in Tech Award.

Gah-Yi Ban (M.S.'08, Ph.D.'12 IEOR), assistant professor of management science and operations at the London Business School, and **Auyon Siddiq** (M.S.'14, Ph.D.'18 IEOR), assistant professor of decisions, operations and technology management at the UCLA Anderson School of Management, were recognized on Poets&Quants' annual list of "World's Best 40 Under 40 MBA Professors."

Timothy Brathwaite (M.S.'14, Ph.D.'18 CEE) earned the first place Eric Pas Dissertation Prize from the International Association for Travel Behavior, an award that highlights the work of exceptional new talent within the field of travel behavior research.

Mechanical engineering professors **Jyh-Yuan Chen, Robert Dibble** and **Michael Frenklach** were elected fellows of the Combustion Institute for their outstanding contributions to the field.

Chen-Nee Chuah (M.S.'97, Ph.D.'01 EECS) has won the UC Davis ADVANCE Scholar Award, which honors faculty members for advancing diverse perspectives and gender equity in STEM. The award also recognizes her research achievements in electrical and computer engineering.

Tejal Desai (Ph.D.'98 BioE), bioengineering professor in residence at UC Berkeley and chair of the UCSF Department of Bioengineering & Therapeutic Sciences, was named a fellow of the National Academy of Inventors.

Reginald DesRoches (B.S.'90 ME, M.S.'92, Ph.D.'97 CEE) has become the provost of Rice University. Previously, he served as dean of the university's George R. Brown School of Engineering.

A team of Berkeley Engineering graduate students — **Emilien Etchevers, Kieran Janin, Michael Karpe, Remi Le Thai** and **Haley Wohlever** — won the 2020 Google Cloud and NCAA March Madness Analytics Competition, hosted through Kaggle. Though this year's March Madness tournaments were cancelled due to COVID-19, the team used machine learning to analyze data from previous seasons in order to uncover the "madness" behind the famous men's and women's college basketball tournaments.

Gregory Fenves (M.S.'80, Ph.D.'84 CEE), former professor and chair of UC Berkeley's Department of Civil and Environmental Engineering, was named president of Emory University.

Mechanical engineering professor **Michael Frenklach** was awarded the Jürgen Warnatz Gold Medal by the Combustion Institute.

Ritu Garg (B.S.'12 CE) has been named by the Women's Engineering Society in the United Kingdom as one of the top 50 women in engineering for her work in sustainability. She works at Arup in London as a senior transport planner.

Bethany Goldblum (M.S.'05, Ph.D.'07 NE), a researcher in the Department of Nuclear Engineering and executive director of the Nuclear Science and Security Consortium, is the 2020 recipient of the Krell Institute's James Corones Award in Leadership, Community Building and Communication.

Mechanical engineering assistant professor **Michael Gollner** is a recipient of the 2020 Hiroshi Tsuji Early Career Researcher Award.

Grace Gu, assistant professor of mechanical engineering, was selected as a 2020 Outstanding Young Manufacturing Engineer by the Society of Manufacturing Engineers.

Kory Hedman (M.S.'08, Ph.D.'10 IEOR), associate professor of electrical engineering at Arizona State University, is the new director of the Power Systems Engineering Research Center, a 12-university research consortium.

Assistant professor of bioengineering **Patrick Hsu** has won the Rainwater Prize for innovative early career scientist.

Clean Air Car Race turns 50

Just over 50 years ago, UC Berkeley's College of Engineering students participated in the Clean Air Car Race from MIT in Boston to Caltech in Pasadena. The rules were simple: Each vehicle must have four wheels, accommodate at least two average-sized adults, be able to maintain a minimum speed of 45 miles per hour over level ground and — most critically — meet the upcoming 1975 federal emission standards. All engine types were allowed to compete.

Two four-man teams from Berkeley Engineering began working on two 1970 Plymouth Satellite sedans provided by the university's garage: one powered by propane and the other equipped with a regular combustion engine running on unleaded gas, which wasn't yet sold at gas stations. The project, led by professor **Robert Sawyer** — now the Class of 1935 professor of energy emeritus — took two academic quarters.

"The most challenging part of building our car turned out to be finding the parts and getting the support of suppliers to make the changes we'd planned," said **Floyd Sam** (B.S.'70 ME, M.S.'71 ME), leader of the propane team.

On August 24, 1970, some 50 cars from colleges around the country began the 3,600-mile, seven-day run from Cambridge to Pasadena, making overnight stops in Toronto, Ontario; Detroit, MI; Champaign, IL; Oklahoma City, OK; Odessa, TX; and Tucson, AZ. From each team, two members rode in the race car and two in an escort car. Unleaded gas and propane were supplied along the way, and the participants stayed at dorms provided by local universities. In Detroit, all vehicles underwent collective testing at the Ford Motor Plant.

Eight hours and fifteen minutes short of a full seven days, **Bak-Ying Chan** (B.S.'70 ME, MBA'79) was the first to cross the finish line at Caltech in the Berkeley-built, propane-powered Plymouth. After two days of emission tests conducted by the state air resources board, the overall program winner was declared from Wayne State University, a 1971 Mercury Capri run on lead-sterile gasoline.

"It was a once-in-a-lifetime experience," said **Peter Venturini** (B.S.'70, M.S.'71 ME). "Seeing the huge scale of this event, bringing together students from across the country, was very special."

The Cal team participants — which also included **Darrel Erickson, Scott MacDonald** (B.S.'70 ME), **Wayne Paulsen** (B.S.'70 ME) and **Charles Simkins** (B.S.'71 ME) — pursued careers across a variety of fields, but none of them ever forgot the lessons of the Clean Air Car Race.

The impact of what they'd achieved stuck with the entire team. "In the Clean Air Act of 1970, auto companies were suddenly required to meet certain standards by 1975," Chan said. "The Big Three manufacturers complained that it wasn't practical. But we proved to the world that even a bunch of college students could do it, using existing technology and five years before the official deadline."

STORY BY KIRSTEN MICKELWAIT | PHOTO BY DENNIS GALLOWAY/BERKELEY ENGINEERING

Vikram Iyer (B.S.'15 EECS) has won a Marconi Society Paul Baran Young Scholar Award. He is now a graduate student at the University of Washington, where his research focuses on bio-inspired and bio-integrative wireless sensor systems.

Michael Jordan, professor of electrical engineering and computer sciences and of statistics, received an honorary doctorate from Yale University, the most significant recognition conferred by its board of trustees.

Daniel Kammen, professor of nuclear engineering, energy and resources and public policy, has been elected to the American Academy of Arts and Sciences.

Dean **Tsu-Jae King Liu** was selected for the 2020 Chang-Lin Tien Award for Leadership in Education from the Asian Pacific Fund. In addition to this honor, the organization is awarding a grant to establish a Chang-Lin Tien Scholarship Fund.

Ron Klemencic (B.S.'85, M.S.'86 CE), chairman and CEO of Magnusson Klemencic Associates, has been elected to the American Society of Civil Engineers' 2020 Class of Distinguished Members.

Laurel Larsen, associate professor of civil and environmental engineering and of geography, has been appointed by the Delta Stewardship Council as its lead scientist.

Ming Lin (B.S.'88, M.S.'91, Ph.D.'93 EECS) has been elected to the Association for Computing Machinery Special Interest Group on Graphics and Interactive Techniques Academy. She is currently chair of the computer science department at the University of Maryland.

Sonita Lontoh (B.S.'99 IEOR) has been selected as an inductee in the inaugural class of the National Women in Manufacturing Association's Hall of Fame. She is currently the senior vice president and global head of marketing, 3D print and digital manufacturing at Hewlett-Packard.

Yi Ma (M.S.'97, Ph.D.'00 EECS), professor of electrical engineering and computer sciences, is among the Class of 2020 Fellows of the Society for Industrial and Applied Mathematics. He was cited for contributions to the theory and algorithms for low-dimensional models and their applications in computer vision and image processing.

Mechanical engineering Ph.D. student **George Moore** has won the 2019–20 Robert J. and Mary Catherine Birgeneau Recognition Award for Service to Underrepresented Students, one of the Chancellor's Awards for Public Service.

C. Daniel Mote (B.S.'59, M.S.'60, Ph.D.'63 ME), former professor and chair of the Department of Mechanical Engineering, was awarded the 2020 Benjamin Franklin Medal for his "outstanding contributions…to the understanding of the dynamics of practical systems such as saws, skis and conveyer belts."

Assistant professor of electrical engineering and computer sciences **Rikky Muller** (Ph.D.'13 EECS) has won a 2020 McKnight Technological Innovations in Neuroscience Award. She has also been selected as one of ten Rising Stars in Computer Networking and Communications in 2020 by N2 Women, a discipline-specific community of researchers in the fields of networking and communications.

Fast Company has recognized Collective Obscura as a 2020 World Changing Idea of the Year finalist, in a category that received over 3,000 entries. Collective Obscura, a project by graduate students **Eleni Oikonomaki** and **Bryan Truitt,** is a series of wearables that block facial recognition technology. The group was a recipient of the Fall 2019 Innovation Catalysts grant from the Jacobs Institute for Design Innovation.

Mechanical engineering professor **Panayiotis Papadopoulos** (M.S.'87, Ph.D.'91 CE) won the 2020 Berkeley Faculty Service Award, given to a member of the Berkeley Division of the Academic Senate for outstanding and dedicated service to the campus.

Harshita Pilla (B.S.'16 CE), who is pursuing a dual MBA/Master in Urban Planning at the University of Michigan, launched MBA Students Care: Fundraiser for Color of Change, to support civil rights advocacy.

The Royal Society has selected **Ramamoorthy Ramesh** (Ph.D.'87 MSE), professor of materials science and engineering and of physics, as a foreign fellow. Membership in the Royal Society, founded in 1660, is considered one of the most prestigious honors in the world's scientific community. His work has led to the development of nanosized materials that can power increasingly small but sophisticated electrical devices with minimal amounts of energy. Ramesh created multiferroic materials that demonstrate both electric and magnetic polarization when exposed to an outside field and, with Intel, invented "magneto-electric spin-orbit" (MESO) logic devices.

PHOTO BY JASON RICHARDS/OAK RIDGE NATIONAL LABORATORY

Kris Pister (M.S.'89, Ph.D.'92 EECS), professor of electrical engineering and computer sciences, has been named the new faculty director of the Marvell Nanofabrication Laboratory.

Mechanical engineering professor **Kameshwar Poola** has been awarded the prestigious 2020 O. Hugo Schuck Best Paper Award by the American Automatic Control Council. This is his second time to win this award.

Stephany Prince has been named the executive director of the Coleman Fung Institute for Engineering Leadership.

Civil and environmental engineering professor **James Rector** has been selected by the Society of Exploration Geophysicists (SEG) to receive its honorary membership, in recognition of his technical contributions, entrepreneurship, dedication to students and service to the SEG.

Paul Ronney (B.S.'78 ME) has been appointed chair of the University of Southern California's Viterbi Department of Aerospace and Mechanical Engineering. His research focuses on topics including micro-scale combustion, turbulent combustion, internal combustion engines, microgravity combustion and fire spread.

Scott Shackleton, the college's assistant dean of capital projects and facilities, has won an Excellence in Management Award from the Berkeley Staff Assembly.

Industrial engineering and operations research professor **Zuo-Jun "Max" Shen** has been named president of the Production and Operations Management Society.

Barbara Simons (Ph.D.'81 EECS) has received the 2019 Association for Computing Machinery's Policy Award for her long-standing, high-impact leadership as president and founding chair of its U.S. Public Policy Committee, while making influential contributions to improve the reliability of and public confidence in election technology.

Masayoshi Tomizuka, professor of mechanical engineering and associate dean of faculty, has been

Virtually engaging

Every summer, the UC Berkeley campus hosts more than 100 kids at its Girls in Engineering (GiE) camp, which introduces middle school students to engineering and design innovation. This year, with the COVID-19 pandemic, GiE's leadership had to quickly reformat the program to an online experience. But this unexpected pivot gave them the chance to reimagine the camper experience from the ground up.

Because GiE seeks out students who don't normally have access to specialized STEM activities, program staff were concerned that they would lose their target demographic — those students who need it the most. So for the first time since its pilot phase, the GiE camp was offered free of charge to all participants. Chromebooks and WiFi hotspots were provided to students who didn't have computers, and kits of supplies were made available at no cost. An additional week was added, and campers had access to all five sessions.

"Our decision to make the camp free stems from the fact that the families in our target demographic are the ones most severely impacted by the COVID-19 crisis, and removing this financial barrier ensures they're able to participate," said GiE program director **Anne Mayoral.** "In addition, many of these families are not equipped to access an online camp experience, so providing the tools and technology was critical for their participation."

In all, 111 campers attended the online camp. The curriculum included virtual tours of research labs, Q&As with researchers, outdoor experiences and activities focused on fabrication skills, prototyping, building and making.

"Every day, our goal [was] to infuse the campers with a little more confidence and a little more love of STEM learning; to pique their curiosity just enough that they'll want to take it to the next step," Mayoral said.

STORY BY KIRSTEN MICKELWAIT | PHOTOS BY ADAM LAU

awarded the prestigious 2020 Nichols Medal in recognition of his pioneering contributions to the control of mechatronic systems.

Civil and environmental engineering professor **Iris Tommelein** has been elected to the National Academy of Construction, given to engineers who have made distinguished contributions to the construction industry.

Julea Vlassakis (Ph.D.'18 BioE), now a postdoctoral scholar, is one of eight U.S. scholars who received a 2020 Burroughs Wellcome Fund Career Award at the Scientific Interface.

Ting Xu, professor of materials science and engineering and of chemistry, was selected as a 2020 fellow of the American Chemical Society's Division of Polymeric Materials: Science and Engineering.

Bioengineering professor **Michael Yartsev** has been named the recipient of the Rising Star Award in neuroscience research from the Mahoney Institute for Neurosciences in the Perelman School of Medicine at the University of Pennsylvania.

Civil and environmental engineering senior **Karilin Yiu** was chosen for the National Academy of Construction's first-ever academic scholarship. She was recognized for leading the Virtual Design and Construction Competition Team and the UC Berkeley Sustainable Solutions Competition Team, as well as for her outstanding academic record.

Tarek Zohdi, professor of mechanical engineering, has received the Humboldt Research Prize in the area of mechanics. The prize recognizes renowned researchers outside of Germany whose "fundamental discoveries, new theories or insights have had a significant impact on their own discipline and who are expected to continue producing cutting-edge achievements in the future."

Michael Athans (B.S.'58, M.S.'59, Ph.D.'61 EECS) died in May at the age of 83. A pioneer in the field of control theory, he was a professor of electrical engineering at MIT for 34 years. He was also the director of the MIT Electronic Systems Laboratory, an award-winning educator and the co-author of three books.

William Gianelli (B.S.'41 CE) died in March at the age of 101. Following graduation, he served in the U.S. Army during World War II, rising to the rank of major. Considered one of California's pioneering leaders in civil engineering, he served as director of California's Department of Water Resources in the 1960s and 1970s to build a then-unprecedented state water and power storage and delivery system. He was later appointed as assistant secretary of the Army, chair of the Panama Canal Commission and awarded the Hoover Medal.

Arthur Gill (Ph.D.'59 EECS), professor emeritus of electrical engineering and computer sciences, died in March at the age of 89. He was a faculty member from 1959–91, served as the college's assistant dean for undergraduate affairs from 1981–91 and conducted research with the Electronics Research Laboratory. The author of several books and numerous journal articles, he taught courses and supervised research in network analysis and synthesis, communication theory, system theory and computer science.

Eliahu Jury, professor emeritus of electrical engineering and computer sciences, died in September at the age of 97. During his 28 years at Berkeley, he made groundbreaking contributions to the field of discrete-time systems and control, including the Jury stability table, the theory of inners and his book, "Theory and Application of the Z-Transform Method."

Edward Rice (B.S.'49, M.S.'51 CE) died in May at the age of 94. He attended Berkeley in the early 1940s but left to join the U.S. Army Air Corps during World War II. After graduating, he co-founded T.Y. Lin and Associates in 1952, where he served as president for 17 years, then founded CTS Cement Manufacturing Corp in 1975. He held 27 patents in cement and concrete technologies and was the inventor of the single-strand post-tensioning system. An adjunct professor of materials science and engineering at UCLA from 1986–90, he was recognized as a UC Berkeley Distinguished Engineering Alumnus in 1987.

Nian Roberts (B.S.'50 CE) died in May at the age of 92. Following graduation, he served in the Korean War, eventually becoming a captain. He also had a long engineering career at A. Teichert and Son, playing a key role in the construction of major projects throughout California and Nevada.

Timothy Sennott (M.S.'14 ME) died in January at the age of 34. At Berkeley, he developed an engine design that delivers emission-free electricity from natural gas or hydrogen, later co-founding Noble Thermodynamic Systems to commercialize the technology. He was also a data scientist at DNV GL.

Paul Spencer (M.S.'77 MSE) died in December at the age of 97. He joined the U.S. Army Air Corps during World War II and served in the United States Air Force for the next 34 years, where he broke the sound barrier three times in an F-111 jet. After retiring as a full colonel in 1974, he earned his master's degree at Berkeley. He then worked as a research scientist and, later, as a principal development engineer at the Department of Materials Science and Engineering.

Daniel Kaye Stasko (B.S.'61 ME) died in May at the age of 87. Before enrolling at Berkeley, he served in the U.S. Army for three years during the Korean War. Following graduation, he worked at American Standard, then joined California & Hawaiian Sugar Company, where he worked for 33 years.

Charles Tateosian (B.S.'47 ME) died in March at the age of 97. During World War II, he left Berkeley and enlisted in the U.S. Navy, serving as a lieutenant. Upon graduating, he embarked on a 40-year career with Pacific Gas & Electric, where he played a key role in bringing natural gas to California. He also worked as a consultant with Gas System Engineering.

Donald Tuttle (M.S.'65 CE) died in May at the of age 81. After working as a coastal engineer, he completed a second bachelor's degree in environmental science at California State University, Humboldt. He then worked as an environmental services manager in Humboldt County for 31 years, setting the requirements for environmental permitting and developing an extensive environmental database for the county.

Richard White, professor emeritus of electrical engineering and computer sciences, died in August at the age of 90. He joined the faculty in 1962 and was most recognized for his research on acoustic properties at the micro-scale, which contributed to the development of ever-smaller sensors and semiconductors. He also invented the interdigital transducer. In 1986, he and Richard Muller established the Berkeley Sensor & Actuator Center, which helped launch the field of micro-electromechanical systems. He authored or co-authored more than 90 research papers, co-founded the Graduate Group in Science and Mathematics Education and was a member of the National Academy of Engineering, among many other honors.

Douglas Wolcott (B.S.'57 Agricultural Engineering) died in September at the age of 89. He had a long career with Chevron, eventually becoming president of Chevron Shipping, where he oversaw the merger the Gulf Oil and Chevron Marine operations, as well as the fleet's operations during the Persian Gulf War. He also served as the first chair of the Marine Preservation Association and was a board member of several global shipping organizations.

Robert Wu (B.S.'53 EECS) died in September at the age of 88. As a leading researcher in China, he pioneered the development of first-generation transistors, microcomputers and integrated circuits. He later returned to the United States, where he worked at the HP Research Institute, helped establish HP China and then co-founded Silicon Magic Semiconductor. He also founded and chaired the U.S.-China Green Energy Council.

Keegan Houser

Dennis Galloway/Berkeley Engineering

Fueling a **Lifelong Connection**

Courtesy Bak Chan

In August 1970, a group of Berkeley's College of Engineering students participated in the weeklong Clean Air Car Race from MIT in Boston to Caltech in Pasadena. (See story on page 17.) Alumnus Bak Chan (B.S.'70 ME, MBA'79), who drove the first car across the finish line, remembers that event as one of the proudest of his life. That experience — along with the value of his Berkeley Engineering degree — helped land Chan his first job. He returned to Cal to pursue his MBA; with that, he pivoted from engineering to a 30-year career as an independent financial adviser.

Such positive outcomes from his Berkeley degree inspired Chan to become an early donor — he remembers his first gift was five dollars in 1975. Since then, he has consistently given back to campus, including gifts to the Berkeley Engineering Fund and to create the Chan M.E.T. Scholarship and Chan Donor Designated Fund. One particularly meaningful gift was to endow a scholarship in honor of his parents in 2008; just a year before he died, Chan's father, who had never gone to college himself, came to campus to meet the scholarship's first recipient.

A donor designated fund (DDF) is a less well-known giving vehicle that offers a charitable tax deduction in the year of the gift, while allowing donors to change or rotate their areas of support among various campus programs from year to year. Chan liked the flexibility of being able to redirect his giving as his priorities evolved.

Now semi-retired after turning his business over to his daughter, Joyce Chan (B.A.'05), he urges potential Cal donors to review their financial situation and find mutually beneficial ways that they can support the university. "It's much more satisfying to support a program you're passionate about," he says.

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