College of Engineering
University of California, Berkeley
Spring 2023
Volume 23

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Berkeley ENGINEER

Forever young
Understanding aging through the study of blood

Engineering new frontiers

Spring is the season of new beginnings, bringing with it a spirit of celebration. It is fitting, then, that we just celebrated the groundbreaking for our new Engineering Center, which will create welcoming and inclusive new spaces for our students to study, collaborate and innovate together. This facility will open in early 2025 and will no doubt have a transformative impact on future generations of engineering students.

This spring we're also celebrating the success of the inaugural year of our aerospace engineering baccalaureate program, our college's first new undergraduate major in 25 years. The Class of 2026 arrived this past fall, and the students' enthusiasm has been contagious. At a recent campus event, Berkeley Engineering alumnus Eugene Tu (B.S.'88 ME), director of the NASA Ames Research Center, and Victoria Coleman, chief scientist of the U.S. Air Force, joined Berkeley Engineering professors Panos Papadopoulos and Adam Arkin for a vibrant panel discussion on the future of aerospace technology and its impact on society.

Hundreds of students and researchers across the Berkeley campus are now actively engaged in aerospace-related activities, including numerous clubs and student organizations. Many of them witnessed the installation of our new wind tunnel; its state-of-the-art closed-loop design is capable of generating air flow speeds up to 140 miles per hour. Our students will be able to put their 3D-printed airfoil and aircraft models to the test in this tunnel, and then refine their designs with the aid of modern software tools to achieve targeted performance characteristics, such as stability and fuel efficiency.

The multidisciplinary nature of our aerospace engineering program distinguishes it from other programs across the nation and around the world. The field is rapidly transforming, thanks to advances in computing, manufacturing, composite materials, human-machine interfaces, bioengineering, clean energy and more. Berkeley Engineering excels across all these areas of specialty, enabling our students to develop the multidisciplinary competency needed to become leaders in a resurgent field.

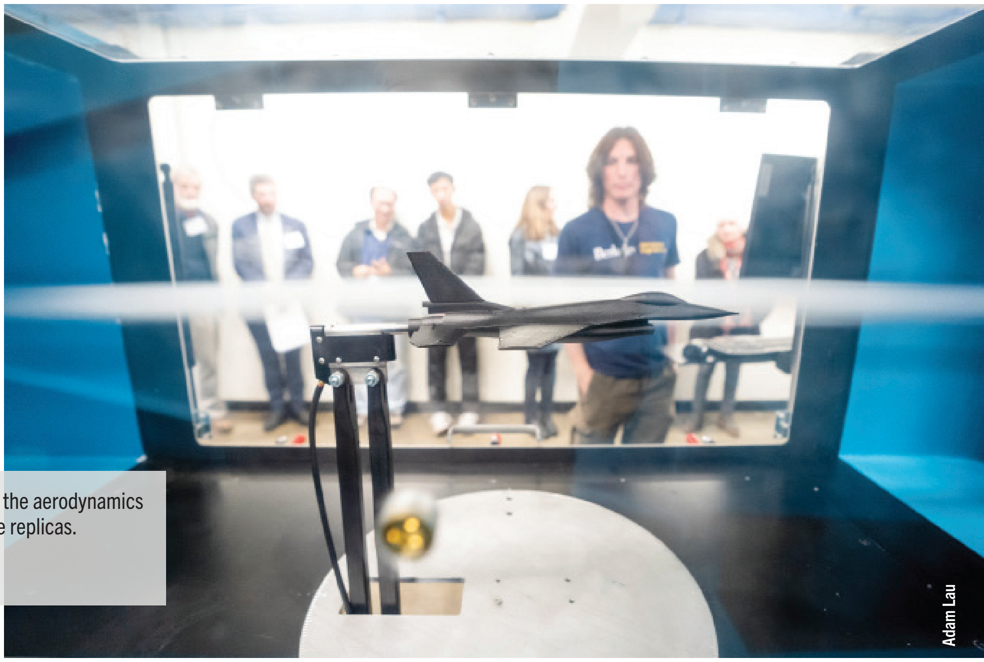
Some Berkeley engineers already have taken to the skies and beyond, as Warren "Woody" Hoburg (M.S.'11, Ph.D.'13 EECS) did when he piloted the SpaceX Crew-6 mission to the International Space Station this March. We look forward to welcoming him back to Earth when this six-month mission is over.

I hope you'll continue to follow us as we explore new frontiers in engineering and in our universe.

Fiat Lux!

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

We're celebrating the inaugural year of the aerospace engineering program, our first new undergraduate major in 25 years.



The college's new wind tunnel allows students to study the aerodynamics of aircraft, cars and other objects by testing small-scale replicas.

See video at **engineering.berkeley.edu/windtunnel**

Adam Lau

in this issue

BerkeleyENGINEER SPRING 2023

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AGRICULTURE

Raising the stakes

Although biofuels offer a renewable source of energy, it comes at a cost: the heavily fertilized soils used to grow biofuel crops emit large amounts of nitrous oxide, a potent greenhouse gas. These emissions, produced by microbial processes within the soil, can vary greatly over time and location, making them challenging — and expensive — to measure. To quantify nitrous oxide emissions and devise more climate-friendly farming practices, **Ana Claudia Arias** and **Kristofer Pister,** professors of electrical engineering and computer sciences, are working with **Whendee Silver,** professor of ecosystem ecology and biogeochemistry, to develop a tracking system for agricultural land using a novel printed sensor array and a wireless communications platform.

Their technology, dubbed the SmartStake system, uses stake-mounted sensors to provide an inexpensive alternative to cavity ring-down spectroscopy, a state-of-the-art but far more costly method for measuring gases like nitrous oxide. The simple printed sensors can be easily replaced at the end of a crop's growing season, enabling the implementation of sensing modalities that would otherwise be impractical. In addition to concentrations of nitrous oxide, nitrate, ammonium and oxygen, the sensor network can measure pH, temperature, moisture and denitrifying microbial enzymes; the resultant data can then be analyzed by a machine learning model. The researchers hope their system may someday transform biofuel agriculture by enabling farmers to fine-tune agricultural practices to lower nitrous oxide emissions, while also optimizing fertilizer and irrigation usage.

ALGORITHMS

Life isn't fair…yet

Algorithms drive critical decisions about healthcare, criminal law, education and even our finances, but they are not immune to harmful bias. Now, Berkeley engineers have devised a way to design fairer algorithms, pushing data-driven decision-making closer to the promise of unbiased accuracy. **Anil Aswani,** professor of industrial engineering and operations research, and **Matt Olfat** (Ph.D.'20 IEOR) have demonstrated the first theoretically proven approach to fairness that can be applied across numerous groups, characteristics and traits.

Previously, creating less biased algorithms required limiting them to a single-use setting, such as income or age, or only accommodating up to two protected labels, like gender and race. In their new approach, the researchers used an optimization hierarchy — a sequence of optimization problems with an increasing number of constraints — for fair statistical decision problems. As a result, complex decisions often tainted by bias can now be proven to be fairer.

The team tested this new technique in a case study involving morphine dosing. After revealing that a biased algorithm was discriminating against women and low-income patients based on their insurance, the researchers trained an algorithm to provide a certifiably fair and automated dosing policy for all patients.

ROBOTICS

Working like a dog

Berkeley researchers may be one step closer to making robot dogs our new best friends. Using advances in reinforcement learning (RL), two separate teams have developed cutting-edge approaches to shorten training times for quadruped robots, getting them to walk — and even roll over — in record time.

In a first for the robotics field, a team led by **Sergey Levine,** associate professor of electrical engineering and computer sciences, demonstrated a robot dog learning to walk without prior training in just 20 minutes. The robot relied solely on trial and error in the field to master the movements necessary to walk and adapt to different settings. Levine's team was able to accelerate the learning speed by leveraging advances in RL algorithms and machine learning frameworks, enabling the robot to learn more efficiently from its mistakes while interacting with its environment. "We are studying how to allow the robot to learn from its mistakes and continue to improve while it is acting in the real world," said **Laura Smith,** a Ph.D. student and co-author of the paper, along with postdoctoral researcher **Ilya Kostrikov.**

A different team at Berkeley, led by **Pieter Abbeel,** professor of electrical engineering and computer sciences, took another approach to helping a robot dog teach itself to roll over, stand up and walk in just one hour of real-world training time. The robot also proved it could adapt. Within 10 minutes, it learned to withstand pushes or quickly roll over and get back on its feet, without any resets or intervention from the researchers. The team — including Ph.D. student **Alejandro Escontrela, Danijar Hafner, Philipp Wu** (B.S.'19 EECS/ME) and **Ken Goldberg,** professor of industrial engineering and operations research and of electrical engineering and computer sciences — employed an RL algorithm named Dreamer that uses a learned-world model. This model is built with data gathered from the robot's ongoing interactions with the world, with the robot using it to imagine potential outcomes. "The robot sort of dreams and imagines what the consequences of its actions would be and then trains itself in imagination to improve, thinking of different actions and exploring a different sequence of events," said Escontrela.

Laura Smith

Adam Lau

Courtesy Jean-Luc Watson

CRYPTOGRAPHY

In training

Keeping sensitive data safe has sometimes come at the expense of speed when training machines to perform automated tasks like biometric authentication and financial fraud detection. But no longer. **Raluca Ada Popa,** associate professor of electrical engineering and computer sciences, and Ph.D. student **Jean-Luc Watson** have developed an innovative privacy-preserving approach to machine learning using a new platform, dubbed Piranha, that harnesses the speed of graphics processing units (GPUs) to train a realistic neural network on encrypted data for the first time.

"Even though people have wanted to do this for at least 20 years, training a realistic neural network model while keeping the data encrypted has not been practical," said Popa. "The key was to make GPUs work with encrypted computation."

GPUs can process large amounts of data simultaneously, making them ideal for high-performance computing and deep-learning applications. While they can be used to quickly train neural networks on plain text, they do not work with encrypted data. Encrypted data is incompatible with GPUs because it uses integers instead of floats — another kind of numerical data — and accesses memory in non-standard ways.

Piranha addresses these issues with a three-layer architecture that allows applications to interoperate with any cryptographic protocol. The researchers, including postdoctoral researcher **Sameer Wagh,** showed that they could train a realistic neural network, end to end, on encrypted data in a little over a day, a significant performance gain over previous approaches. They estimated that accomplishing the same task on Falcon, a state-of-the-art predecessor to Piranha, would have required 14 days, making it prohibitively expensive and impractical.

"With Piranha, we not only trained a realistic network for the first time with encrypted data, but we also improved performance by 16 to 48 times," said Popa.

Courtesy the researchers

MATERIALS

As tough as they come

As far as materials go, a class of metals called high entropy alloys (HEAs), made of an equal mix of each constituent element, are among the toughest. Now, a research team led by **Robert Ritchie** — professor of materials science and engineering and of mechanical engineering, and senior faculty scientist at Berkeley Lab — has measured the highest toughness ever recorded, of any material, while investigating an HEA alloy made of chromium, cobalt and nickel (CrCoNi). Not only is the metal extremely ductile (highly malleable) and strong (resistant to permanent deformation), its strength and ductility improve as it gets colder. This runs counter to most other materials in existence.

Using neutron diffraction, electron backscatter diffraction and transmission electron microscopy, the scientists examined lattice structures of CrCoNi samples that had been fractured at room temperature and at 20 kelvin. The images and atomic maps generated from these techniques revealed that the alloy's toughness is due to a trio of dislocation obstacles that come into effect in a particular order when force is applied to the material. This sequence of atomic interactions ensures that the metal keeps flowing, but also keeps meeting new resistance from obstacles far past the point that most materials snap from the strain.

Now that the inner workings of the CrCoNi alloy are better understood, it and other HEAs are one step closer to adoption for special applications. The researchers say these findings, taken with other recent work on HEAs, may also compel scientists to reconsider long-held notions about how physical characteristics give rise to performance.

COMMUNICATION

Speak and spell

Aiming to help people who have lost the ability to speak due to severe paralysis, researchers in the UCSF-UC Berkeley bioengineering graduate program have developed a new way for brain-computer interfaces (BCIs) to make communication faster and easier. Building off a groundbreaking 2021 study led by UCSF neurosurgeon **Edward Chang,** the team designed a BCI that allows users to silently spell out sentences from a vocabulary of more than 1,000 words in real time with nearly 100% accuracy.

The 2021 study, in which users with paralysis controlled a BCI to generate full sentences by trying to say the desired words, was limited to a preliminary vocabulary of 50 words and required the participant to try to vocalize. In this new study, researchers wanted to see if it was possible for the same participant to silently spell out sentences from a much larger vocabulary. The participant would silently attempt to say NATO code words for each letter of the Roman alphabet to spell out intended words and sentences while researchers recorded signals from their brain. The BCI then used custom machine learning algorithms to translate brain activity directly into text.

"We were able to decode these sequences of code words — for example, Charlie-Alpha-Tango for cat — with 94% accuracy," said **Sean Metzger,** Ph.D. student and co-lead author of both studies. "In addition, offline simulations showed this approach could still work with a vocabulary of over 9,000 words while maintaining an accuracy up to 92%."

The other co-authors of both studies are **Jessie Liu,** graduate student in the UCSF-UC Berkeley program, and **David Moses,** a postdoctoral engineer at UCSF. Other co-authors of this study are **Gopala Anumanchipalli,** assistant professor, and **Kaylo Littlejohn,** a Ph.D. student, both from the Department of Electrical Engineering and Computer Sciences.

ENERGY

Keep it cool

Salt has been long used to prevent ice from forming on roads by lowering the freezing point of water. Now, mechanical engineering Ph.D. student **Drew Lilley** and adjunct professor **Ravi Prasher,** working with Berkeley Lab researchers, have used this same concept to develop a new method of heating and cooling. Known as ionocaloric cooling, the technique has the potential to compete with or even exceed the efficiency of gaseous refrigerants found in the majority of systems today. It could also help phase out refrigerators and air conditioners that rely on hydrofluorocarbons (HFC) refrigerants, which emit powerful greenhouse gases.

To provide cooling, the method uses ions to drive solid-to-liquid phase changes. The ionocaloric cycle causes this phase and temperature change through the flow of ions (electrically charged atoms or molecules) which come from a salt. Running current through the system moves the ions, changing the material's melting point. When it melts, the material absorbs heat from the surroundings, and when the ions are removed and the material solidifies, it gives heat back. Using a liquid has the added benefit of making the material pumpable, making it easier to get heat in or out of the system, something solid-state cooling has struggled with.

Thor Swift/Berkeley Lab

To demonstrate the technique, Lilley used a salt made with iodine and sodium, alongside ethylene carbonate, a common organic solvent used in lithium-ion batteries. The first experiment showed a temperature change of 25 degrees Celsius using less than one volt, a greater temperature lift than demonstrated by other caloric technologies. The team is continuing work on prototypes to determine how to scale the technique and improve the temperature change and efficiency.

ARTIFICIAL INTELLIGENCE

Stopping traffic

Many traffic jams are caused by small behaviors: a slight tap on the brakes can ripple through a line of cars, triggering a slowdown or even gridlock. But in a massive traffic experiment, more than 50 scientists from the CIRCLES Consortium — including 18 Berkeley Engineering students, postdoctoral researchers, staff and faculty — tested whether introducing just a few AI-equipped vehicles to the road can help ease these jams and reduce fuel consumption for everyone. The answer seems to be yes.

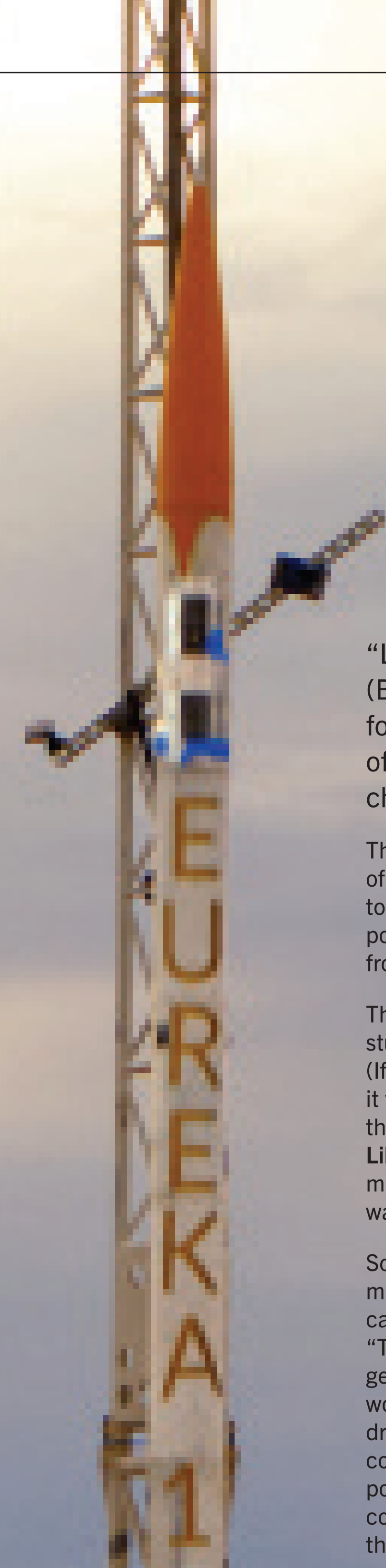
Over five days, researchers deployed a fleet of 100 vehicles onto a busy stretch of I-24 in Nashville during the morning commute. Each vehicle was equipped with an AI-powered cruise control system designed to automatically adjust the speed of the vehicle to improve the overall flow of traffic. Trained drivers took the AI-powered vehicles on a stretch of the interstate that has been equipped with a dense high-res video camera network to monitor traffic. As the drivers traversed their route, researchers collected traffic data from both the vehicles and the I-24 MOTION traffic monitoring system.

"Our preliminary results suggest that, even with a small proportion of these vehicles on the road, we can effectively change the overall behavior of traffic," said **Alexandre Bayen,** professor of electrical engineering and computer sciences. "The game changer here was the coordination — the fact that the vehicles leverage each other's presence and can react preemptively to downstream traffic conditions."

Berkeley researchers have taken the lead in developing machine learning algorithms that govern how fast AI-powered vehicles should go. The new technology incorporates information about traffic conditions and adjusts the speed to help smooth the overall flow of traffic.

The experiment also demonstrated a new feature developed by the CIRCLES team: the ability to simultaneously push collaborative algorithms to different car platforms (Nissan, GM and Toyota). The team is now in the process of planning how the technology can be deployed in California.

A Eureka-1 moment



"Let's light this candle!" yelled **Benjamin Tait** (B.S.'23 EECS), the since-graduated chief engineer for Space Enterprise at Berkeley (SEB). On the count of five, Eureka-1 shot up into the sky to the loud cheers of the undergraduate throng.

The December launch of this liquid-fueled rocket hit a high point of 11,000 feet in altitude. Now that college teams are competing to cross the Kármán line, you could say that SEB — largely composed of Berkeley Engineering students, including half the roster from the new aerospace major — is already on their way there.

Three years in the making, Eureka-1 was entirely designed by the student club in a process that took between $65,000 to $75,000. (If you were to build the rocket from scratch with the final formula, it would take between $8,000 to $10,000.) "One of the cool things about SEB is that we try to do everything ourselves," said **Lilly Etzenbach,** SEB's chief executive officer and a junior in mechanical engineering. "I'd say most people who are in the club want some kind of aerospace career."

So it helps that the student team can build experience — and make a few discoveries along the way. Take their engine's pintle cap. The initial plan was to build the propellant mixer out of steel. "The pintle is in the middle of the engine," Etzenbach said. "So it gets super hot." The thinking was that steel's high-melting point would withstand intense burns. Wrong! While SEB scrambled to dream up a replacement, they landed on a peculiar idea. Perhaps copper could take the heat in spite of its much lower melting point, given its higher thermal conductivity. "It worked," she continued. "Copper pintle caps are still something we use." Call that a Eureka moment.

Still, the 60-plus member team's work is not over. "The goal of Eureka-1, initially, was to go to space," Etzenbach said. "We realized that wasn't possible. So very early on, we decided that Eureka-3 would be the space shot."

Looking to the future, the aerospace-minded team is plotting a recovery system for their next model, Eureka-2, which is set to launch in September. "We're aiming for 20,000 feet, which would pave the way to Eureka-3 and space," the SEB president said.

Then it's blue skies and bright stars for Eureka-3, taking off in Spring 2026.

STORY BY CAITLIN KELLEY, PHOTO COURTESY SEB

See video at **engineering.berkeley.edu/eureka1**

Forever young

Understanding aging through the study of blood

STORY BY ZAC UNGER

Scientific advances in recent decades have made the world's population healthier — and also much, much older. The number of people over the age of 60 recently surpassed one billion and is projected to double by 2050. However, while the medical community has made great strides in reducing infant mortality, malnutrition and communicable diseases, advanced treatments for the maladies associated with aging have been limited.

But what if conditions like Alzheimer's disease, Parkinson's disease and arthritis could be delayed or even reversed? That's a question that Irina Conboy, professor of bioengineering, has been researching for the last 20 years. Describing her work as "developing solutions to keep humanity healthier and younger for additional decades," Conboy is studying the role blood plays in the aging process and its connection to such seemingly distinct diseases as dementia and certain cancers.

Conboy and her collaborators — including her husband, Michael Conboy, a research scientist and lecturer in the Department of Bioengineering — are aiming to determine if the secret to vitality truly lies within the bloodstream. "We want to figure out why people age synchronously," she says. "It's not like your head is young and your hands are old. You age systemically, all at once, which suggests that there is something in blood that controls healthspan and longevity."

After almost two decades of research, scientists at the Conboy lab have now identified crucial mechanisms underlying the aging process: the overabundance of specific blood proteins. These proteins, at levels that are vital for our health when we're young, become elevated and counterproductive as we age, bringing about disrepair and its related gerontological conditions.

Most promising, their studies of plasma dilution suggest that the actual key to rejuvenation may lie in targeting these molecular excesses, providing a safer and more effective alternative than other treatments, such as infusing patients with youthful blood or its related components.

Understanding rejuvenation

In a groundbreaking 2005 study published in Nature, the Conboys were lead scientists on the team that surgically connected young to old mice. What they found was significant: certain markers of aging were reversed in the old mice, while aging was induced in the young mice.

The study looked at how well muscle tissue recovered and how well liver cells regenerated; in both cases, old mice with preexisting conditions healed much quicker when connected to young mice than did mice in the control group. (The study also examined how well new brain cells were formed, but those findings were published six years later, in a different study.)

The evidence also suggested that it wasn't the young blood cells that were beneficial, but rather, that the blood-exchange process rejuvenated the regenerative capacity of the old stem cells in the old tissues. The process wasn't like rehydrating a thirsty body — it was more about triggering specific signaling mechanisms to get older cells to act more like their younger selves.

In 2016, Conboy and her team published a better-controlled study that examined the underlying reasons why mice experienced rejuvenation or aging in a matter of days. The researchers used a new experimental technique to exchange blood between the mice, helping to pinpoint the effects of blood alone and allow for more precise measurements.

When looking at liver health, agility, cognition, neuroinflammation and senescence, the study showed that young mice that received old blood manifested declines in many of these areas.

"There were some positive effects of young blood [on old mice], but not in the brain," says Conboy, "and the young mice became immediately aged by a single transfusion of old blood, manifesting neuroinflammation and problems with agility and cognition."

Because the benefits were not evident in the brain, the researchers theorized that young blood by itself may not reverse the process of aging. Rather, it may be the reduction of specific proteins found in old blood that was the benefit.

Hitting the reboot button

By the early 2020s, Conboy recalls, "we started to ask ourselves, what if, instead of exchanging old blood with young blood, we exchanged it with something that has no age?" So instead of parabiosis or blood exchange, they experimented with plasmapheresis, the dilution of natural blood plasma with a saline solution and albumin, which replenished natural albumin lost during the procedure.

"We expected this would be a negative control," Conboy says. "We thought that if we simply diluted 50% of the blood plasma there would be no effects. But the effects were actually huge," rejuvenating tissue "to such an extent that in many of the tests we did, the old mice were statistically the same as young mice."

In a 2020 study, the researchers found that young blood was unnecessary for significant rejuvenation, and that a single "neutral" blood exchange yielded significant improvement across multiple physiological systems in the muscles, liver and brain.

Through a single, 30-minute procedure, half of the plasma in mice was replaced with the saline-albumin solution. This single therapeutic blood exchange made older mice demonstrate better muscle repair, reduced fattiness and fibrosis in the liver, improved formation of new neuronal cells in the brain, better cognition, reduced neuroinflammation and reduced brain senescence.

Why were the results so robust and rapid? The answer came from comparative proteomics, where signaling proteins that circulate in blood were studied before and after the procedure.

As Conboy explains, when blood is diluted, it's like hitting the reboot button on a computer so that the cells overproducing proteins recalibrate to a younger, healthier profile. Although plasma proteins turn over and get replaced constantly, changes in the systemic milieu over time, such as an excess of certain circulatory proteins, interfere with tissue. For example, one such signal is TGF-beta, a protein that is crucial for embryonic development and for adult health, but becomes overproduced in the old as a response to cellular damage.

"You have insult after insult, injury after injury," Conboy says, and every time protein levels go up, they reach the point where they start inhibiting the levels of beneficial proteins in the body. "It's like an army of old bureaucrats," she adds. "They're not capable of doing the job anymore, but they don't want to be replaced by a new generation."

> "We started to ask ourselves, what if, instead of exchanging old blood with young blood, we exchanged it with something that has no age?"

"A youthful recalibration"

Mice are one thing, but how relevant are these findings to humans? Early results from a clinical study in 2022 are promising.

Working with clinical doctor Dobri Kiprov and Joel Kramer, a neuropsychologist at UCSF, Conboy and her team studied the effects of multiple rounds of plasmapheresis on humans, in which their plasma was replaced with saline and purified albumin, similar to the neutral blood exchange in mice.

The researchers examined blood samples before and after the subjects underwent the procedure. In addition to other markers, says Daehwan Kim, a postdoctoral researcher in the Conboy lab, they analyzed levels of "inflammaging," or the process by which "the immune system becomes less effective at fixing infected or damaged tissues and clearing dead cells." Inflammaging can lead to the accumulation of inflammatory molecules and the harmful overactivation of immune cells.

The study, published in the journal GeroScience, showed that this process of diluting blood plasma by 60-70% had dramatic results in humans. Not only was inflammaging reduced, but protein markers for neurodegeneration and even cancer were diminished. In their paper, the researchers described plasmapheresis as providing "a youthful recalibration of canonical signaling pathways" that regulate tissue health.

One of the biggest initial advances from the 2022 study was the identification of 10 novel protein biomarkers, which, when deregulated by age, lead to an increase in a person's biological age; these markers might help in the development of rejuvenating therapies. "We are trying to find and sample more," says Kim, "because 10 probably isn't all it takes to provide rejuvenation."

The researchers emphasize, however, that plasmapheresis isn't being looked at as a potential treatment for aging or its associated diseases. Conboy stresses that the circulatory system is a closed loop for a reason. When blood is removed for plasmapheresis, it travels through plastic tubing and then into a device where the cells themselves are spun or filtered out and then returned to the body along with the saline and albumin. "But that procedure alone might be damaging for cells and deregulate clotting factors," she cautions. "They can clot, they can be shredded and they can even activate a native immune response."

Rather, the long-term goal of their work is to produce safe therapeutics that will extend a healthy, enjoyable life. The researchers are hopeful that it will yield insights into the larger process of cellular signaling; in time, the benefits of the crude "oil-change" model of blood exchange may even be replicable in pill form.

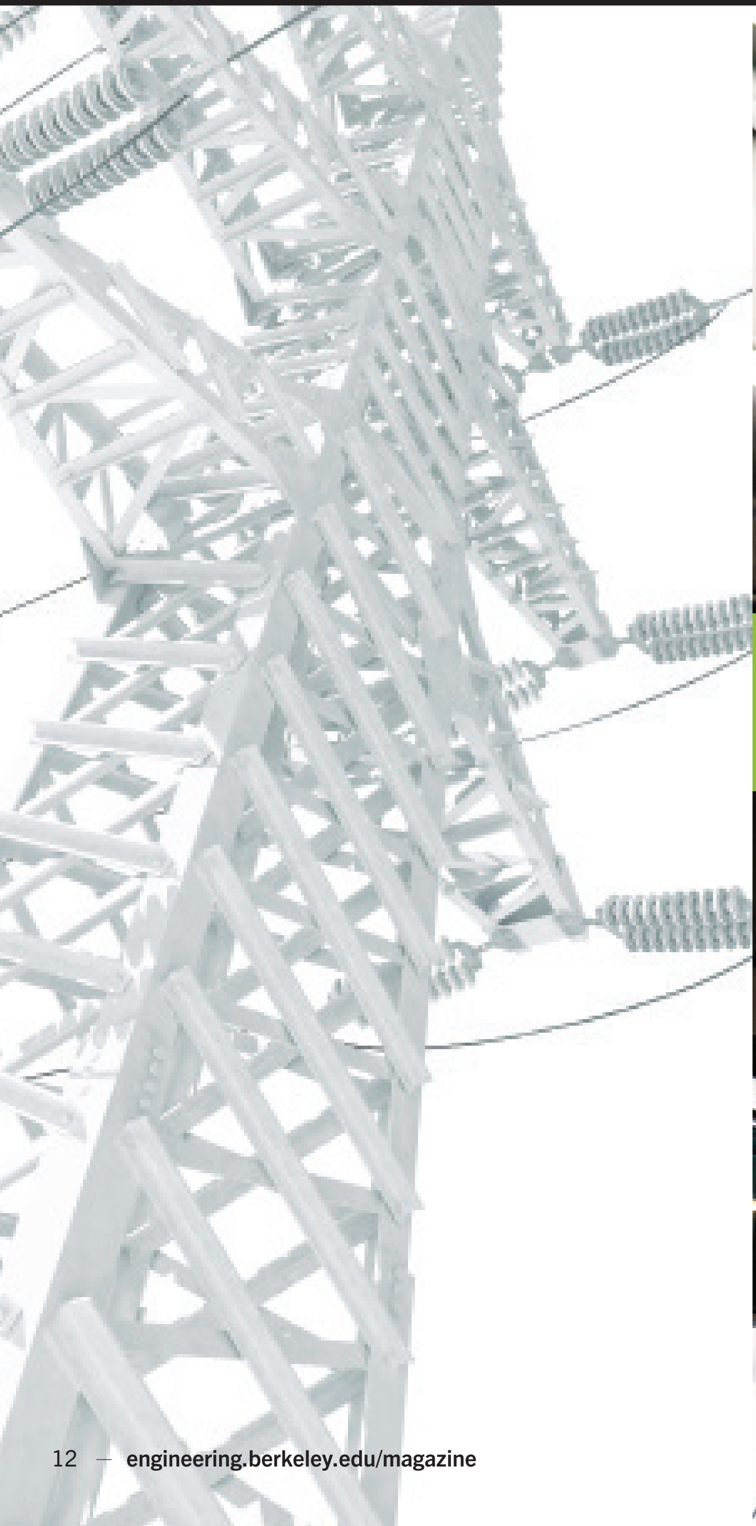
In recognition of the promise of this research, the grantmaking organization Open Philanthropy recently awarded Conboy over $3 million to develop tools to track and reveal the fundamental mechanisms of aging — and eventually attenuate, reverse or even prevent this process.

As for Conboy, who always publishes her results as quickly as she can, "that's success in academia. Not having a trade secret but being collaborative and altruistic so more people can be involved and move the work forward."

Ultimately, Conboy, who has had a curiosity about the elderly since her childhood, finds it gratifying that her life's work may be a critical link in protecting people from the declines associated with aging. "Working on this is a rational decision," she says. "It's almost like you're on an airplane that you know is going to crash. It doesn't help to panic, but if you have the materials to make a parachute, why not start putting it together and see how far you can get?" BE

Young blood by itself may not reverse the process of aging. Rather, it may be the reduction of specific proteins found in old blood.

SMART AND IN CHARGE



Adam Lau

Integrating zero-emissions vehicles into California's electric grid

Adam Lau

STORY BY ANDREW FAUGHT

Twice a week, Erin Murphy-Graham drives her electric Volkswagen ID.4 to UC Berkeley's Recreational Sports Facility (RSF) parking garage and plugs in to one of eight charging ports.

There, the associate adjunct professor of education, who is joined on the ride by her husband, economics professor Bryan Graham, is taking part in a novel project: the Smart Learning Research Pilot for Electric Vehicle Charging Stations (SlrpEV), which aims to provide a blueprint for the future of electric vehicles (EVs) — and more to the point, how best to power them.

For Murphy-Graham, the process is simple and straightforward: using a specialized app, she chooses whether to pay a higher rate to have her car charged quickly or to opt for a cheaper, slower rate. In either case, she schedules a departure time at which she must retrieve her car or face an overstay fee.

SlrpEV's charges Murphy-Graham's Volkswagen using machine learning and behavioral economic models to understand, predict and efficiently manage her car's power needs. Different from other charging station networks, whose prices do not respond to real-time electric grid conditions, SlrpEV gives travelers an "optimized" discount for deciding how much energy and at what speed the vehicle is charged. Optimized pricing, as a result, reduces strain on the electric grid. The process is dictated by algorithms that consider the price and wider outlay of grid electricity use at the moment a car is connected to the station.

The SlrpEV project is of no small consequence. By 2035, the state of California is requiring that all new car and light truck sales be zero-emission vehicles. With that comes a giant and obvious question: How will California's electric grid be able to handle the influx of 12.5 million EVs?

Overseeing SlrpEV is Scott Moura, the Clare and Hsieh Wen Shen Distinguished Professor in Civil and Environmental Engineering. Collaborating with TotalEnergies SE, Moura spearheaded efforts to bring the chargers to campus in 2020. Since then, SlrpEV has delivered more than 225,000 e-miles to over 200 unique users. As Moura explains, the model provides critical data for designing a system that maximizes the consumer experience in parallel with the objective of grid stability.

"I tell everybody, the products we are creating here at UC Berkeley are people and knowledge," says Moura, whose engineering training is in controls and optimization. "Within this whole transition to electrifying transportation, we need people who understand not just the technology, but how it intersects with economics, business and infrastructure policy. That is my North Star and center point."

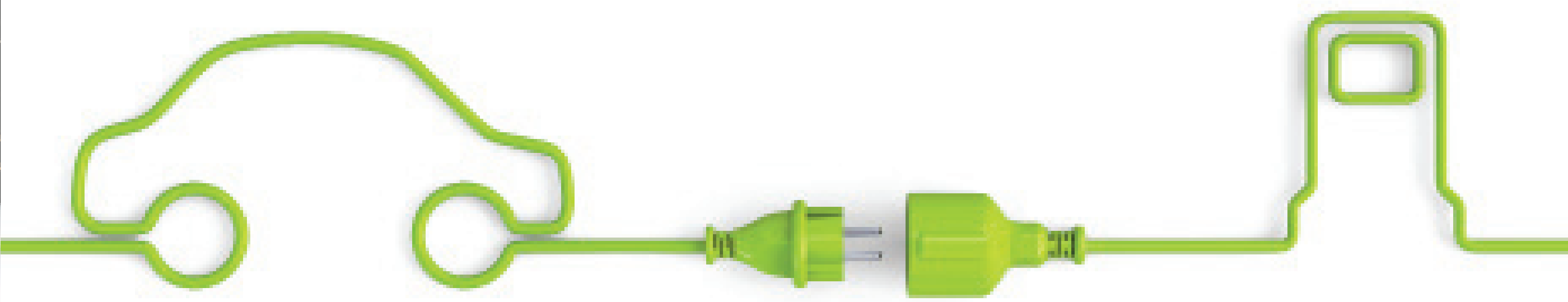
IN THE LOOP

On his smartphone, Moura is able to view real time RSF charger usage. On a late weekday morning in February, seven vehicles are charging. Some of the owners are paying higher rates for the faster charge at maximum power. Others, who have scheduled a departure time and selected the number of miles of range to be added, pay a discounted rate, which grants flexibility to the station in determining charging speed. The researchers have found that, with significant discounts, 80% of users will choose the second flexible option.

"The deeper discount we give, the more people will accept the scheduled option," Moura says.

Data from the users' apps allows the researchers to identify unique preference trends and learn how discounts can best incentivize flexibility. In addition to optimizing prices for users, this data also helps the team determine how to make smart charging stations economically sustainable and discourage users from charging elsewhere — such as at home.

"If we present people with different options, and they have a set of conditions that they're working in, there's some probability that they're going to behave a certain way," he adds. "It's basically the same concepts that are used in advertisements."



The idea is to encourage consumers to schedule their EV's energy consumption for a time that's optimal for the grid, instead of when it seems convenient. It's akin to Amazon offering discounted shipping to shoppers willing to delay delivery of their order ("optimizing their logistics on the back end," says Moura), and the process is similar to Netflix algorithms that personalize programming recommendations.

"As engineers, we've been reticent to put humans in the loop because there's not some simple equation that describes how they operate," he adds. "But with certain advancements in machine learning and being able to get data, we now can include them in the loop."

THE EVENING CHARGING PROBLEM

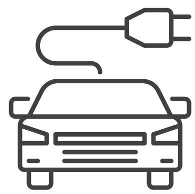
Smart chargers, and especially workplace chargers that can dispense abundant electricity derived from solar power, are expected to temper one of the more pointed criticisms of electric cars: owners are most likely to charge the vehicles at home and in the evening after work, a peak time for energy demand.

Charging during peak demand is one of the worst things for reducing emissions. It requires the grid to use more power from polluting sources, such as coal or natural gas-fired power plants, nullifying the impacts of zero-emission vehicles.

On the other hand, charging in the middle of the day, when solar energy is available, is coincident with the least emissions. Smart chargers, particularly at workplaces, can incentivize behaviors that reduce demands on the grid and capitalize on the availability of renewable energy sources.

This will become more critical as California attempts to enact the world's first detailed pathway to carbon neutrality by 2045. So-called "net zero" carbon pollution would cut air pollution and greenhouse gas emissions by 71% and 85%, respectively; drop gas consumption by 94%; create 4 million new jobs; and save Californians $200 billion in health costs due to pollution, according to the state's Air Resources Board. Separately, the goal that 90% of the state is powered by clean electricity by 2035 hinges on investing in charging infrastructures and investments in clean cars, trucks and buses.

But for now, given the dearth of such infrastructure, concerns persist. By 2035, the number of EVs on California roads and highways will represent a 15-fold increase from today. Avoiding brownouts will require increased flexibility in the grid, which is where vehicle-grid integration comes into play.



Smart charging aligns with California's attempts to enact the world's first detailed pathway to carbon neutrality by 2045.

"We need flexible electricity assets that balance supply and demand, since solar and wind power undulate," Moura says. "Smart EV chargers are unquestionably one important tool in the toolset. The challenge, moving forward, is to transition our electricity system from large fossil fuel generators to an orchestra of clean energy assets, without suffering from brownouts."

"A GIANT BATTERY"

Moura, who drives a Tesla Model 3, is bullish about the future. "We've got our transportation system that's operating, and then we've got our electric power grid that's operating," Moura says. "These two networks have not been coupled."

Given that personal vehicles are not in use for 90% of the day, there's plenty of flexibility for pricing and charging innovation and incentives, Moura says.

"If you understand something about human behavior, people are willing to go for discounts. If we can manage how the vehicle is charged, then putting all of these EVs on the grid is not so much of a burden. They become a powerful distributed energy resource, a giant battery."

For example, in hot summer months when air conditioning units are stressing the grid, EVs can be paid to reduce or delay their charging. Also, during periods of low demand and clear skies, EVs can be incentivized to soak up solar power during the day, instead of charging at night.

Moura says that EVs can be integrated into the power grid, selling back solar energy to power companies during periods of high demand — a process known as vehicle-to-grid or "V2G." After feeding leftover electricity from their batteries back into the grid, the vehicles could recharge later, when demand has dipped, and renewable energy is available.

For its part, the California Energy Commission maintains that EVs will not tax the grid. In 2022, EVs used 1% of the power supply; the total will climb to 5% in 2030, and 10% in 2035, officials say.

The Berkeley smart chargers are part of a larger effort to modernize the grid with more renewable energy and flexible resources like energy storage and EVs, says Wente Zeng, who works in research and development at TotalEnergies, which helped develop the smart chargers at RSF and is the lead sponsor of the SlrpEV research. Because a number of drivers lack garages or the ability to charge at home, workplace and public chargers can also make EV ownership more convenient and widely adopted. When it comes to electricity producers and users, Zeng says, "both sides need to evolve and become smarter."

SLURPING ELECTRONS

Moura developed SlrpEV in response to growing up in smog- and traffic-choked Los Angeles, and he also was influenced by his time pursuing a doctorate in mechanical engineering at the University of Michigan. It was the early 2000s, and hybrid vehicles were beginning to make their way into the market. Amidst his studies, automakers Chrysler and GM went bankrupt. The car industry was in flux.

"I really got interested in the sustainable fuel, alternative fuel area," Moura says. "I also realized that I was interested in energy infrastructure, and I didn't want to become an automotive guy because, who knows, we might not have an automotive industry."

Moura — who created the pilot project's name as an homage to the electron-slurping vehicles in the Pixar film "Cars" — says the initial launch of SlrpEV was tough, as campus was shut down due to COVID-19. However, users have been steadily increasing, and there are now plans in the next couple of years to add 25 more smart chargers to campus.

The university does face some challenging limitations, says Seamus Wilmot, assistant vice chancellor and executive director of business operations. Wilmot, who oversees the university's 6,100 parking spaces, worked with Moura to bring the RSF chargers to the university.

"It's an old campus, so in many locations we don't have enough electrical capacity to install EV chargers," Wilmot says, noting that many of the garages on campus were built in the 1960s. "With load balancing, there may be other ways to provide the EV charging, but on our campus particularly, that's been one of the challenges."

Meantime, research through SlrpEV remains in progress, as it accommodates a variety of users, vehicles and constraints. While Moura has optimized the price and power of SlrpEV chargers, the next phase will be to coordinate EV charging with other campus resources.

The technology, he says, could be incorporated into other distributed energy resources on campus, including rooftop solar photovoltaic equipment (technology that converts sunlight into electricity); building heating, ventilation and air-conditioning systems; and hot water systems. It's what he calls a "SlrpEV-EnergyHub."

For Moura, kicking off the project at Berkeley has afforded the opportunity to gather data under real-world conditions — an effort he hopes will make things better for consumers, and ultimately, the environment: "There's always some probability that someone says, 'I'm not willing to play that game.' Fate is never determined by us, but at least we can shape it." BE

> "Within this whole transition to electrifying transportation, we need people who understand not just the technology, but how it intersects with economics, business and infrastructure policy."

Adam Lau

Associate professor Scott Moura, left, and Charisse Dyer, one of the more than 200 SlrpEV users, at UC Berkeley's Recreational Sports Facility garage.

Zakaria Al Balushi, assistant professor of materials science and engineering, has been selected to receive the Micron Corporation Early Career Award.

Sofia Arevalo (B.S.'16, M.S.'18, Ph.D.'22 ME), **Kristina Monakhova** (Ph.D.'22 EECS) and **George Moore** (M.S.'19, Ph.D.'22 ME) were selected for MIT's Postdoctoral Fellowship Program for Engineering Excellence.

Hari Balakrishnan (M.S.'95, Ph.D.'98 CS) has been awarded the 2023 Marconi Prize in recognition of the "broad impact to society of his fundamental discoveries in wired and wireless networking, mobile sensing and distributed systems." He is a professor at MIT and the founder, chief technology officer and chairman of Cambridge Mobile Telematics.

The National Academy of Engineering (NAE) has elected to its ranks **Kenichi Soga,** professor of civil and environmental engineering, as well as the founding director of the Center for Smart Infrastructure. He was cited "for advances in geomechanics and computational modeling, as well as simulation and monitoring of underground infrastructure." Soga (Ph.D.'94 CEE) is among seven Berkeley Engineering alumni elected to the NAE this year. The others are **Andrew George Alleyne** (M.S.'92, Ph.D.'94 ME), **J. Richard Capka** (M.S.'77 CE), **Shih-Fu Chang** (M.S.'91, Ph.D.'93 EECS), **David Alan Friedman** (B.S.'75 CE), **Linsey C. Marr** (M.S.'97, Ph.D.'02 CEE) and **Amin Vahdat** (B.S.'92, Ph.D.'98 EECS).

STORY BY MARNI ELLERY | PHOTO BY ADAM LAU

Professors **Alexandre Bayen** and **Ali Javey** of electrical engineering and computer sciences have been named 2023 IEEE Fellows.

Alison Burklund (MEng '16 BioE), **Courtney Chow** (B.S.'16 IEOR), **Joey Kabel** (M.S.'17, Ph.D.'20 NE) and **Jiachen Li** (Ph.D.'22 AS&T) were named to Forbes' "30 Under 30" list. Burklund is the co-founder and CTO of Nanopath, which creates diagnostics that quickly test for pelvic and gynecologic infections; Chow is the vice president of Battery Ventures, a technology and software-focused investment firm; Kabel's startup, Electrified Thermal, is building a thermal battery that converts and stores cheap, renewable electricity as high-temperature heat; and Li is working on an all-season, smart roof coating in collaboration with materials science professor **Junqiao Wu.**

Norman Chang (B.S.'85, M.S.'87, Ph.D.'90 EECS) has been selected as an IEEE Fellow "for leadership in the physical-level sign-off of electronic design automation for SoC/3DIC."

Electrical engineering and computer sciences professor emerita **Constance Chang-Hasnain** (Ph.D.'87 EECS) won the 2022 Welker Award at Compound Semiconductor Week for "pioneering contributions to VCSEL photonics, nanophotonics and high contrast metastructures for optical communications and optical sensing."

Tina Chen (Ph.D.'22 MSE) and materials science and engineering Ph.D. students **KyuJung Jun** and **Ji Min Kim** have been selected to receive the Materials Research Society Silver Award.

Jason Cheng-Hsiang Hsu, Ph.D. candidate in electrical engineering and computer sciences, won the best student presentation award at the 2022 Magnetism and Magnetic Materials Conference.

Electrical engineering and computer sciences associate professor **Prabal Dutta** (Ph.D.'09 CS) has won the 2022 ACM SenSys Test of Time Award. The paper — co-authored by **Stephen Dawson-Haggerty** (M.S.'10, Ph.D.'14 CS), among others — was recognized "for pioneering the use of synchronous transmissions in low-power protocols by exploiting their benefits at the MAC layer and pushing the limits of radio operation."

Orla Feely (M.S.'90, Ph.D.'92 EECS) has been appointed president of University College Dublin, becoming the university's first woman president. Previously, she served as the vice president for research, innovation and impact.

Philip Fine (B.S.'93 MSE/ME) is the new executive officer of the Bay Area Quality Management District.

Civil and environmental engineering professor **Ashok Gadgil** co-edited an open access graduate-level textbook, "An Introduction to Development Engineering," which includes contributions from more than 40 practicing experts as co-authors. Springer published the book, which is available as a free PDF.

Rakesh Goel (M.S.'85, Ph.D.'90 CE) is the new dean at UC Merced's School of Engineering. He most recently served as executive associate dean of engineering at California Polytechnic State University, San Luis Obispo.

Venkatesan Guruswami, professor of electrical engineering and computer sciences, has won a 2023 Guggenheim Fellowship. He plans to use the fellowship to continue his research into understanding and devising the most resource-efficient approaches to solving computational problems, and mapping the boundary between their tractable and intractable variants.

Electrical engineering and computer sciences assistant professor **Nika Haghtalab,** professor **Michael Jordan** and Ph.D. student **Eric Zhao** have won a NeurIPS

Distinguished Teaching Awards

Abigail De Kosnik, director of the Berkeley Center for New Media, and **Joshua Hug** (Ph.D.'11 EECS), associate teaching professor in the Department of Electrical Engineering and Computer Sciences, are among this year's recipients of UC Berkeley's Distinguished Teaching Award, the campus's most prestigious honor for teaching. The award, first given in 1957, recognizes teaching that incites intellectual curiosity, engages students in learning and has a lifelong impact.

STORY BY GRETCHEN KELL | PHOTOS BY KEEGAN HOUSER

"I believe that people learn most by doing and speaking, not listening to someone else. When students speak and enact their own ideas about the concepts and texts I put in front of them, then they are the experts — and I've done my job as their teacher," said De Kosnik.

Hug said that although he presents highly technical subjects in CS 61B, it is "never enough to teach technical concepts." Part of his teaching philosophy is "devoted to building solid ethical foundations for students," supporting them as they "embark on intense internal journeys" that can be "transformative" and "emotional."

2022 Outstanding Paper Award for "On-Demand Sampling: Learning Optimally From Multiple Distributions."

Computer science professor **Joseph Hellerstein** (M.S.'92 CS) has won the IEEE VIS Test of Time Award for a 2012 paper he co-wrote with **Jeffrey Heer** (B.S.'01, M.S.'04, Ph.D.'08 EECS), **Sean Kandel** and **Andreas Paepcke:** "Enterprise Data Analysis and Visualization: An Interview Study."

Alishba Imran, an undergraduate student studying computer science and materials science, was named to Teen Vogue's "21 under 21" list. Her work focuses on using machine learning to solve real-world problems.

Cesunica Ivey, assistant professor of civil and environmental engineering, has been awarded a Women in Science Incentive Prize by the Story Exchange in recognition for her work using supercomputers and wearables to monitor air pollution.

Assistant professor of electrical engineering and computer sciences **Angjoo Kanazawa** has been named a 2023 Sloan Research Fellow.

William Kastenberg (Ph.D.'66 NE), professor emeritus of nuclear engineering, has published a memoir, "As a Matter of Heart: A Nuclear Engineering Professor's Life-changing Journey From Safety to Self," which tells the story of his quest to discover his authentic self, which was hidden behind the role of professor.

Yasser Khan (Ph.D.'18 EECS) has joined the faculty at the University of Southern California's Department of Electrical and Computer Engineering as an assistant professor.

Jikun Kim (B.S.'86 EECS) is the new senior vice president and chief financial officer of CalAmp Corp., a connected intelligence company.

Civil and environmental engineering associate professor **Dimitrios Konstantinidis** (B.S.'99, M.S.'01, Ph.D.'08 CEE) has received the 2021 Best Paper in Analysis and Computation Award from the ASCE Journal of Structural Engineering.

Andrea Kritcher (M.S.'07, Ph.D.'09 NE) was named one of Time's "100 Most Influential People" of 2023. She works at Lawrence Livermore National Laboratory and was the lead designer on the National Ignition Facility's effort to achieve fusion ignition for the first time in history.

Industrial engineering and operations research professor **Javad Lavaei** was named a Fellow of IEEE as well as a Fellow of the Asia Pacific Artificial Intelligence Association. He has also been awarded the IEEE CSS Antonio Ruberti Young Researcher Prize for "outstanding and highly interdisciplinary contributions to distributed control, nonlinear optimization and innovative applications to energy systems."

Edward Lee (Ph.D.'86 EECS), professor emeritus of electrical engineering and computer sciences, has won the Association for Computing Machinery Special Interest Group on Embedded Systems Technical Achievement Award.

Electrical engineering and computer sciences professor emeritus **Michael Lieberman** has won the AVS Plasma Prize from the Plasma Science and Technology Division of AVS for "his foundational contributions to the field of low temperature plasmas and plasma processing."

Dean Tsu-Jae King Liu has been named to the new Industrial Advisory Committee for the U.S. Department of Commerce. The advisory body, led by the National

Institute of Standards and Technology, will provide guidance to the secretary of commerce on a range of issues related to domestic semiconductor research and development in support of CHIPS for America.

Arun Majumdar (Ph.D.'89 ME) has been named the first dean of Stanford University's Doerr School of Sustainability.

Sifat Muin (M.S.'13, Ph.D.'18 CEE) has joined the faculty at the University of Southern California as a research assistant professor in the Department of Civil and Environmental Engineering.

Associate professor **Rikky Muller** (Ph.D.'13 EECS) and professor **Jaijeet Roychowdhury** (M.S.'89, Ph.D.'93 EECS), both from the Department of Electrical Engineering and Computer Sciences, have been named 2023 Bakar Prize winners.

Civil and environmental engineering Ph.D. student **Aqshems Nichols** has been named the Collaborative Sciences Center for Road Safety's Student of the Year.

Melinda Ng (B.S.'96 CE) has released "Mattie and the Machine," a young adult historical novel based on 19th century inventor Margaret Knight. The book was published under the pen name Lynn Ng Quezon.

Daniel Ogg (M.S.'91 NE) has been selected as the executive director of the U.S. Nuclear Waste Technical Review Board. Earlier in his career, he worked at the U.S. Defense Nuclear Facilities Safety Board and served in the U.S. Navy aboard a nuclear-powered submarine.

Mechanical engineering professor **Oliver O'Reilly** has been selected for the University of Galway's Alumni Award for Engineering, Science and Technology.

Electrical engineering and computer sciences researcher **Girish Pahwa** has won the 2022 IEEE Electron Device Society Early Career Award. He is currently the executive director of the Berkeley Device Modeling Center.

Colin Parris (M.S.'87, Ph.D.'94 EECS), senior vice president and digital chief technology officer at General Electric, was named 2023 Black Engineer of the Year by US Black Engineer and Information Technology magazine for his significant contributions to the fields of science and engineering and his work in digital transformation.

Materials science and engineering professor **Kristin Persson** was elected a lifetime Fellow of the American Association for the Advancement of Science for her work on the Materials Project. She was also selected as the recipient of the Cyril Stanley Smith Award by the Minerals, Metals & Materials Society.

Lisa Pruitt, professor of mechanical engineering, has published "Soul of a Professor: Memoir of an Un-Engineered Life." In the book, she shares how she battled alcohol abuse and an eating disorder behind a "protective armor" of academic and professional achievements, ultimately finding healing through work with her horse.

Arvind Raman (Ph.D.'99 ME) is the new dean of Purdue University's College of Engineering. He has served as the university's executive associate dean of engineering since 2019.

Materials science and engineering professor **Ramamoorthy Ramesh** (Ph.D.'87 MSE) has been elected as a Fellow of the National Academy of Inventors.

J. David Rogers (M.S.'79, Ph.D.'82 CE), professor of geological engineering at the Missouri University of Science and Technology, has received the Schuster Medal from the Canadian Geotechnical Society and the Association of Environmental and Engineering Geologists.

Electrical engineering and computer sciences professor **Alberto Sangiovanni-Vicentelli** has received the BBVA Foundation's Frontiers of Knowledge Award for transforming chip design from a handcrafted process to the automated industry that powers today's electronic devices. He was also awarded the Honoris Causa Doctorate in Electronic Engineering by the Tor Vergata University of Rome.

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

Susan Shaheen, professor of civil and environmental engineering, and **Bill Quirk,** ITS senior fellow, have been appointed to the California Air Resources Board.

Scott Shenker, professor emeritus of electrical engineering and computer sciences, has won the 2023 IEEE Computer Society Women of ENIAC Computer Pioneer Award for "pioneering contributions to scheduling and management of packet-switched networks, impacting the theory and practice of communication networks."

Somayeh Sojoudi, assistant professor of electrical engineering and computer sciences and of mechanical engineering, and mechanical engineering Ph.D. student **Elizabeth Glista** have won a Best of the Best Conference Paper Award at the 2022 IEEE Power and Energy Society general meeting.

Electrical engineering and computer sciences professors **Dawn Song** (Ph.D.'02 CS) and **David Wagner** (M.S.'99, Ph.D.'00 CS) have won the Test-of-Time Award from the Association for Computing Machinery's Special Interest Group on Security, Audit and Control for their 2011 paper, "Android Permissions Demystified."

Brian Spears (Ph.D.'04 ME) was part of the efforts at Lawrence Livermore National Laboratory's National Ignition Facility to achieve fusion ignition for the first time in history. He led the modeling half of the inertial confinement fusion program's science and physics team.

Nuclear engineering Ph.D. student **Sarah Stevenson** has been selected for the 2023 ANS Glenn T. Seaborg Congressional Science and Engineering Fellowship.

Bioengineering professor **Aaron Streets** was named to Popular Science's "Brilliant 10," a list honoring trailblazing early-career scientists and engineers who are tackling pressing challenges with innovative solutions. Additionally, he has won the 2023 Chancellor's Award for Advancing Institutional Excellence and Equity, and he was also named to the inaugural class of Science Diversity Leadership Award winners, a new partnership between the Chan Zuckerberg Initiative and the National Academies of Sciences, Engineering and Medicine.

Emma Vargo, a materials science Ph.D. student, was named the winner of the 2022 Gareth Thomas Materials Excellence Award.

Junqiao Wu (Ph.D.'02 AS&T), professor of materials science and engineering, has received the 2023 FMD John Bardeen Award from the Minerals, Metals & Materials Society in recognition of his outstanding contributions in the field of electronic materials. In addition, he was elected vice chair of the Division of Materials Physics of the American Physical Society.

Industrial engineering and operations research professor **Candace Yano** has received the INFORMS President's Award in recognition of her many research contributions and impact on educating future operations research professionals, as well as for her extensive INFORMS service.

Associate professor of bioengineering **Michael Yartsev** has been awarded the Cajal Club Krieg Cortical Kudos for his "superb contributions to our understanding of the neuroscience of behavior, social learning and anatomical pathways involved in group sociality and communication" through his research on bats. He was also named the winner of the 2022 Peter Gruss Young Investigator Award by the Max Planck Florida Institute for Neuroscience, as well as the 2022 Young Investigator Award from the Society for Neuroscience.

SEND YOUR CLASS NOTES to **berkeleyengineer@berkeley.edu,** submit at **engineering.berkeley.edu/update** or mail to: Berkeley Engineer magazine, 201 McLaughlin Hall #1704, Berkeley, CA 94720-1704

On the grid

Tim Barat (B.S.'19, M.S.'20 EECS) will never forget seeing the devastation caused by wildfires in his home state of Victoria, Australia. On Feb. 7, 2009 — a day now known as Black Saturday — 400 bushfires raged across more than 1,700 square miles, killing 173 people and destroying approximately 2,000 homes. Many fires were ignited by collapsed power lines, including the Kilmore East-Kinglake fire, which alone caused 120 deaths.

At the time, Barat was a high school dropout working as an electrical lineman, climbing power poles. When a power outage was reported, crew members would have to locate the faulty line, which sometimes required an 11-hour hike into the backcountry. Often, they would find fully energized lines sparking on the ground, dangerously close to dry vegetation.

The lack of a system to accurately detect power line failures confounded Barat. "We have sensors on our wrists, sensors in our pockets, all these incredible ways to sense the world," said Barat. "And yet, if you have a power line failure, or you have a power line fall to the ground, often the utility doesn't know that has happened."

When Barat arrived at UC Berkeley in 2017, he was determined to develop a solution. Joining forces with classmates **Hall Chen** (B.S.'19 EECS) and **Abdulrahman Bin Omar** (M.S.'20 ChemE), Barat co-founded a startup, Gridware, to monitor telltale harmonics from power poles to evaluate electrical grid integrity and the potential hazard risks from power lines. Their device — called Gridscope — mounts to a power pole and detects anomalies using highly sensitive sensors, including a vibrometer and microphone. By continuously taking measurements at a rate of 6,000 times per second, it observes the grid's environment, stress levels and equipment response. Any deviation from the expected behavior could indicate issues such as a strong wind blowing a line down or a car striking the post.

"Our technology feels the vibrations in the lines, listening to the very interesting and unique acoustic and vibration signals that are produced when these events occur," said Barat. "For example, if you have vegetation hit a line, the line is going to be oscillating in a unique way. And those vibrations travel down through the pole, and we detect them."

Gridscope uses analog and digital signal processing and an advanced analytics engine to then process the sensor data locally and determine what action to take, such as whether to report activity to utility managers.

The team credits co-founder and mentor **Prabal Dutta,** associate professor of electrical engineering and computer sciences, with helping optimize the technology. The CITRIS Foundry provided key support to help them secure funding and launch their startup.

Currently, Gridware anticipates producing 100,000 units by the end of 2023. According to Barat, most utilities on the West Coast that have a wildfire mitigation plan are either on the waitlist for Gridscope or have engaged with the company. And their efforts have not gone unnoticed. Gridscope was recognized by Time magazine as one of the best inventions of 2022, and Barat, Chen and Bin Omar were featured on Forbes' "30 Under 30" list of top entrepreneurs.

For Barat, realizing his original vision has been incredibly rewarding — and an important reminder that everyone at Berkeley has the potential to make an impact, even a former high school dropout. "I stepped into EECS with a lot of self-doubt and a major case of imposter syndrome," he said. "But if I could rewind and show myself just a glimpse of where we are now and what we've built, I think that would be incredibly encouraging."

STORY BY MARNI ELLERY | PHOTO COURTESY GRIDWARE

Rajnikant Desai (M.S.'53 CE) died in November at the age of 94. His engineering firm, Raj Desai Associates, specialized in seismic engineering projects throughout California and Nevada.

Danard Emanuelson (B.S.'51 ME) died in November at the age of 95. He served in the U.S. Navy during World War II, and he later worked at the Avon Refinery, Tidewater Associated Oil Co. and TOSCO Corp.

Richard Fernandez (B.S.'66 ME; M.S.'68, Ph.D.'72 NE) died in October at the age of 80. He had a long career in the nuclear power industry and was a founding member of the Electric Power Research Institute.

Louis Flores (B.S.'60, M.S.'65 EECS) died in September at the age of 91. He co-founded the North Bay Human Development Corp., a nonprofit that assisted farmworkers and low-income people, and co-created Clinic OLE, which provided medical care. He also earned a law degree from UC Hastings and had a law practice.

Victor Galindo (M.S.'62, Ph.D.'64 EECS) died in January 2022 at age 93. Joining the Jet Propulsion Lab in 1974, he retired as senior research engineer reporting to the chief scientist. An award-winning expert on the analysis and design of antennas and phased-arrays, he last consulted for Princeton in January 2000 on the Microwave Anisotropy Probe antenna system design.

Edward Goeppinger (B.S.'49 ME) died in October at the age of 97. During World War II, he served in the U.S. Army. Following graduation, he worked at Bourns Laboratories for 40 years as an engineer, salesman and corporate officer.

James Graber (B.S.'58 ME) died in October at the age of 87. After earning his degree, he worked in the defense industry.

David Green (MEng '66 CE) died in October at the age of 80. He served as professor of structural engineering, dean and vice principal at the University of Glasgow in Scotland.

David Hodges (M.S.'61, Ph.D.'66 EECS) died in November at the age of 85. He joined the Berkeley faculty in 1970, where his pioneering work in integrated circuit design and semiconductor manufacturing helped ensure the continuation of Moore's law and contributed to the rapid growth of the tech industry. He served as the dean of Berkeley Engineering from 1990-96 and was highly regarded as an educator. He also held multiple leadership roles in IEEE and was a member of the National Academy of Engineering.

Robert Howard (M.S.'67 ME) died in October at the age of 80. He was an aeronautical engineer at Boeing Corp., working on the supersonic transport. Later, he started a gourmet food business and worked as the CEO of Reisen Lumber Industries.

Rudin Johnson (B.S.'50 EECS) died in October at the age of 96. During World War II, he served in the Army Air Corp. After graduating, he worked at Berkeley Lab for over 40 years.

Donald Johnstone (B.S.'64, M.S.'66 EECS) died in October at the age of 80. He earned his Ph.D. degree from Stanford University, then had a 44-year career working for various Silicon Valley companies.

Stephen Kenney (M.S.'73 CE) died in December at the age of 72. After a job as a civil engineer, he worked as a high school math teacher.

Robert Moe (MEng '57 CE) died in October at the age of 90. He worked as an engineer for the Wisconsin Department of Transportation, where he remained for the course of his career. Prior to Berkeley, he was a surveyor with the U.S. Army Corps of Engineers.

Peter Molinari (B.S.'49 Agricultural Engineering) died in December at the age of 97. He served in the U.S. Army, and over his career, worked as an engineer for Soule Steel as well as in the insurance industry.

Stephen Nesvold (M.S.'76 ME) died in December at the age of 74. He worked as a civil engineer at Omsburg & Preston for 22 years.

Randall Pack (M.S.'71 NE) died in December at the age of 82. A U.S. Navy veteran, he worked at the Electric Power Research Institute, the Institute for Nuclear Power Operations and General Physics Corp. In 1997, he earned a master's degree in computer science at Johns Hopkins University and then worked as a consultant.

Clements Pausa (B.S.'53 Metallurgy, M.S.'54 MSE) died in December at the age of 92. He served in the U.S. Navy during the Korean War and in the reserves for 20 years, retiring as a captain. Over the course of his career, he held leadership roles at National Semiconductor, Power Integrations, Alphatec Group and PricewaterhouseCoopers.

James Quist (B.S.'69, M.S.'74 ME) died in September at the age of 75. He was a member of the U.S. Army Reserves, and he worked as an engineer for major companies, including Brown & Root, Pacific Gas and Electric Co., Duke Energy Corp., Chevron Corp. and Bechtel Corp.

John Ravera (B.S.'60 EECS) died in November at the age of 88. He worked at Sacramento Municipal Utility District for 30 years, then went to work at PTI, where he developed and taught a power generation and transmission course.

David Charles Riley (Ph.D.'88 EECS) died in October at the age of 76. He worked at NASA on its Stellar Tracking Rocket Attitude Positioning (STRAP) System, related to identifying sources of energy outside our solar system. He worked as a professor at California Polytechnic State University, San Luis Obispo, and then joined Eneron, researching innovative fluorescent lighting.

Robert Sawyer died in November at the age of 87. A professor emeritus of mechanical engineering, he joined the Berkeley faculty in 1965. He was a member of the National Academy of Engineering, and he was considered a renowned expert in air pollutant emissions and their control.

Harold Scates (B.S.'58 ME) died in August at the age of 94. He served in the U.S. Army during World War II, then worked as an engineer until retiring from the Port of Oakland.

Ronald Schmidt (B.S.'66, M.S.'68, Ph.D.'71 EECS) died in September at the age of 78. He worked at Bell Labs and Xerox PARC before co-founding SynOptics Communications Inc. A pioneer in the field of intelligent LAN hubs over shielded twisted pair telephone wire, he was a member of the National Academy of Engineering, a UC Berkeley Foundation trustee and longtime member of the Berkeley Engineering Fund board.

Richard Smith (B.S.'46 ME) died in October at the age of 97. A veteran of the U.S. Navy, he worked at General Electric Co. for 44 years.

John Taber (M.S.'50 EECS) died in November at the age of 97. He worked at Hughes Aircraft and at TRW Inc. on satellite communications systems. His concept for Landsat image processing earned him the NASA Medal for Scientific Achievement in 1974.

Philip Threefoot (B.S.'61 EECS) died in August at the age of 84. He served in the U.S. Army for 32 years, rising to the rank of colonel and earning a master's degree in computer science from Stanford University. Following military retirement, he had a second career as a software engineer.

Roger Tokunaga (B.S.'56 Agricultural Engineering) died in July at the age of 90. He served in the U.S. Army during the Korean War and was awarded the Bronze Star. Later, he worked as an engineer and was the co-owner of Von Geldern Engineering.

Bernard Weiss (B.S.'58 EECS) died in September at the age of 90. He worked as an electrical engineer, and later, as a builder throughout Southern California. During the Korean War, he served in the U.S. Air Force as a radar technician.

Keegan Houser

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"Fire has been a field that everywhere you turn your head and look, you think, 'Let's see if we can make a solution to a real-world problem.'"

- Michael Gollner, associate professor of mechanical engineering

FIRE RESEARCH LAB PHOTO

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