College of Engineering
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Volume 21

The future of meat
From classroom to the market

Wastewater testing
Tracking viruses beyond SARS-CoV-2

Berkeley ENGINEER

A new time for titanium
Making a stronger, cheaper, more sustainable metal

Public partners in innovation

Adam Lau

Core to Berkeley Engineering's mission is to serve the public good, and this past year has seen the launch of new partnerships with state and local agencies that exemplify this ethos.

You can read about one example of collaboration with public partners in this issue of Berkeley Engineer. Kara Nelson, professor of civil and environmental engineering, and Rose Kantor, assistant research engineer, have led the effort to monitor wastewater for the SARS-CoV-2 virus on campus and throughout the Bay Area. The technique their team developed to detect the virus and its variants is not only very sensitive and fast, but also doesn't require difficult-to-source materials. Working with more than 20 local wastewater agencies, they were able to detect the Omicron variant before it showed up in clinical samples. They have made their data available to the public at covid-web.org.

The Berkeley researchers have received state funding to transition their wastewater monitoring system to the California Department of Public Health, as part of its long-term public health surveillance program, and they are now applying what they've learned from monitoring the SARS-CoV-2 virus to other infectious agents, including the influenza virus.

Another public partnership is helping us better prepare for a world that is grappling with the effects of climate change. The spring 2021 issue of Berkeley Engineer featured civil and environmental engineering professor Kenichi Soga's innovative use of advanced sensor technologies. Since then, Soga has been serving as special advisor to the dean for resilient and sustainable systems, and led the establishment of the Center for Smart Infrastructure in partnership with the East Bay Municipal Utility District (EBMUD). This new center focuses on research to address risks associated with aging infrastructure systems posed by climate change and natural hazards, and talks are underway to include other public utilities as partners.

Close collaborations with public partners are key to the success of these research programs, helping us translate research results into practical benefit. I look forward to a better future shaped by these and other innovations created by Berkeley Engineers, one that is healthier and more sustainable for all members of our global society.

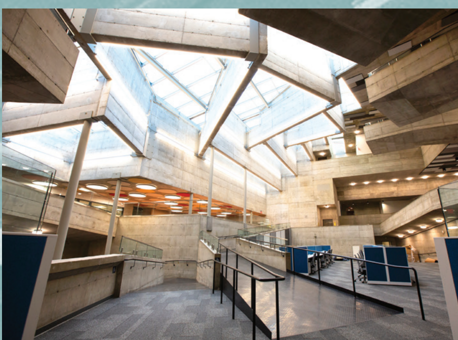
Fiat Lux,

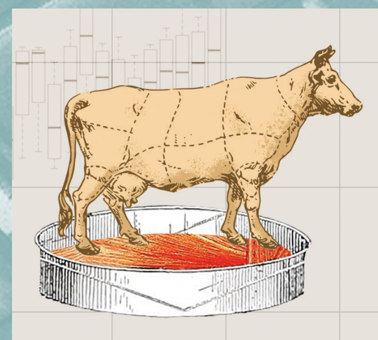
—*Tsu-Jae King Liu*
DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING

Close collaborations with public partners are key to the success of research programs, helping us translate results into practical benefit.

in this issue

Berkeley**ENGINEER SPRING** 2022





MORE >

> COVER PHOTO: **Pure titanium with a nanotwinned structure. The image was created using an electron microscopy technique called electron backscatter diffraction.**

IMAGE BY **ANDREW MINOR**

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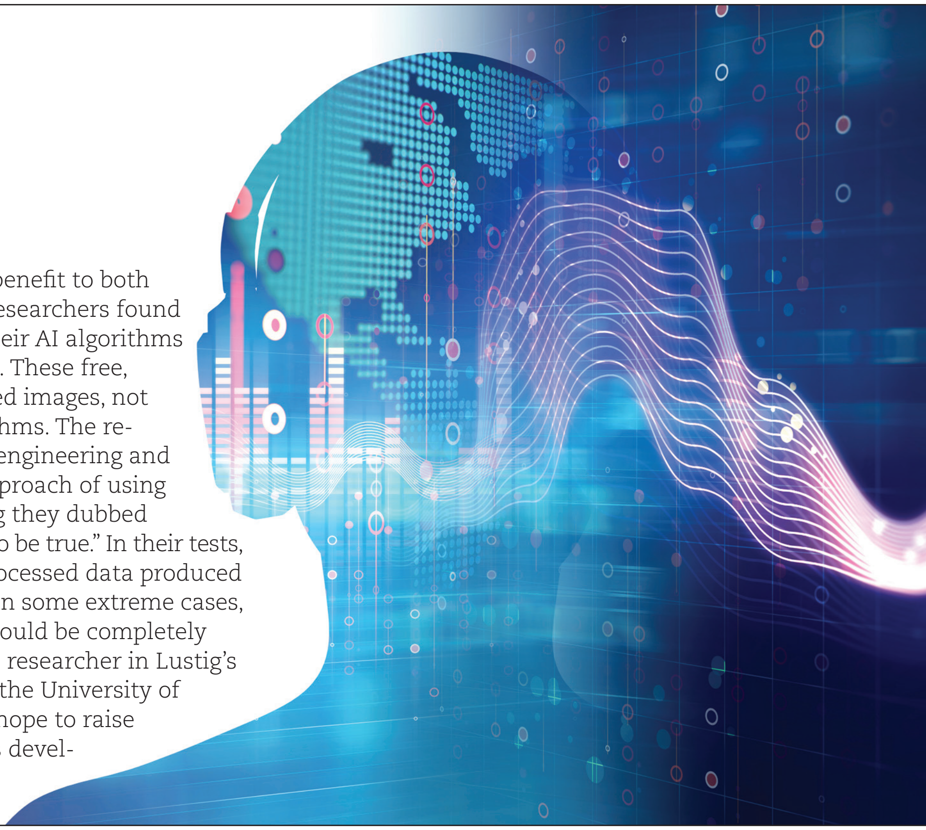
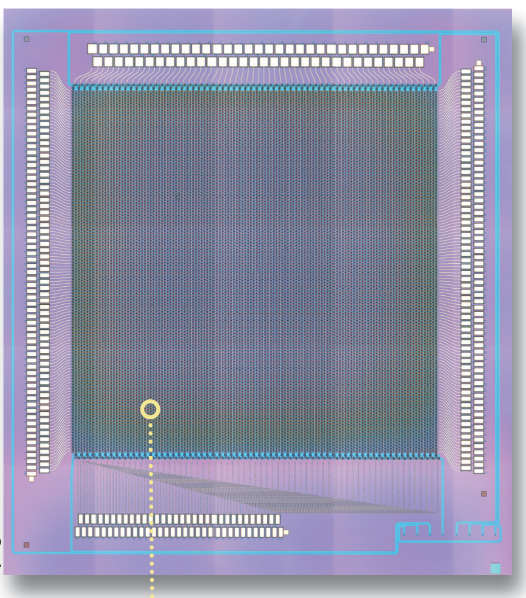


MACHINE LEARNING

Too good to be true

Artificial intelligence could make MRI scans faster — a benefit to both patients and clinicians. But a recent study by Berkeley researchers found that developers may unknowingly introduce bias into their AI algorithms through their "off label" use of medical image databases. These free, online databases often contain compressed, preprocessed images, not the raw scanner data needed to properly train AI algorithms. The researchers, led by **Michael Lustig,** professor of electrical engineering and computer sciences, showed how this mix-and-match approach of using processed and raw files to train algorithms — something they dubbed "implicit data crimes" — yields images that are "too good to be true." In their tests, the researchers found that algorithms pre-trained on processed data produced inaccurate results when handling real-world, raw data. "In some extreme cases, small, clinically important details related to pathology could be completely missing," said lead author **Efrat Shimron,** a postdoctoral researcher in Lustig's lab. The study's authors — including **Jonathan Tamir** of the University of Texas at Austin and Berkeley Ph.D. student **Ke Wang** — hope to raise awareness about these "data crimes" among researchers developing new AI methods for medical imaging.



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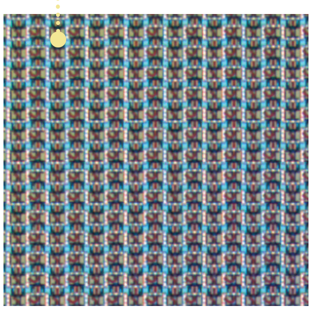


MEMS

Tiny switches

When Google unveiled its first autonomous cars in 2010, the spinning cylinder mounted on the roofs really stood out. It was the vehicle's light detection and ranging (LiDAR) system; together with cameras and radar, LiDAR mapped the environment to help the cars avoid obstacles and drive safely. Since then, inexpensive, chip-based cameras and radar systems have moved into the mainstream for collision avoidance and autonomous highway driving. Yet LiDAR navigation systems remain unwieldy mechanical devices that cost thousands of dollars.

That may be about to change, thanks to a new type of high-resolution LiDAR chip developed by researchers led by **Ming Wu,** professor of electrical engineering and computer sciences. Their LiDAR is based on a focal plane switched array (FPSA), a semiconductor-based matrix of micrometer-scale antennas that gathers light.

Mechanical LiDAR systems have powerful lasers that visualize objects hundreds of yards away, even in the dark. Yet putting these capabilities on a chip has stymied researchers for more than a decade, with the most imposing barrier involving the laser. But the FPSA — consisting of a matrix of tiny optical transmitters, or antennas, and switches that rapidly turn them on and off — can channel all available laser power through a single antenna at a time.

Switching, however, poses problems. Almost all silicon-based LiDAR systems use thermo-optic switches, which are both large and power-hungry. Jam too many onto a chip and they will generate too much heat to operate properly. The team's solution replaces them with microelectromechanical system (MEMS) switches that physically move the waveguides from one position to another. Compared with thermo-optic switches, they are much smaller, use far less power, switch faster and have very low light losses.

The result is 16,384 pixels on a 1-centimeter-square chip — dwarfing the 512 pixels or less found on FPSAs until now. Equally significant, the design is scalable to megapixel sizes using the same complementary metal-oxide-semiconductor (CMOS) technology used to produce computer processors. This could lead to a new generation of powerful, low-cost 3D sensors for autonomous cars as well as for drones, robots and even smartphones.

INNOVATION

Bakar BioEnginuity Hub opens

In November, the Bakar BioEnginuity Hub (BBH) opened on the UC Berkeley campus, providing an innovative space that pairs the Bakar Labs incubator with programming and fellowships for students and researchers. The new state-of-the-art facility equips current and aspiring STEM entrepreneurs with labs, offices, equipment and community areas, creating a place where scientific research and entrepreneurship converge.

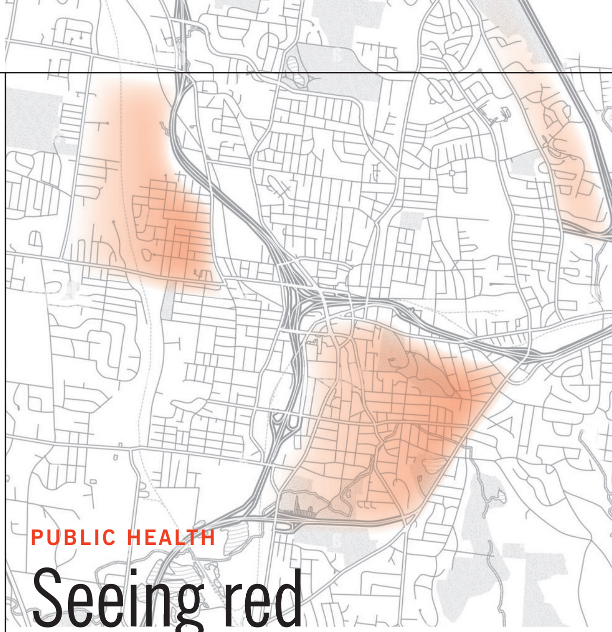
The Bakar Labs incubator, jointly founded by Berkeley and QB3, supports early-stage startups by leasing as little as a single lab bench or half of a freezer shelf. This flexibility enables qualified companies to launch with modest funding. Thirteen startup companies have already moved into the new space, which can ultimately support more than 50 companies.

The Hub is located at 2630 Bancroft Way in the 94,000 square-foot Woo Hon Fai Hall, the former home of the Berkeley Art Museum and the Pacific Film Archive. Built in 1970, the cast concrete structure was originally designed by Mario Ciampi in the Brutalist architecture style. The building was declared a City of Berkeley landmark in 2012 and is also listed on the National Register of Historic Places. A two-year structural retrofit of the building was headed by a team of Berkeley alumni from Forell/Elsesser Structural Engineers.

Brittany Hosea-Small

"BBH recasts an architectural landmark into a world-class innovation space and incubator for life science."

—**DAVID SCHAFFER,** BBH EXECUTIVE DIRECTOR AND PROFESSOR OF BIOENGINEERING, OF CHEMICAL AND BIOMOLECULAR ENGINEERING AND OF MOLECULAR AND CELL BIOLOGY



PUBLIC HEALTH

Seeing red

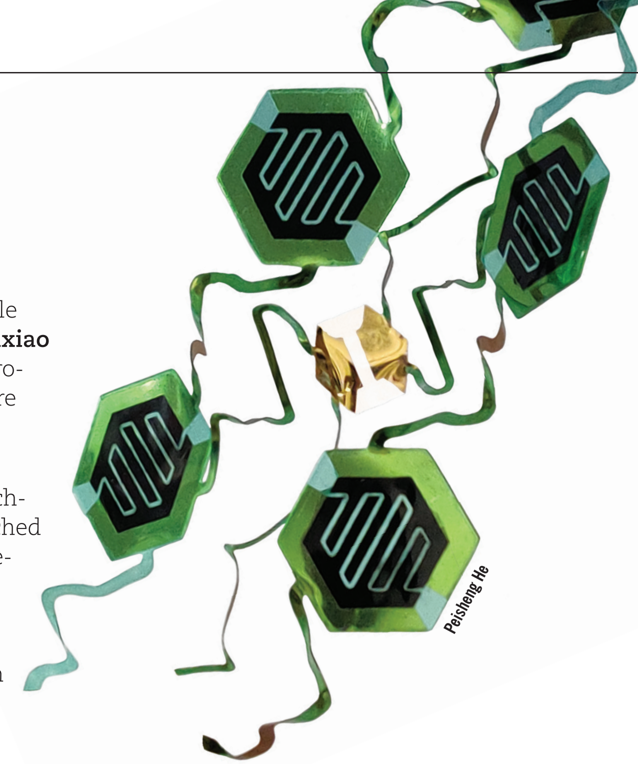
Redlining — a federally-backed, discriminatory mortgage appraisal practice dating to the 1930s — was a widespread policy that deemed certain areas as hazardous and excessively risky for investment if they included high concentrations of Black, Asian, immigrant or working-class residents. This designation blocked access to favorable lending and other services.

A new study has now found a strong association between present-day air pollution levels and historical patterns of redlining. Looking at year-2010 levels of two regulated air pollutants — nitrogen dioxide (NO_2) and fine particulate matter ($PM_{2.5}$) — in 202 U.S. cities, the study's researchers found that areas that were redlined in the 1930s consistently had higher levels of pollution today than those areas that received favorable treatment. Strikingly, air pollution disparities associated with historical redlining status in these cities were even larger than those associated with race and ethnicity.

The paper also found racial disparities within redlined neighborhoods, suggesting that housing discrimination is one of many factors propelling environmental racism. In other words, white people who happen to live in redlined neighborhoods still have lower air pollution exposure than people of color in that same community. That trend held across non-redlined and redlined neighborhoods alike.

"Redlining is a good predictor of air pollution disparities, but it's only one of the things that drive the racial and ethnic disparities in air pollution," said senior author **Joshua Apte,** assistant professor of civil and environmental engineering and of public health. "It's not the only source of disparity that we ought to be concerned about."

Haley Lane, Ph.D. student in civil and environmental engineering, was the study's first author; **Rachel Morello-Frosch,** professor of environmental science, policy and management, and **Julian Marshall** of the University of Washington were co-authors.



Peisheng He

SENSORS

Making the cut

Wearable sensors are often used by researchers to gather medical data from patients over extended periods of time. They range from adhesive bandages on skin to stretchable implants on organs, and they harness sophisticated sensors to monitor health or diagnose illnesses.

In the past, researchers have built systems for these devices using photolithography, a multistep process that uses light to create patterns on semiconductor wafers. But making wearable sensors this way requires a clean room and sophisticated equipment. Now, Berkeley engineers have developed a new technique for making wearable sensors that is simpler, faster and more economical, especially when making the one or two dozen samples that medical researchers typically need for testing.

This new technique replaces photolithography with a $200 vinyl cutter. The novel approach slashes the time to make small batches of sensors by nearly 90% while cutting costs by almost 75%, said **Renxiao Xu** (Ph.D.'20 ME). Xu and **Liwei Lin,** professor of mechanical engineering, were the study's lead researchers.

To demonstrate the technique, the researchers developed a variety of stretchable elements and sensors. They attached an adhesive sheet of polyethylene terephthalate to a Mylar substrate, used a vinyl cutter to shape the surface, and attached sensor elements and other components to the contact pads. Then they used the vinyl cutter to carve the sensor's contours, including spirals, zigzags and other features.

"Most researchers working on medical devices have no background in photolithography," Xu said. "Our method makes it easy and inexpensive for them to change their sensor design on a computer and then send the file to the vinyl cutter to make."

The researchers believe this technique could one day become a standard feature in every lab studying wearable sensors or new diseases. Prototypes could be designed using high-powered computer-aided design (CAD) software or simpler apps made especially for vinyl printers.

ENVIRONMENT

Tracking smoke

Courtesy the researchers

During the 2018 Camp Fire, **Tina Katopodes Chow,** professor of civil and environmental engineering, went looking for information on when the smoke might clear from the San Francisco Bay Area — more than 100 miles away from the wildfire raging in Butte County, California. What she found was a new experimental tool from the National Oceanic and Atmospheric Administration (NOAA) Global Systems Laboratory. Known as HRRR-Smoke, it is the only real-time 3D high-resolution U.S. weather forecasting model that predicts the movement and concentration of smoke. Using data collected by weather satellites, such as the radiative energy from a fire, the model estimates the amount of smoke emitted; it then computes wind speed and direction to predict the smoke plume's trajectory, density and impact on weather and visibility.

After noticing some inaccuracies, Chow contacted the developers and offered to help test the model. Her team's analysis found that HRRR-Smoke successfully forecast the general movement and concentration of the smoke plume, especially given the complex terrain and wind conditions. But it also identified aspects of the model that could be improved — such as how the arrival of smoke in the Bay Area as predicted by the model was delayed. Including high-frequency fire detections from geostationary satellites would help fires be detected more rapidly in the model, said **Katelyn Yu,** Ph.D. student and co-author of the study.

On some days, the model underpredicted the concentration of air pollution by 70%; the researchers believe that the smoke plume itself may be the cause of this error because the thick smoke blocked the satellites' view of the fire. "To complement the satellite detections, we need to assimilate additional datasets into our smoke forecast models, for example the ground-based $PM_{2.5}$ measurements," said Chow, noting that NOAA researchers are continuing to improve the HRRR-Smoke model, which became operational in 2020.

Q+A on wastewater testing

Ivan Bandura/Unsplash

Since early on in the COVID-19 pandemic, civil and environmental engineering professor **Kara Nelson** and assistant research engineer **Rose Kantor** (Ph.D.'16 Microbiology) have led a campus effort to test wastewater samples from across the Bay Area for the SARS-CoV-2 virus. Their team not only developed a novel method to detect the virus, but also worked closely with wastewater agencies and public health departments to monitor samples for infection levels and the presence of new variants. Next up: improving pandemic preparedness and health equity through wastewater-based epidemiology, thanks to a new multimillion-dollar research grant from the University of California.

Why wastewater?

RK: People have used wastewater to track down typhoid and polio, but it was never applied widescale. Fast forward to this pandemic, it became apparent early on that it could be a useful tool because of some of the aspects of COVID-19, including a lot of asymptomatic cases and the lack of availability of clinical testing.

KN: One of the amazing benefits is that, from a single sample, we can get information on thousands to millions of people. It's efficient, convenient and non-invasive — and it's not biased by who is able to get tested. There has been concern among public health agencies that they're missing cases, so our data is complementary to the clinical data that helps authorities make important decisions.

What were some of the biggest challenges?

KN: When the pandemic started, many of my graduate students and postdocs pivoted away from their regular research to work on this, and then students from other disciplines joined our team. But even though my group had experience measuring pathogens in wastewater, we had never looked for SARS-CoV-2. The virus is different than the viruses we were used to because of its structure, so we had to develop new approaches to detect it.

RK: On top of that, everything had shut down, and there were supply chain issues. We needed a method that was really sensitive but also readily available. We overcame a lot of barriers by working with a student who had proposed a novel method. So by using table salt, ethanol and a silica-based column, we found something that was sensitive, fast and safe — and didn't require materials that were hard to get, which ultimately made it cheaper.

How does your partnership with public agencies work?

KN: In early 2020, I was contacted by our local water agencies to ask if we could partner together to do this. They were eager to support the pandemic response and began collecting samples for us. We process the samples and provide results. As part of our routine analysis, we also test for variants of concern, like Omicron, which we were able to track before it was seen in clinical samples. Our results are posted to a public dashboard, and we have a website with information for our public health partners. We also provide the information to the California Department of Public Health. We now have funding to transition the routine monitoring to the state. We are close to finishing that transition, and the state will take on wastewater monitoring as part of their long-term public health surveillance.

What's next for wastewater testing? Where might we see innovation?

KN: The holy grail is an untargeted method: being able to analyze each wastewater sample and use sequencing approaches to identify all of the viruses that are present without knowing what they are. That's the tool that we need to have to detect the arrival of a new virus. A large emphasis of this new grant is developing untargeted detection methods that we can use for detecting the next pandemic virus and get early warning. The other areas that we are emphasizing is how to better understand the health disparities that exist and plan for how to minimize them in the future.

RK: I think we'll continue monitoring wastewater for Covid-19 and for new strains, including those that might be missed by clinical testing. But we'll also see a new focus on health equity and on using wastewater testing to monitor public health in a more unbiased fashion than previously, when we relied on the access to healthcare. I'm excited to see how wastewater testing can be used with other public health data to focus resources where they're most needed.

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

Meet our new Engineering Student Center

On the horizon: our new Engineering Student Center, which will transform the student experience with cross-campus collaboration, innovation and entrepreneurship. Its four floors of dedicated student space will create an environment of inspiration for the visionary ideas that will help transform our world.

Encasing the existing Bechtel Engineering Center and overlooking Memorial Glade, the new building will add 35,500 square feet across two new floors. Groundbreaking is slated for 2023; doors will open in early 2025. The $95 million cost will be funded entirely by philanthropy, and more than three-quarters of this figure has been raised to date.

A new challenge grant was launched this spring that will match five commitments of $1 million. To learn more about this transformative project and how you can support it, please contact **Jasmine Payne** at: jpayne@berkeley.edu.

See more: https://engineering.berkeley.edu/studentcenter

The Terrace
A wrap-around terrace on the third floor offers outdoor gathering space, as well as direct views to the Campanile, Memorial Glade and the University Library.

The Forum
Three floors will provide an active hub for collaboration and connection, with visible and open space that welcomes everyone.

Room to grow

With planning for new programs and majors underway, space for future needs is crucial.

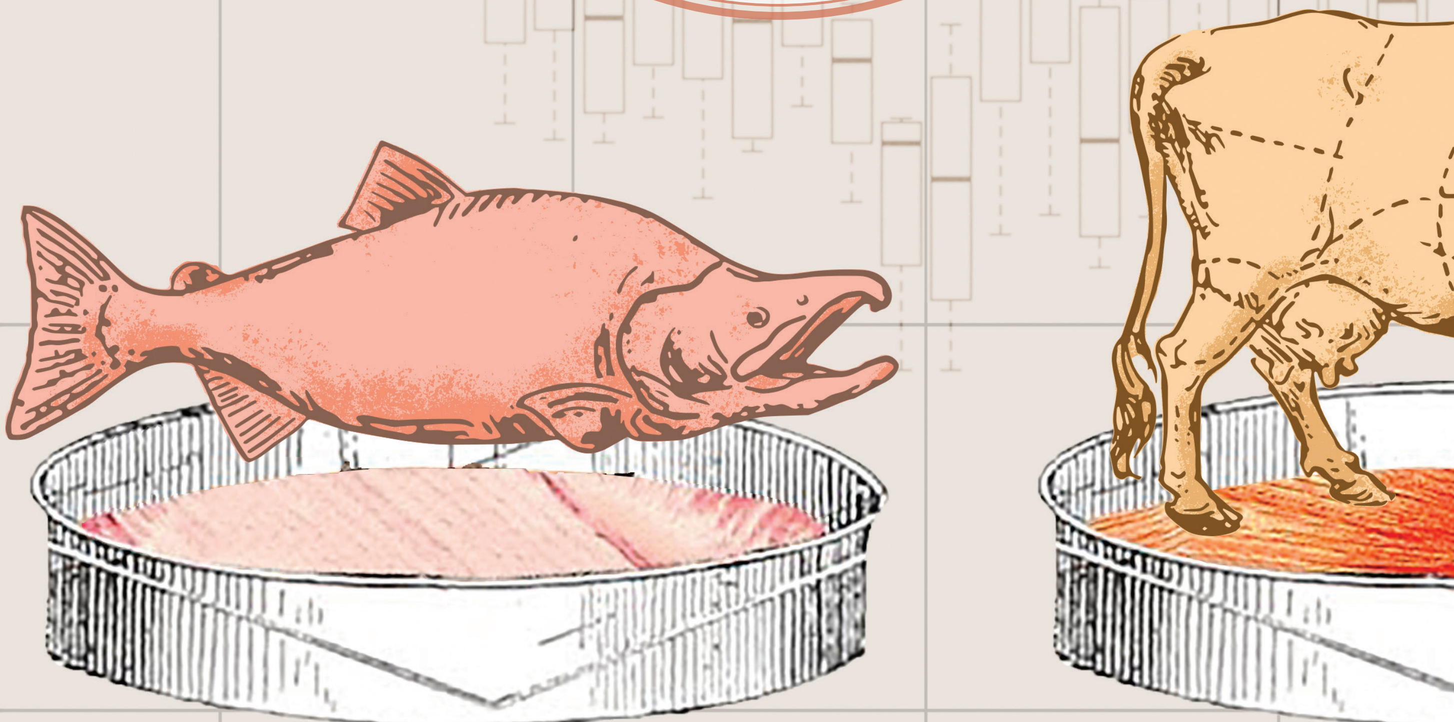
Inclusive excellence

Programs will include Girls in Engineering, K-12 outreach, faculty diversity and engagement.

Engineering Student Services

Expanded space for advising, counseling, tutoring, workshops, mentoring, leadership, PREP/T-PREP and more.

THE FUTURE OF MEAT



THE ALT: MEAT LAB BRINGS PLANT-BASED PROTEINS

STORY BY ANDREW FAUGHT
ILLUSTRATIONS BY ADAM LAU

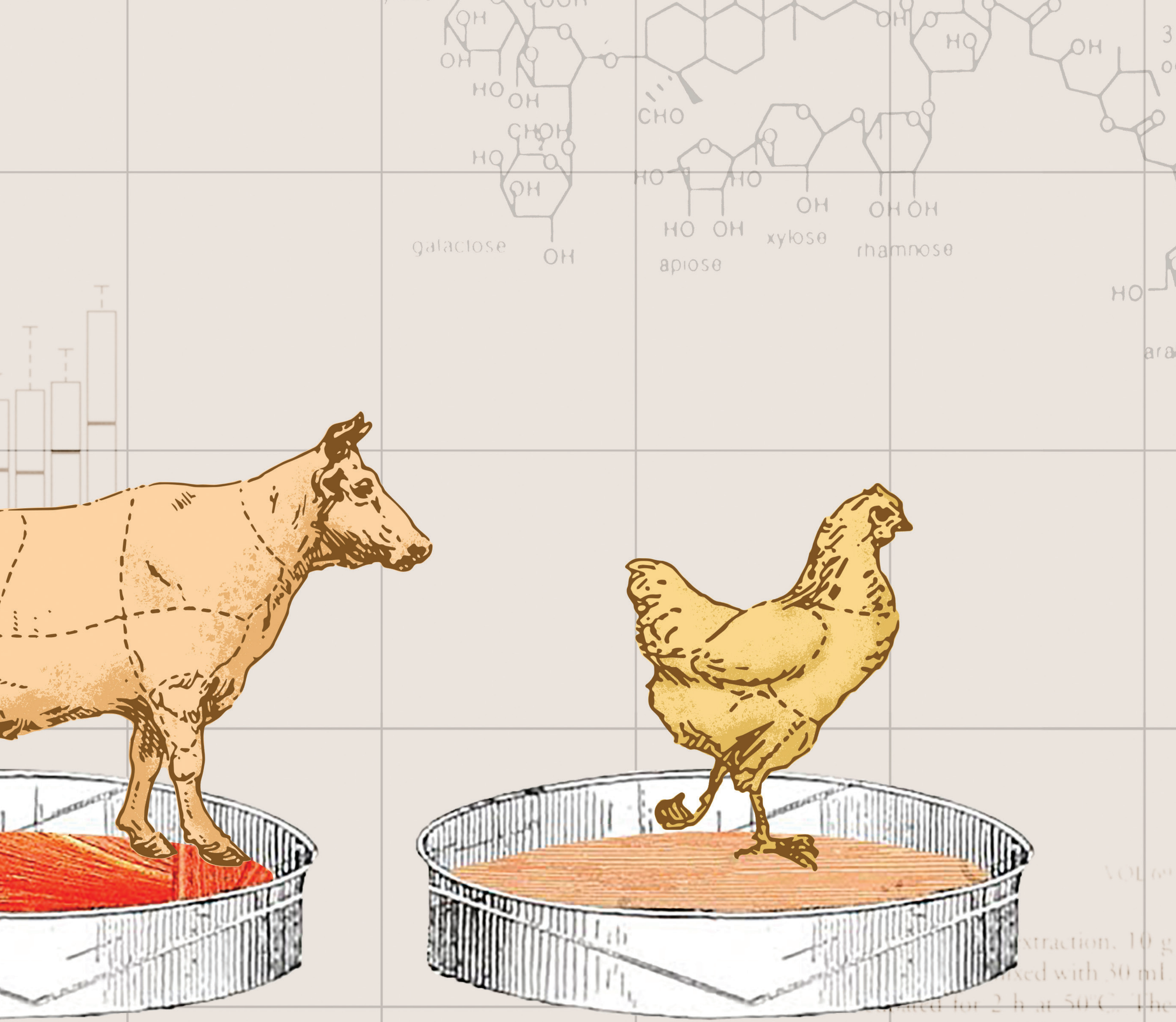
At the start of each semester, research director Ricardo San Martin of Berkeley Engineering's Alt: Meat Lab poses a fundamental question to his 40 students, two-thirds of whom are undergraduates majoring in one of the sciences: "Why are you here?"

It's a clarifying query for San Martin, who founded the lab in 2017. Five years later, at a time when plant-based meat substitutes ranging from hamburger patties to faux tofurky have helped carve out a rapidly growing share of the American meat industry, understanding student motivations is as important as divining alt meat consumer habits.

The students answer in near unanimity.

"It's not so much veganism or animal welfare," San Martin notes, "but sustainability."

Students come into the program aware of the urgency to develop food innovations and protein alternatives. The United Nations reports that the meat production emits "significant" amounts of greenhouse gases that contribute to deforestation, water stress, environmental degradation and coastal dead zones.



FROM THE CLASSROOM TO THE MARKET

The impact on the environment helps explain the program's esteem among students and the food industry alike. The lab's core tenets in addition to sustainability — affordability, minimal processing and a sensitivity to cultural fare — resonate with students' values, and the food industry has latched onto sustainability to whip up fortunes in alternative proteins.

It makes the Alt: Meat Lab, housed at Berkeley Engineering's Sutardja Center for Entrepreneurship & Technology, one of a kind in the United States and beyond. It's the only food science program anywhere, San Martin says, to pair scientific innovation with entrepreneurship through classroom instruction and novel collaborations with industry.

As the lab gets underway, students are organized into 10 four-member teams. They take on challenges from food behemoths such as Nestlé, which has at times puzzled over the texture of some of its plant-based meats. Another business, Miyoko's Creamery in Sonoma, asked students to improve their fermentation processes for its nut-based "cheese."

"Every semester before we start, we ask the companies, 'What challenges would you like the students to tackle?'" says San Martin, who teaches a course called Product Design of Plant-Based Foods. "The topic has to be entrepreneurial, like it has to lead to a real startup. It has to be very specific, and that's where the action starts."

Other projects, those created by students and that are not tethered to a business, are limited only by team members' imaginations. Projects need not focus on alt meat, but on any alternative to animal-derived food, including dairy, eggs and fish. In February, one team proposed using rejected and wasted fruits and vegetables to create "ugly milk"; another team presented research on developing an egg alternative using atypical protein sources such as fava, chickpeas, quinoa, potatoes and oats.

San Martin calls the lab rigorous and students "very motivated." Of the 10 teams, two on average launch their own businesses, with entrepreneurs often hiring classmates. Still others go on to complete internships with industry leaders, such as Beyond Meat and Impossible Foods, before taking full-time work with the companies.

Into the marketplace

The alternative protein market continues to surge. By 2035, it is forecast to be a $290 billion global industry, with one in 10 meals around the world expected to be made from alternative proteins, according to the Boston Consulting Group.

Entrepreneurs include Kimberlie Le, co-founder (with classmate Josh Nixon) and CEO of Berkeley-based Prime Roots. The pair use koji, a Japanese fungus, to create ham, turkey and bacon. In February, the company introduced its new alt meat line of pates, pepperoni and foie gras. Le started developing her company as a member of the Alt: Meat Lab's inaugural class.

It was during her time in the lab that she started working with the thready fungus to replicate meat. ("It was a lot of throwing stuff against the wall for a long time," she says.) Koji only takes two to three days to grow and produces no byproducts. Other plant proteins — such as soy, pea and gluten — must be isolated, modified and processed to approximate meat.

Le still proclaims herself a "proud meat eater." She studied microbiology at Berkeley, where she first learned of the climate perils wrought by meat production. The lab allowed her to pull all of her expertise together "to find a solution that will benefit humanity as a whole."

"I call myself a flexitarian, which is a growing movement of people who are trying to eat more sustainably and make options as we see fit," says Le, whose mother is a professional chef in Canada. "I love food through and through, and that's really what got me thinking about how it can help to solve a lot of the large climate and sustainability challenges that we have."

Another entrepreneur to come through the Alt: Meat Lab is Jessica Schwabach, co-founder (with labmate Siwen Deng) of Albany, California-based Sundial Foods. The company makes vegan chicken wings, complete with plant-based skin, muscle and bone. The wings are expected to be available in U.S. restaurants sometime this spring.

Sundial uses proprietary technology to simulate a whole piece of chicken. It's made of eight ingredients, including water, chickpeas and sunflower oil. The company has raised $4.25 million to date from investors that include Nestlé, Food Labs and Clear Current Capital.

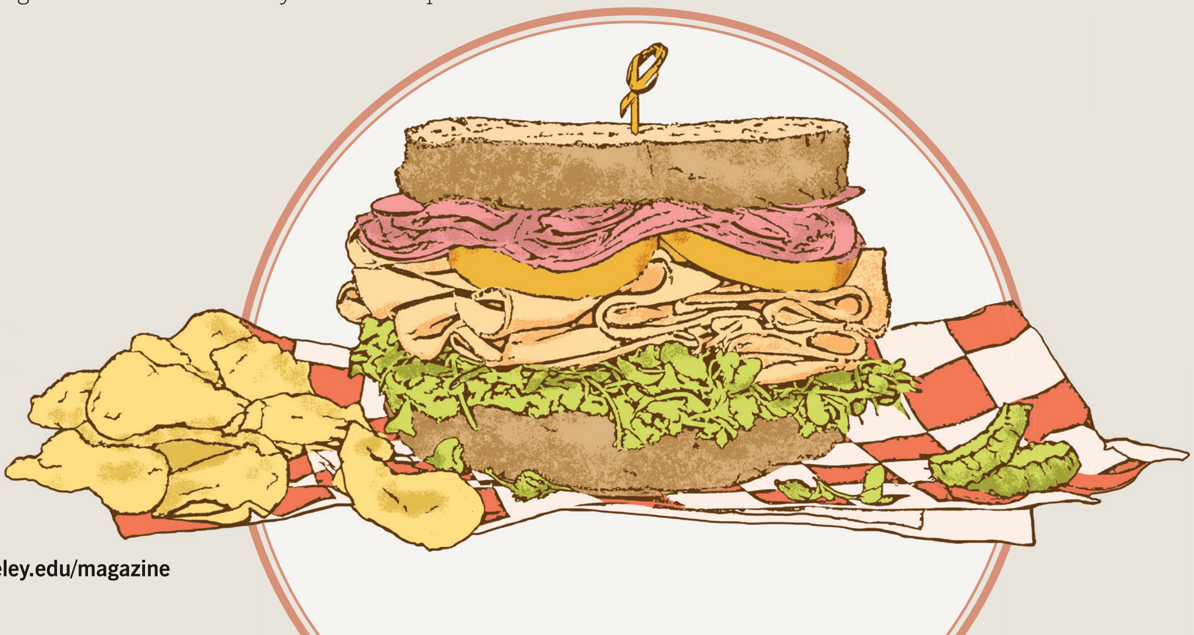
Schwabach enrolled at Berkeley as a pre-med major, becoming a vegan her freshman year "because it was a very Berkeley thing to do, I suppose." She enrolled in the lab for fun, and then quickly became enthused at the entrepreneurial possibilities after working with San Martin.

"From the very first day, he brought in industry representatives to speak to the class from all angles," Schwabach says. "He brought in protein specialists and flavor scientists to talk about the different aspects of formulating plant-based meat products. And he brought in people from the business and entrepreneurial side, who taught us how we could build a financial model for a startup. This wasn't just a class where we were going to learn theoretical things. It was very applied."

An uncommon approach

The lab started in 2017, not as a whole-cloth program, but as a course: the Alt: Meat Challenge Lab, designed to consider alternative proteins, with students doing much of their experimentation at home. There was no funding and no ties to food companies. The Sutardja Center's mission is to explore topics that can be relevant to society, and plant-based meats were making regular headlines. Ikhlaq Sidhu, the center's chief scientist and faculty director, approached San Martin, whose background is in chemical engineering biotechnology, about expanding the course into something more.

"There were no alt meat labs anywhere, so I said yes, and it was a good decision," San Martin says. "Companies were very attracted to the quality of the students, their ideas and their enthusiasm."



Dollars have followed. The Open Philanthropy foundation recently donated $1.1 million to cover the 2022–23 academic year. The state of California threw in $1 million from its most recent budget. What the future holds for the lab is anybody's guess. These days, alt meat producers are confined to 10 or so raw materials — each limited to conversion into alt meat by their own biological structures. But farmers could turn up new ingredients if they make economic sense, according to San Martin.

Students typically take two semester-long courses through the lab, which for the moment is borrowed space in the chemical engineering department; San Martin says funding will allow him to open dedicated research facilities later this year. The center also works closely with industry experts, entrepreneurs and investors, who give lectures as well as provide direct feedback on projects.

Students who take at least three classes from the Sutardja Center earn a certificate in entrepreneurship and innovation. While there are other programs in the country researching plant-based foods, they focus only on science and don't offer students business perspectives, such as the cost scalability of bringing a product to market.

The Berkeley program isn't just preeminent in the United States. Plant-based programs in Europe also hew solely to food science, and they aren't known for creating new spaces within the industry, San Martin says.

Weird science

The research facilities have been closed due to COVID-19, but there are hopes they will reopen in coming months. In the meantime, students have been working on their experiments, or prototypes, in their kitchens or dorm rooms, reporting findings via Zoom. The pace is frenetic: students present results to investors and industry leaders four times per semester.

Behind-the-scenes experiments might be construed as weird science. Students use specialized machines to check the texture and "flowability" of their alt meats and other creations. They make and test emulsions needed to incorporate fats into plant-based foods. They analyze physical properties. Are their meat creations too elastic, like chewing gum? Or, conversely, crunchy like a protein bar?

Some lab participants aren't willing to let machinery have the final say.

"There are always a couple of guys who can eat anything," San Martin says. "They smell it and taste it and say, 'oh, yummy.' It's a very subjective appreciation."

Not all of them are science majors; each team usually includes a business student. This year's crop of students includes a design major and a sociology major. "We always have room for a nonscientist," San Martin says.

"The only agenda we have is with plants and helping with food sustainability," he says. "And because of that, we try to instill in our students a critical understanding of the space: Is it environmentally friendly? And is it as healthy as the companies say, or is it just marketing, and can we do better?"

Creating plant-based foods isn't without seemingly intractable challenges. Meats have varying fiber structures, while plants do not share a like biological diversity. "There are limits on how much you can process stuff to look like other stuff," San Martin says.

There also are wild cards at play. Plants, to protect themselves from insects, develop substances known as secondary metabolites, organic molecules that serve no purpose when it comes to growth, development and reproduction. But they do serve one critical function: to give off a foul astringency, the kind of bitterness to keep bugs — and, by extension, humans — far away.

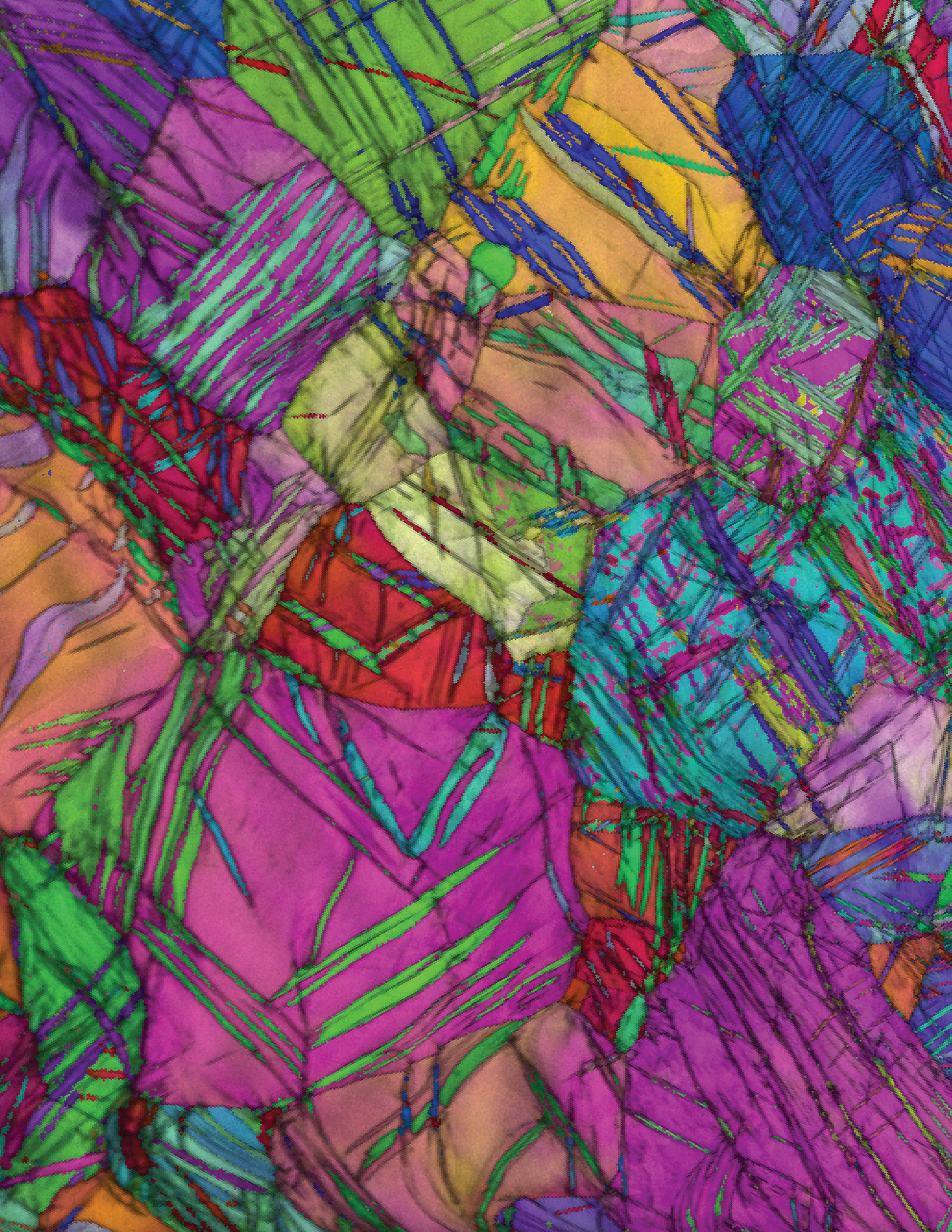
San Martin describes his role as that of mentor. He works with Alt: Meat Lab co-director Celia Homyak, who most recently led a research team at Ripple Foods, a Berkeley food and beverage company. There, she worked on plant-based food innovation and managed collaborations with universities and industry partners.

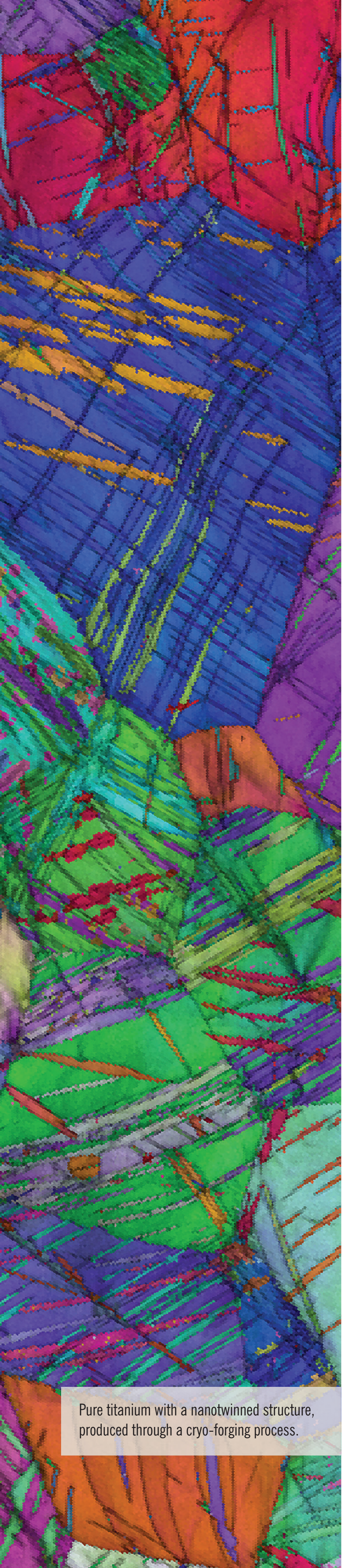
At the lab, she is helping to create additional coursework in plant-based food and ingredient technology and in plant-based food entrepreneurship.

"The alt protein space is relatively new, making the candidate pool for these companies quite small," Homyak says. "Businesses are typically looking for people with a proven ability and desire to solve new challenges. We have gotten direct feedback from our partners saying they greatly appreciate how our students have a more technical mindset tackling new alt protein challenges, while still presenting themselves as entrepreneurs."

San Martin, meanwhile, compares the lab's role in the rise of the alt meat industry to the advent of the personal computer. Apple founder Steve Jobs "wasn't an MBA guy," in the same way that his students aren't business mavens.

"Although our program touches on business, it's not a business approach," he says. "It's more about understanding the science behind the solution that you're coming up with, and then teaching them how that can be profitable going forward." BE





Pure titanium with a nanotwinned structure, produced through a cryo-forging process.

Andrew Minor

A NEW TIME FOR TITANIUM

STORY BY WILLIAM SCHULZ

Among metals, titanium's strength and lightness, corrosion resistance and ability to withstand extreme temperatures have long distinguished its value, particularly for weight- and environment-sensitive applications. When it was first described in the late 18th century, a co-discoverer named the metal for the Titans — gods born of Earth and sky in ancient Greek mythology.

Time has only burnished titanium's luster. "I'm a materials scientist, and so people sometimes ask me, 'what's your favorite element?'" says Andrew Minor, professor of materials science and engineering. For buildings, airplanes, missiles, spaceships and more, he says, "if you want the strongest material for the least amount of weight, it's titanium. If we could, we would make everything out of titanium."

Indeed, for industrial designers, the prospect of strong, lightweight, highly fuel-efficient cars, trucks and airplanes, for example, or super corrosion-resistant cargo ships, titanium must be the stuff of dreams.

The problem? "It's too expensive," Minor says of industrial-grade titanium or titanium alloys that might otherwise replace steel when only the strongest, most durable materials will suffice. In fact, the cost of making titanium is about six times greater than that of stainless steel. As a result, its uses have remained limited to specialty parts for aerospace, high-end items like jewelry or other niche applications.

What's more, pure titanium has only moderate strength, Minor explains. It can be strengthened with elements like oxygen, aluminum, molybdenum, vanadium and zirconium; however, that is often at the expense of ductility — a metal's ability to be drawn or deformed without fracturing.

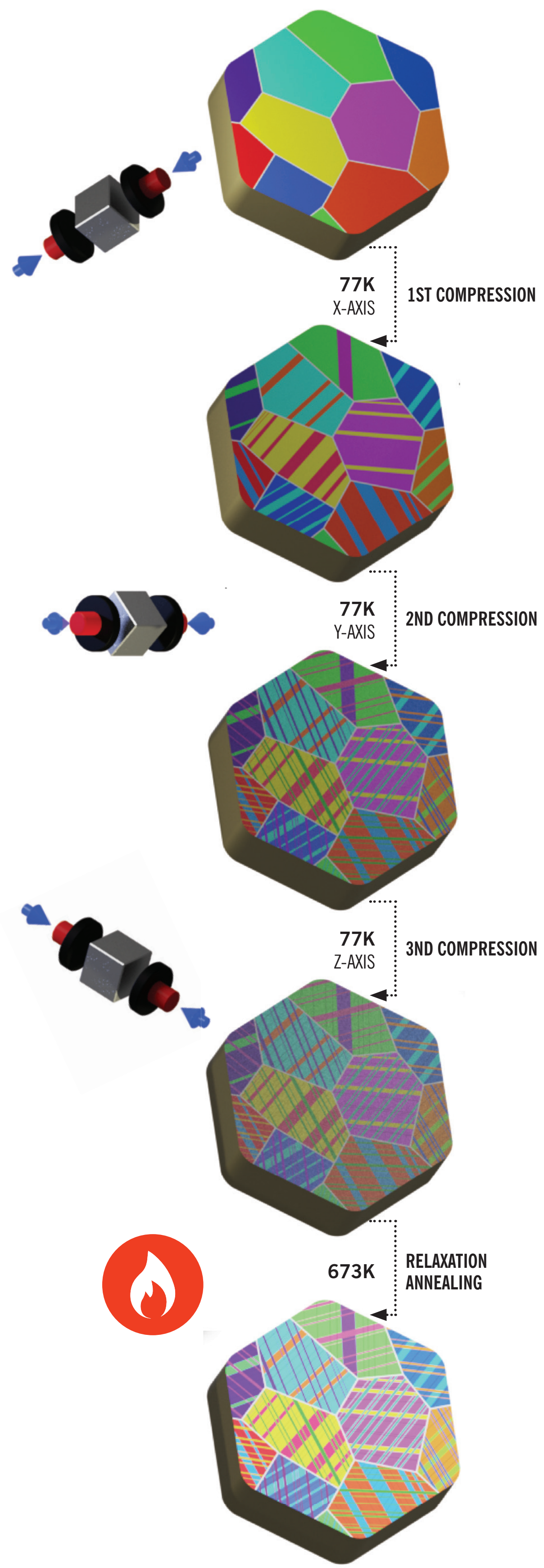
Now, after a decade of research, a new era for titanium, including greatly expanded engineering applications, may be approaching, thanks to Minor and his Berkeley colleagues, including Mark Asta, Daryl Chrzan and J.W. Morris Jr., also professors in the Department of Materials Science and Engineering. They've been probing and prodding titanium in any number of ways in hopes of expanding its practical use for a variety of structural or engineering applications.

In a series of studies, the researchers have developed critical new insights about titanium, including recipes for making better titanium alloys as well as a cryo-forged technique for making industrial-grade titanium — advances that could ultimately lead to more cost-efficient and sustainable manufacturing.

THE OXYGEN CONUNDRUM

It's important to understand that the cost of titanium is not due to its rarity. Titanium is not a precious metal; rather, it is found almost everywhere around the world, in igneous rocks near the surface. It's Earth's ninth most abundant element and fourth most abundant metal, and it can be used to make things both in its pure form or as an alloy.

Instead, what drives the excessive cost of commercial-grade titanium, Minor explains, is the complex Kroll process most often used



A schematic drawing of the cryo-mechanical process that results in nanotwinned titanium.

IMAGE: ANDREW MINOR

to make titanium bars, ingots and other forms of the metal that can be fabricated into useable parts and other products. The process includes the use of expensive materials like argon gas, and it is energy intensive, requiring multiple melts at extremely high temperatures, especially to control oxygen impurities.

Indeed, titanium and oxygen have a puzzling relationship, one that Minor, Asta, Chrzan, Morris and colleagues have wanted to understand better. The team knew that an oxygen impurity is often used for titanium alloys to harness a potent strengthening effect. Titanium made with just a tiny increase in the amount of atomic oxygen can result in a metal with a several-fold increase in strength.

Unfortunately, the oxygen can also yield an even larger decrease in the metal's ductility. It becomes brittle and will fracture and break.

But "oxygen is everywhere," Minor says of the difficulty in maneuvering around titanium's high responsiveness to oxygen. "It's not some impurity coming from the source material that you can just avoid."

He characterizes titanium's sensitivity to oxygen as extreme. "It's truly strange how powerful it is," Minor says. It exerts effects on the metal, both good and bad, whereas the presence of similar amounts of oxygen are insignificant for metals like aluminum and steel because it can be dealt with in processing much more easily.

To learn more, the team turned to high-performance computing to model the deformation process in titanium under stress and with differing amounts of oxygen. Computer models, Asta says, are a "powerful set of tools that let us investigate this outstanding challenge in titanium metallurgy."

Of the team's major discoveries, a shuffling of oxygen atoms in titanium's crystal structure when the metal is under stress, became key to understanding the loss of ductility. In a non-stressed state, oxygen molecules reside without incident in natural gaps between atoms of titanium. But under mechanical forces, the oxygen atoms can shuffle to adjacent spaces where they provide less resistance to dislocations that, if they spread, weaken the metal.

"The oxygen promotes a structural weakness," says Minor. As mechanical forces deform the metal, the displaced oxygen atoms, rather than blocking the spread of structural defects, can facilitate a so-called planar slip.

A planar slip, Asta says, is like a ripple of defects in the metal's crystal structure that build one on the other, eventually leading to fractures, cracks and a brittle piece of metal.

To understand how a dislocation can form and spread in titanium, Chrzan suggests visualizing trying to move a large, heavy rug.

"A very large rug can be picked up at one end and dragged across the floor to a new position," he says. But another way to move the rug is to create a ripple at one end and then, by shuffling your feet across the top of the carpet, you can "walk" the ripple to the other end. Provided nothing blocks its movement, the entire rug will have been displaced by a distance equal to the width of the ripple.

Such "ripples" in titanium can be seen with electron microscopy. "You can see all the dislocations are lined up, in rows," Minor says. "And that's bad for ductility because if they line up and only follow each other, they don't get tangled up [and thus stopped] such that the metal doesn't work harden. You get a stress concentration, and that's where you get a crack."

CREATING BETTER ALLOYS

Design strategies that interrupt the oxygen-atom shuffling process or promote nanostructures to stop planar slips from piling up could lead to better alloys. These alloys would have applications especially in the automotive and aerospace industries, Minor says.

To address these and other issues, the team relies on a mix of computer modeling, transmission electron microscopy (TEM) and other imaging modalities, and experiments.

"One of the things that's been really nice about this project is that sometimes the computationalists and theorists are out a little bit ahead, and other times it's the experimentalists," Asta says. "We meet frequently and talk about our findings and our new ideas."

The team's study of titanium's oxygen sensitivity, for example, led to a study of titanium alloyed with aluminum and oxygen. They found that oxygen embrittlement could be eliminated by adding small amounts of aluminum, especially at cryogenic temperatures, which are below -150 degrees Celsius.

With just the right amounts of aluminum and oxygen, the team says, a new ordering of the titanium crystal structure prevented a shuffling of oxygen atoms that would lead to a damaging pileup of dislocations and ultimately fractures. What's more, because the introduction of aluminum reduced the oxygen sensitivity of titanium overall, processing costs to create a useable metal would also be reduced.

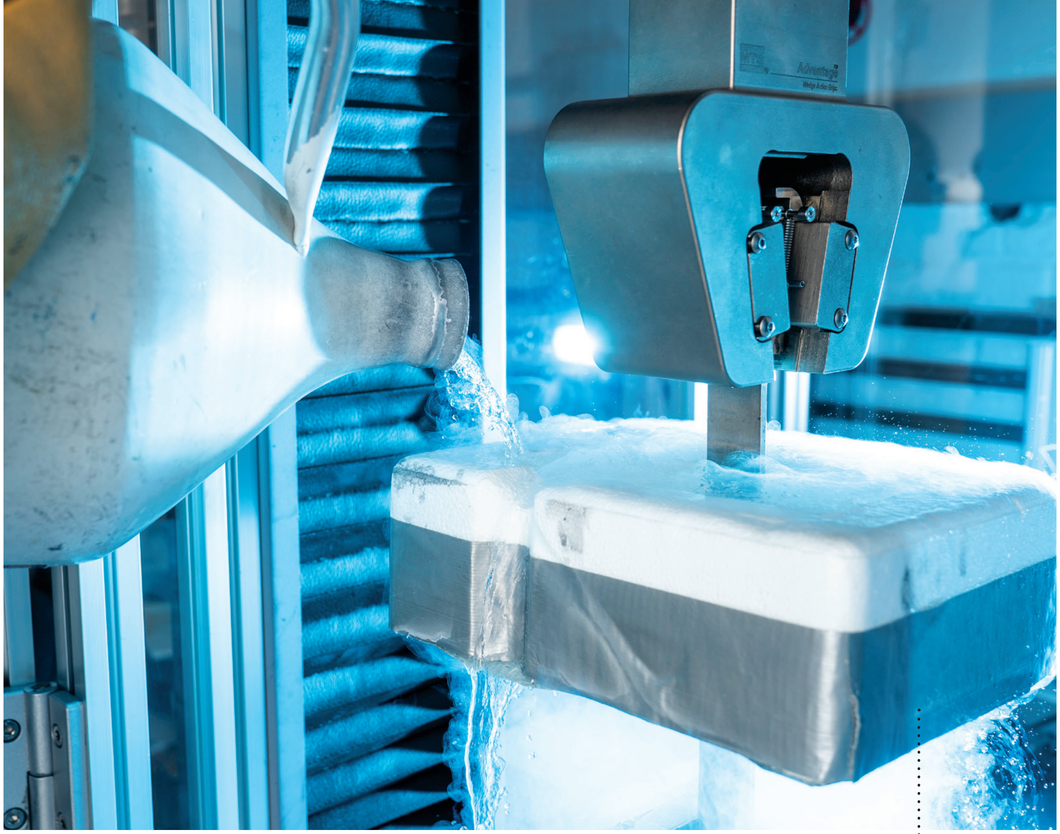
In yet another study, the team looked at research going back to the 1960s showing that many metals and alloys display dramatic increases in ductility when subjected to periodic electrical pulses during deformation of the metal. But the underlying mechanisms on why this so-called electroplasticity might be true are not clear.

"Electroplasticity can lead to reduced costs for metallurgical processing, since it takes less energy to form metal with electrical pulses than heating the entire metal up to a high temperature to achieve the same formability," Minor says. "Interestingly, this effect of electroplasticity is universal in that it has been shown to work for essentially every metal, not just titanium."

The team performed tensile tests of the metal under three different conditions: room temperature with no electric current, with a periodic electrical pulse of 100 milliseconds duration and with constant current. Because applying electric current heats the metal, the team was worried about distinguishing the effects caused solely by electricity from those caused by heat.

Their results showed that, despite using a smaller periodic pulse than previous studies, the pulsed-current method improved tensile elongation of the titanium alloy as well as its maximum strength. They note that this effect was specific only to the pulsed-current experiment.

With the aid of TEM to see changes in the metal's crystal structure, their results suggest that the pulsed-current treatment suppresses planar slip dislocations. The researchers found that the electrical pulse hardens the material and frustrates development of planar slip by maintaining a diffuse, 3D dislocation pattern that ultimately delivers high strength and ductility.



Adam Lau

Cryo-forging nanotwinned titanium

NANOTWINNED TITANIUM

Most recently, Minor and Robert Ritchie, professor of materials science and of mechanical engineering, developed a pioneering bulk processing method to make pure titanium that is less expensive and yields a metal with greater tensile strength and ductility.

Aside from alloys, another way to strengthen structural metals is to tailor the size of crystals — also known as grain — that make up the metal by using heat and mechanical processing, such as rolling or pressing. By reducing the grain size to sub-micrometers or nanometers, researchers can introduce so-called nanotwinned structures, or defects in the metal caused by aligned crystal structures. The nanotwinned structures improve strength and lower the risk of fracture by acting as a barrier to planar slips. By tailoring the spacing and orientation of the nanotwinned structures, Minor says, the mechanical properties can be optimized even further. But traditional methods of doing so are neither trivial nor cheap.

Instead, Minor, Ritchie and colleagues introduced multiple nanotwinned structures in pure titanium by means of a cryo-mechanical process. They used cube-shaped pieces of titanium that were pressed along three sides in liquid nitrogen. The gentle compression, Minor says, controls the density of nanotwinned structures that strengthen the metal while preserving its initial grain structure. Best of all, the process does not rely on intense heat and may be a more sustainable way to make titanium for a much wider range of applications than today.

The mechanical properties of the cryo-forged material, specifically strength and ductility, hold at extremely high as well as cryogenic temperatures. Minor says the performance of the nanotwinned titanium makes it ideal for things like extremely hot jet engines as well as very cold operating environments that would suggest uses like retaining rings for superconducting magnets, structural parts of liquefied natural gas tanks, as well as materials to be exposed to deep ocean or deep space environments.

Asked if the new commercial-grade titanium fabrication process might be brought to scale one day soon, Minor says, why not? It's actually harder to do things like the Kroll process that's used today, where the material has to be isolated electrically and the entire process takes massive amounts of power. "And this cryo-forging, you know, we would just be putting things in a bath." BE

Electrical engineering and computer sciences graduate student **Rose Abramson** has won the European Power Electronics and Drives Association's 2021 Young Author Best Paper Award. The paper was co-authored by **Zichao Ye** (Ph.D.'20 EECS) and electrical engineering and computer sciences professor **Robert Pilawa-Podgurski.**

Zakaria Al Balushi, assistant professor of materials science and engineering, and **Kosa Goucher-Lambert,** assistant professor of mechanical engineering, have received National Science Foundation CAREER awards.

James Alpert (B.S.'04 EECS) recently became a shareholder and equity partner at Posz Law, PLC, a patent preparation and prosecution boutique in Washington, D.C.

Electrical engineering and computer sciences Ph.D. student **Matthew Anderson** has won the Google-CMD-IT LEAP Fellowship Award, which recognizes computer science scholars from underrepresented groups who are "positively influencing the direction and perspective of technology."

Electrical engineering and computer sciences professor **Murat Arcak** and graduate student **He Yin** have won the second Systems and Control Letters' Brockett-Willems Outstanding Paper Award. Co-authors include the late **Andrew Packard,** mechanical engineering professor, and Packard's former graduate student, **Peter Seiler.**

Electrical engineering and computer sciences professors emeriti **Ruzena Bajcsy** and **Eric Brewer** (B.S.'89 EECS) have been named 2021 Honorary Fellows of the American Association for the Advancement of Science. Additionally, Bajcsy has also won the PAMI Azriel Rosenfeld Lifetime Achievement Award.

Anantha Chandrakasan (B.S.'89, M.S.'90, Ph.D.'94 EECS), has been awarded the 2022 IEEE Mildred Dresselhaus Medal. He is currently an electrical engineering and computer sciences professor at MIT and the dean of the School of Engineering.

Eight Berkeley Engineering faculty members have been named Chan Zuckerberg Biohub investigators: **Sarah Chasins, Nilah Ioannidis** and **Laura Waller** of electrical engineering and computer sciences; **Daniel Fletcher, Amy Herr, Liana Lareau** and **Aaron Streets** of bioengineering; and **Amy Pickering** of civil and environmental engineering.

Bioengineering professor **Irina Conboy** has been appointed editor-in-chief of Rejuvenation Research.

Luca Daniel (Ph.D.'03 EECS) and **Eric Fosler-Lussier** (Ph.D.'99 EECS) have been named 2022 Fellows of the Institute of Electrical and Electronics Engineers. Daniel is a professor of electrical engineering and computer science at MIT, and Fosler-Lussier is a professor of computer science and engineering, of biomedical informatics and of linguistics, and the associate chair of computer science and engineering at Ohio State University.

Christopher Delre (Ph.D.'20 MSE) was awarded the 2021 Kavli Thesis Prize.

Tejal Desai (MTM'98 BioE) has been appointed the next dean of Brown University's School of Engineering, effective September 2022. She is currently a professor and former chair of the Department of Bioengineering and Therapeutic Sciences at UCSF.

Reginald DesRoches (B.S.'90 ME, M.S.'92, Ph.D.'97 CEE) has been named Rice University's next president, effective July 2022. He is currently serving as provost at the university.

Deborah Estrin (B.S.'80 EECS) has won the Institute of Electrical and Electronics Engineers' John von Neumann Medal. A professor at Cornell University, she was cited for her "leadership in mobile and wireless sensing systems technologies and applications, including personal health management."

Electrical engineering and computer sciences professor **Shafi Goldwasser** (Ph.D.'84 EECS) won the 30 Year Test of Time Award at the 2021 Symposium on Theory of Computing. She was also among five co-authors who won the 2021 Foundations of Computer Science Test of Time Award in the 30-year category.

Sumit Gulwani (Ph.D.'05 EECS), a partner research manager at Microsoft Research, has been selected to receive the 2021 Max Planck-Humboldt Medal for "automatic programming and computational education."

Warren "Woody" Hoburg (M.S.'11, Ph.D.'13 EECS), one of the first graduates of NASA's Artemis astronaut basic training program in 2020, has been assigned to launch on the agency's SpaceX Crew-6 mission. He will pilot the spacecraft when it is expected to launch from a Falcon 9 rocket at NASA's Kennedy Space Center in 2023. This will be his first mission into space.

Huue, a startup founded by **Tammy Hsu** (Ph.D.'19 BioE), has developed a process for creating environmentally friendly indigo dye through synthetic biology that has been named one of Time Magazine's "Best Inventions of 2021."

Nathanial Huebsch (B.S.'03 BioE), assistant professor of biomedical engineering at Washington University in St. Louis, has been named a 2021 Young Innovator by Cellular and Molecular Bioengineering.

Michelle Khine (B.S.'99, M.S.'01 ME, Ph.D.'05 BioE), biomedical engineering professor and associate dean for the Division of Undergraduate Education at UC Irvine, has been named one of six inaugural Samueli Scholars by the Susan Samueli Integrative Health Institute.

Dean and electrical engineering and computer sciences professor **Tsu-Jae King Liu** has been selected to receive the 2021 IEEE Electron Devices Society's Education Award. She was cited for "outstanding contributions to education in the field of electron devices and achievements on diversity and inclusion."

Two alumni have been honored with awards from the 2021 Nuclear Science and Security Consortium: **Kelly Kmak** (Ph.D.'21 NE) won Outstanding Thesis for Radiochemistry and Forensics, and **Hi Vo** (Ph.D.'21 NE) won Outstanding Thesis for Nuclear Engineering.

Interim executive vice chancellor and provost **Catherine Koshland,** the Wood-Calvert Professor in Engineering, will retire this summer after 38 years of service to UC Berkeley. In addition to her faculty positions, she has served as chair of the Academic Senate, vice provost, vice chancellor and executive vice chancellor and provost.

Leung-Ku Stephen Lau (B.S.'53, M.S.'55, Ph.D.'59 CE), professor emeritus of civil engineering at the University of Hawaii, was the lead author in a re-investigation of the status of organic chemical contamination of Hawaii's Pearl Harbor aquifer. His article, "Protecting the Vital Groundwater Sources of Oceanic Islands," was recently published in the Journal American Water Works Association.

Robert Leachman, professor of industrial engineering and operations research, has been named an INFORMS Fellow for "notable contributions to applied research and implementation of production planning methodologies and manufacturing processes management in multiple industries."

Electrical engineering and computer sciences professor emeritus **Ed Lee** (Ph.D.'86 EECS) has won the 2022 European Design and Automation Association Achievement Award.

Steve Lee (MTM'15 BioE) has been named to Forbes' "30 Under 30" list in the social impact category. With his brother, Daniel, he is the co-founder of Aura, an app that offers wellness and mental health coaching and resources.

Xiaoye Sherry Li (Ph.D.'96 EECS) and **Richard Vuduc** (Ph.D.'03 EECS) have, along with **Piyush Sao** of Georgia Tech, won the 2022 Society for Industrial and Applied Mathematics Activity Group on Supercomputing's Best Paper Prize. Li is a senior scientist at Berkeley Lab, and Vuduc is an associate professor in the School of Computational Science and Engineering at Georgia Tech.

Electrical engineering and computer sciences professor **Chunlei Liu** has been named a Fellow of the International Society for Magnetic Resonance in Medicine.

Linsey Marr (M.S.'97, Ph.D.'02 CEE), professor of civil and environmental engineering at Virginia Tech, has been selected to receive a 2022 Outstanding Faculty Award from the State Council of Higher Education for Virginia.

The power of yes

There are millions of startup ideas out there. But a concept's success depends not just on its value proposition or product-market fit — it must first find a supportive environment in which to grow. Just ask master of design (MDes) graduate student **Abhi Ghavalkar.**

Ghavalkar's product, Prana, is an attachment for hospital ventilators that enables up to four patients to share a single continuous positive airway pressure (CPAP) machine, a noninvasive device that delivers a constant level of air pressure to a patient's upper respiratory tract. The new system will cost less than $2,500 per unit serving four patients, compared to traditional noninvasive ventilators that cost up to $17,000 per unit per patient.

The medical device could address ventilator shortages around the world for numerous respiratory conditions, including chronic obstructive pulmonary disease (COPD). Noninvasive ventilators can also support pre-term infants whose lungs have not yet fully developed.

The first prototype was developed in 2019 by Ghavalkar and **Zach Mudge,** a former classmate from Loughborough University. With about £50 ($68), Mudge bought some plumbing pipes and valves from a hardware store, attached four balloons to simulate lungs and connected the setup to his vacuum cleaner to prove that the splitter could regulate the amount of air that each patient received. The next step was to prove that the system could work in a clinical setting with medical grade parts. But without funding or a support team, progress hit a standstill.

In late 2020, Ghavalkar arrived in Berkeley to begin the MDes program. After connecting with fellow MDes students **Mercedes Saldana** and **Peipei "Penny" Lin,** he won a student grant from the Jacobs Institute for Design Innovation to create a second prototype.

Ghavalkar also took a challenge lab through the Sutardja Center for Entrepreneurship & Technology, with the goal of launching a startup and having a working prototype by the end of the semester. **Athena Lopez,** a bioengineering undergrad, joined the team, and suddenly, Ghavalkar found himself surrounded by enthusiastic peers, experienced faculty, even grant funding. The path of "nos" he'd been on was suddenly turning into one of "yeses."

Since then, work on Prana has continued to accelerate. The team has expanded to 12, built a second prototype using medical grade parts and electronics, and coded the device to get it operational. This year, Prana won honors at the New York Product Design Awards, Fast Company's World Changing Ideas Awards, the San Francisco Design Week Awards and the Core77 Design Awards.

The team was a accepted into the CITRIS Foundry incubator and the Berkeley SkyDeck Accelerator's Pad-13 program. The group hopes to submit a product for medical device approval within a year and have one batch operational in the market within the next two to three years.

Looking forward, Ghavalkar feels more optimistic than ever about the startup. "This project would have died if I hadn't come to Berkeley," he said. "Just knowing that I have access to so many fantastic people and resources — that's lifted our effort more than anything else. I couldn't be more grateful to be here."

STORY BY KIRSTEN MICKELWAIT | PHOTO COURTESY PRANA

Pieter Mattelaer (M.S.'06 CEE) is the project manager for the High-Luminosity LHC Project at CERN in Geneva, Switzerland. An article describing the project has been accepted at the 2022 World Tunnel Congress.

Gary May (M.S.'88, Ph.D.'91 EECS), chancellor of UC Davis, was awarded an honorary doctorate from Georgia Tech and delivered the keynote address at its undergraduate commencement.

Robin McGuire (M.S.'69 CE) and **Jack Moehle,** civil and environmental engineering professor emeritus, have each received the 2022 Honorary Membership Award from the Earthquake Engineering Research Institute.

Civil and environmental engineering professor **Khalid Mosalam** and postdoctoral scholar **Martin Neuenschwander** are recipients of the Journal of Structural Engineering's 2020 Best Paper Award in materials and structural response.

Electrical engineering and computer sciences professor **Jelani Nelson** has won the 2022 Computing Research Association-Education's Undergraduate Research Faculty Mentoring Award.

Electrical engineering and computer sciences professor **Aditya Parameswaran** has been selected to receive the 2022 Young Alumni Achievers Award from the Indian Institute of Technology, Bombay.

Colin Parris (M.S.'87, Ph.D.'94 EECS) was one of 13 executives named as leaders and winners of the 2022 BIG Innovation Awards from the Business Intelligence Group.

Computer science professor emeritus **David Patterson** has won the 2022 Charles Stark Draper Prize for Engineering from the National Academy of Engineering for "contributions to the invention, development and implementation of reduced instruction set computer (RISC) chips."

Civil and environmental engineering lecturer **Jasenka Rakas** and four students — **Paul Ambrose, Jeffrey Jeung** and **Duston So** from civil and environmental engineering, and **Valeria Chupina** from the Goldman School of Public Policy — have won the Distinguished Paper Award at the 40th Digital Avionics Systems Conference.

Materials science and engineering professor **Ramamoorthy Ramesh** has been elected to the Indian National Science Academy as a Foreign Fellow.

Stuart Russell, professor of electrical engineering and computer sciences, is slated to direct the future Kavli Center for Ethics, Science, and the Public, which aims to make ethics and social equity more central to scientific decision-making, and which will try to ensure that the public has a greater say in future scientific advances. The new center at UC Berkeley will combine forces with a sister center at the University of Cambridge.

David Schaffer, professor of bioengineering, of molecular and cell biology and of chemical and biomolecular engineering, has been named a Fellow of the National Academy of Inventors.

Mark Schanfein (M.S.'74 MSE) has been elected vice president of the Institute of Nuclear Materials Management.

The California Transportation Foundation has named **Susan Shaheen,** professor in-residence and co-director of the Transportation Sustainability Research Center, to its 2022 board of directors.

Electrical engineering and computer sciences assistant professor **Sophia Shao** has won the inaugural Workshop on Modeling and Simulation of Systems and Applications' 2021 Dr. Sudhakar Yalamanchili (Sudha) Award.

Ryan Shelby (M.S.'08, Ph.D.'13 ME) has been honored with the Mark Bingham Award for Excellence in Achievement by Young Alumni. He is a career diplomat and supervisory foreign service engineering officer at the U.S. Agency for International Development/Southern Africa, where he is the main infrastructure and construction expert for 15 countries in Sub-Saharan Africa.

Adnan Shihab-Eldin (B.S.'65 EECS, M.S.'67 and Ph.D.'70 NE) was presented with the 2022 Spirit of Abdus Salam Award from the International Centre for Theoretical Physics.

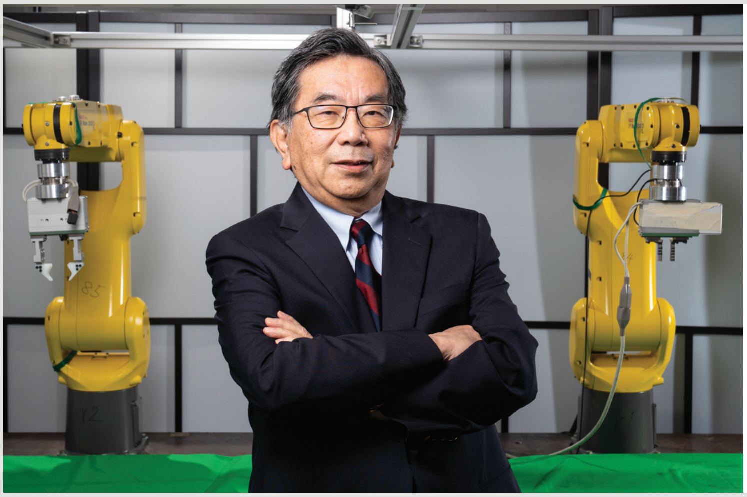
Ikhlaq Sidhu, industrial engineering and operations research professor, as well as chief scientist and faculty director of the Sutardja Center for Entrepreneurship & Technology since its founding 16 years ago, has been appointed dean and professor of IE School of Technology in Spain.

Alistair Sinclair, professor of electrical engineering and computer sciences, won the inaugural 20 Year Test of Time Award at the 2021 Symposium on Theory of Computing for his paper, "A polynomial-time approximation algorithm for the permanent of a matrix with non-negative entries," which solved a problem that had been open for decades.

R. Tyson Sohagi (B.S.'03 ME), a partner in the Sohagi Law Group, was a finalist for the Los Angeles Business Journal's 2021 Leaders in Law Awards.

Bret Strogen (M.S.'04, Ph.D.'12 CEE) received a Meritorious Public Service Medal from the Secretary of the Army for his contributions while serving as the Army's special assistant for energy and sustainability. In April, he became the director of research for Boundless Impact Research and Analytics.

Madhu Sudan (Ph.D.'92 EECS) has won the Institute of Electrical and Electronics Engineers' Founders Medal. A professor at the Harvard School of Engineering and Applied Sciences, he was cited for "fundamental contributions to probabilistically checkable proofs and list decoding of Reed-Solomon codes."



Masayoshi Tomizuka, professor of mechanical engineering, has been elected to the National Academy of Engineering (NAE) for his "leadership in control of mechanical systems through innovations applied globally in industry, and education of coming generations of leaders." The roster of new NAE members also includes 11 Berkeley Engineering alumni: **Charles Bridges** (M.S.'93 NE), **John Hooper** (M.S.'84 CE), **Jill Hruby** (M.S.'82 ME), **Marc Levoy** (Ph.D.'89 CS), **Sanjay Mehrotra** (B.S.'78, M.S.'80 EECS), **Stephen Monismith** (B.S.'77, M.S.'83, Ph.D.'79 CE), **Guy Nordenson** (M.S.'78 CE), **Colin Parris** (M.S.'87, Ph.D.'94 EECS), **Maryann Phipps** (MEng'81 CE), **Daniel Sperling** (M.S.'79, Ph.D.'82 CE) and **Keh-Chyuan Tsai** (Ph.D.'88 CE).

PHOTO BY ADAM LAU

Industrial engineering and operations research assistant professor **Rajan Udwani** has won the 2021 INFORMS Junior Faculty Interest Group Paper Competition.

Electrical engineering and computer sciences professor emeritus **Pravin Varaiya,** Professor of the Graduate School, has won the Institute of Electrical and Electronics Engineers' 2022 Simon Ramo Medal.

Geoff Wehmeyer (Ph.D.'18 ME), assistant professor of mechanical engineering at Rice University, has won a National Science Foundation CAREER Award.

Chantale Wong (M.S.'82 CE), an international development expert, has been appointed to an ambassador-level position for the United States as director of the Asian Development Bank.

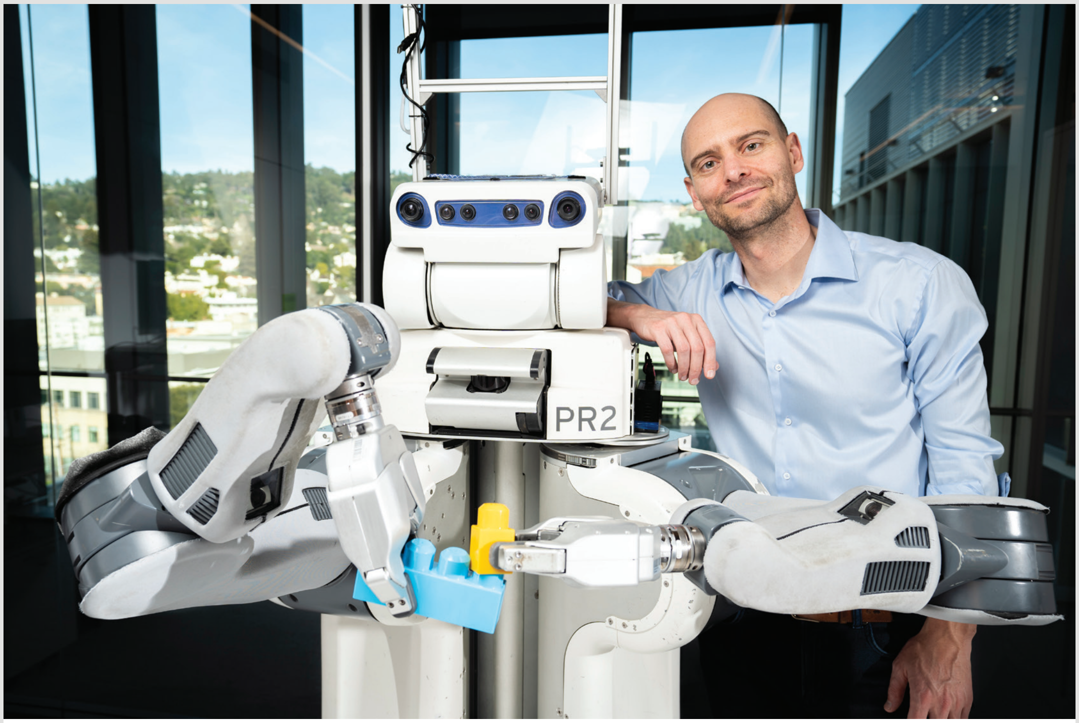
Master of design student **Jennifer Wong** is the recipient of Microsoft's Hack for Mental Health Award for Empathie, a self-guided mobile app that delivers affordable, clinical-grade and easily accessible mental wellness content and tools for racial minorities.

Recent civil and environmental engineering alum **Stephen Wong** (M.S.'16, Ph.D.'20 CEE) has earned the 2020 Eric Pas Dissertation Award from the International Association for Travel Behaviour Research.

Glyphic Biotechnologies, founded by **Joshua Yang** (MTM'16 BioE), is one of three winners of QIAGEN's new biotech grants program. Glyphic is developing a first-of-its-kind, next-generation sequencing platform for proteins.

Bioengineering professor **Michael Yartsev** was the winner of the C.J. Herrick Award in Neuroanatomy from the American Association for Anatomy, which recognizes early career investigators who have made important contributions to biomedical science through their research.

Yang You (Ph.D.'20 EECS), professor of computer science at the National University of Singapore, has won the IEEE Computer Society Technical Consortium on High Performance Computing's Early Career Researcher Award.



Abbeel hosts AI robotics podcast

Pieter Abbeel, professor of electrical engineering and computer sciences, is already well-known as a leading researcher of robotics and artificial intelligence. But in the spring of 2021, he added podcast host to his accomplishments with the launch of his popular show, "The Robot Brains Podcast." In each episode, Abbeel sits down with top experts and entrepreneurs to discuss the real-world applications of AI, along with its many possibilities.

The inspiration for the podcast came during the first year of the pandemic, when Abbeel found himself limited to remote instruction. To mix things up for students in his lab, he began inviting researchers to join their conversations on Zoom. The guests were a big hit with the students, who were able to learn more about the research process and the people behind the research. So it was a natural progression to adapt these conversations to a podcast format, where a larger audience could listen in.

"I see the podcast as another way to educate people in an enticing way. It'd be great if our alumni came back to school and kept taking classes," Abbeel said. "But most people don't have the schedule or excitement to go back to school, so if they can be entertained and learn at the same time, why not?"

"What's possible in AI and robotics today is so different from what was possible even five years ago. It's a space where things are changing very fast and in ways that are going to impact people's lives," he added. "My podcasts highlight the people who are making it happen. Getting into where those pioneers are coming from, what they're excited about, what drives them, what they did earlier in their lives — it's really fun to share that."

Now in its second season, the podcast is available through all major providers, including Apple, Google, Spotify and YouTube.

STORY BY JULIANNA FLEMING | PHOTO BY ADAM LAU

Paal Bakstad (B.S.'62 NE) died in November at the age of 86. A trained nuclear engineer, he spent his career at the Norwegian Atomic Energy Institute and TRW Inc. He later worked for 10 years as a substitute teacher in public schools.

George Ban-Weiss (B.S.'03, M.S.'05 ME) died in October at the age of 40. An associate professor of civil and environmental engineering at the University of Southern California, he researched ways to counter the impacts of climate change and reduce public exposure to air pollutants. He won a National Science Foundation Early Career Award and was named to MIT Technology Review's "35 under 35" list, among other accolades.

Richard Blum died in February at the age of 86. A successful investment banker and graduate of the Haas School of Business, he was known for his extensive philanthropy and service. In 2006, he founded UC Berkeley's Blum Center for Developing Economies, a multidisciplinary research center addressing global poverty and inequity through education and technology. He also served as a UC regent for nearly two decades and was chairman emeritus of the board.

Ernest Cravalho (B.S.'61, M.S.'62, Ph.D.'67 ME) died in April 2021 at the age of 82. A professor emeritus of mechanical engineering at MIT, he was a member of their faculty for 44 years, holding leadership roles at MIT and Massachusetts General Hospital. He was a pioneering researcher in cryopreservation, thermodynamics, heat transfer and energy conversion.

Didier de Fontaine, professor emeritus of materials science and engineering, died in November at the age of 90. He was a pioneer in the field of ab-initio alloy theory, where he paved the way for the modern discipline of computational materials science. He also made seminal contributions to the fields of phase transformations and materials thermodynamics.

Angelo Demattei (B.S.'50 CE) died in October at the age of 95. He served in the Merchant Marines during World War II and in the U.S. Army during the Korean War. He spent his career at Guy F. Atkinson Co., working on Pakistan's Mangla Dam and the Diablo Canyon Power Plant in San Luis Obispo, California, among other projects.

John Dracup (Ph.D.'66 CE), professor emeritus of civil and environmental engineering, died in December at the age of 87. He joined the Berkeley faculty in 2000, after serving for 35 years on the faculty at UCLA. His research centered on the impact of climate change on hydraulic processes and the optimization of groundwater and large-scale river basin systems. He also conducted clean water projects in Africa, Central America and South America, and in retirement, focused his expertise on providing sustainable clean water systems in developing countries.

Peter Dunne III (B.S.'57 EECS) died in October at the age of 91. He served in the U.S. Navy during the Korean War. Following graduation, he spent his career as an electrical engineer in Silicon Valley, most notably at Ampex Corp.

Galen Etemad (Ph.D.'54 ME) died in October at the age of 98. A thermodynamics expert, he had a distinguished career in the aerospace industry, working at The Martin Co., Lockheed Missiles and Space Co., Bell Labs and North American Aviation, where he led the team that designed the heat shields used on all Apollo missions to allow for safe re-entry into the Earth's atmosphere.

William Flowers (B.S.'44 EECS) died in September at the age of 98. He served in the U.S. Navy during World War II and then embarked on a 40-year engineering career with Pacific Gas and Electric Co.

James "Jay" Graham (B.S.'56 EECS) died in October at the age of 92. He served in the U.S. Air Force from 1948–52. Following graduation, he began his career with the North American Aviation Apollo Space Program, then worked at General Electric Co. for 30 years.

Deane Judd (B.S.'60, M.S.'68 EECS) died in December at the age of 84. He served as an officer in the U.S. Navy; afterwards, he spent his career working in Silicon Valley, largely at Amdahl Corp. He was also an airport advisory commissioner for the Hollister Municipal Airport.

Hans Mark died in December at the age of 92. He was a world-renowned aerospace engineer whose work was essential to the development of advanced nuclear technology, government aeronautics and early space exploration. He served as chair of Berkeley's Department of Nuclear Engineering and as administrator of the Berkeley Research Reactor from 1964–69. He went on to serve as director of NASA's Ames Research Center, secretary of the U.S. Air Force, director of the National Reconnaissance Office, deputy administrator of NASA and director of defense research and engineering at the Pentagon, as well as chancellor of the University of Texas system.

Robert Renouf (B.S.'66 EECS) died in March 2021 at the age of 77. He served in the U.S. Air Force Reserves from 1966–72. Later, he worked for Pacific Gas and Electric Co. and the City of Oakland, and he was also an electrical engineering consultant.

Daniel Rydzewski (M.S.'93 CE) died in January at the age of 60. He had a long career in transportation, traffic management and related information technology systems. He spent most of his career working for the cities of Norfolk and Virginia Beach, enhancing public highway systems.

Bit Seto (B.S.'64, M.S.'64 EECS) died in December at the age of 79. Over his long career, he worked for various companies in the Silicon Valley as an engineering manager on sensors used in manufacturing.

Hsieh Wen Shen (Ph.D.'61 CE), professor emeritus of civil and environmental engineering, died in December at the age of 90. He joined the Berkeley faculty in 1985, after 18 years at Colorado State University. A member of the National Academy of Engineering, he was a leading researcher of environmental hydraulics, river mechanics and basic sediment transport. He was best known for his work to restore southern Florida's Kissimmee River and his role in boosting research of the San Francisco Bay.

John Winzler (B.S.'51 CE) died in December at the age of 91. For over 40 years, he was the president and principal engineer of Winzler and Kelly Consulting Engineers. He was also the principal engineer for the Humboldt Bay Municipal Water District and president of the California Board of Registration for Professional Engineers.

Adam Lau

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