College of Engineering
University of California, Berkeley
Spring 2021
Volume 19

The health lab in your pocket
COVID-19 tests via smartphone

The future of our cities
What's next in transit, energy

Berkeley ENGINEER

Coming to light

Monitoring infrastructure with advanced sensor technologies

Next-gen engineering leaders

In just a few weeks, we will be honoring our 2021 graduates with a virtual commencement ceremony, celebrating their milestone achievement at the end of an extraordinary year. They will be embarking on their next stage in life equipped with technical knowledge and skills for which Berkeley engineers are well known — and with perspectives that have been profoundly influenced by their experiences over the past year.

The pandemic has brought to light inequities that persist in our society, as it has disproportionately impacted people of color and low-income households, while ongoing political unrest and racial violence have laid bare the pervasiveness of hate and racism in our country. The fact that technology designed and built by engineers — such as broadband communications technology and social media platforms — has played a role in each of these issues has spurred us to take action to better prepare students to become engineering leaders.

Last year, Berkeley Engineering launched its Grand Challenges Scholars Program (GCSP) to provide a framework for engineering students to develop a broader range of competencies necessary to address society's greatest challenges. Participants in this program develop awareness and skills for considering cultural, political, social, ethical and economic contexts for engineering solutions. To graduate as a GCSP scholar, students must demonstrate not only technical talent but also multicultural competency, multidisciplinary knowledge, entrepreneurship and social consciousness.

We aim for our graduates to become inclusive leaders who support and inspire others. Thanks to a generous gift from an alumnus, the college is now developing a new program to connect Berkeley Engineering students with mentors in their fields of study; to recognize outstanding mentors among our faculty, staff, students and alumni; and to promote best practices for mentorship. The new Berkeley Mentorship Cohort program will launch in the fall, with the goals of supporting student success and transforming students into effective mentors by the time they graduate.

I am inspired by the resilience and community spirit of our students, faculty and staff in weathering the unprecedented challenges of the past year, and also deeply touched by the generosity of our alumni, parents and friends whose contributions have helped to sustain — and elevate — our mission to educate leaders, create knowledge and serve society.

As we look forward to returning to campus, resuming in-person classes and meetings this fall, I am excited to apply the insights gained over the past year to innovate new programs that will empower Berkeley engineers to create a better, more equitable future for all.

Fiat Lux!

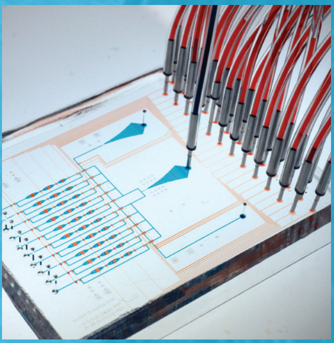
—*Tsu-Jae King Liu*
DEAN AND ROY W. CARLSON PROFESSOR OF ENGINEERING

We aim for our graduates to become inclusive leaders who support and inspire others.

In March 2021, materials science professor Gerbrand Ceder held an outdoor class for graduate students.

Adam Lau

in this issue



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> COVER PHOTO: **Civil and environmental engineering professor Kenichi Soga**

PHOTO BY **ADAM LAU**

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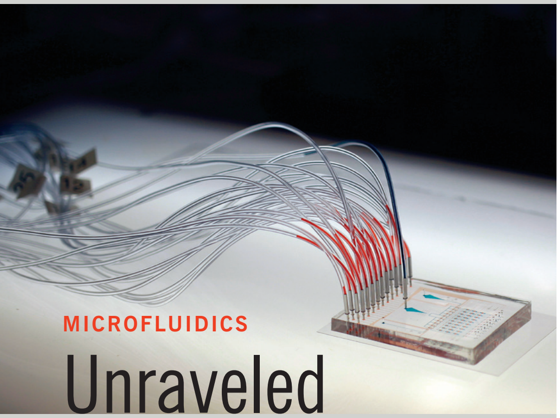


Annie Maslan

MICROFLUIDICS

Unraveled

Think about untangling a ball of yarn hundreds of feet long and trying to re-wind it in exactly the same way — that's essentially what a cell does with its DNA every time it divides. Now, new research from assistant professor **Aaron Streets'** bioengineering lab attempts to make sense of this process, using a novel technique for unraveling and imaging lengthy strands of DNA. Their microfluidic platform, µDamID (or MicroDamID), can trap a single cell and then apply DNA sequencing to read exactly which sequences are where inside of it.

While microscopy still represents the gold standard for validating where molecules are in a cell, high-throughput DNA sequencing technologies have allowed researchers to sequence the DNA and RNA from single cells, providing rich information about the information that is encoded in our genome. Until now, it's been very difficult to take a picture of a single cell with a microscope and then pick that cell from the microscope slide and sequence its DNA.

"MicroDamID is a technique that takes a picture to 'see' where proteins are binding to DNA inside the cell, then sequences the DNA at those same binding sites from the same single cell to reveal where they are in the genome," said bioengineering Ph.D. student **Nicolas Altemose.** "It's hard enough to do one or the other, but this tool allows us to measure and understand both the spatial and the linear organization of the DNA. It improves our ability to create these protein-DNA binding maps to study how DNA is regulated in the nucleus."

Possible applications of the technology include areas such as meiotic recombination and chromosomal segregation, as well as studying other key processes that differ among individual cells.

CHEMISTRY

It's elemental

New research coming from nuclear engineering assistant professor **Rebecca Abergel** — working in collaboration with colleagues from Berkeley Engineering, Berkeley Lab, Los Alamos National Lab and other institutions — could lead to better cancer treatments as well as improve our fundamental knowledge about a little-known element.

In an advance that could ultimately transform therapies for certain cancers, Abergel and her fellow researchers developed new methods for the large-scale production, purification and use of radioisotope cerium-134. The team was successful in using cerium-134 as a new material for targeted alpha therapy (TAT), a treatment in which alpha-emitting radioisotopes are guided to cancer cells by molecules such as antibodies, destroying the cancer cells but leaving healthy tissues unaffected. Other isotopes — including actinium-225 and thorium-227 — have been used for TAT, but researchers are unable to monitor where these drugs are going in patients, even with the use of positron emission tomography (PET). Now, by tuning the oxidation state of cerium-134 and encapsulating it in metal-binding molecules called chelators, the researchers showed that it, too, could be utilized for TAT, with the added benefit of being detectable through PET. This work could allow clinicians to watch a patient's response to these targeted therapies in real time, as well as make such treatments more widely available.

In a second study, Abergel and another group of researchers reported the first measurements of einsteinium, otherwise known as atomic number 99, a synthetic element that is part of the actinide series on the periodic table. Because einsteinium is highly radioactive, rapidly decays and is difficult to work with, scientists have learned very little about it since its discovery in 1952. But the team, using just 200 nanograms of the element, were able to determine an einsteinium bond distance — a basic property that indicates the average distance between two bonded atoms — and found that it differs from what would be expected based on studies with other actinides. Their findings could make it easier to purify einsteinium in the future, study other elements in the actinide series and even discover new elements.

Marilyn Sargent/Berkeley Lab

SUSTAINABILITY

Out of the bag

Plastic bags have a harmful impact on the environment, but recycling polyethylene, which makes up one-third of all plastic production worldwide, has proven difficult. There's little economic incentive, as recycled bags end up in low-value products, such as decks and construction materials. But a new chemical process, developed by a UC Berkeley research team, converts polyethylene plastic into a strong and more valuable adhesive, potentially changing that calculus.

The researchers — including **Phillip Messersmith,** professor of bioengineering and of materials science and engineering, working with chemistry professor **John Hartwig** — used a ruthenium-based catalyst, polyfluorinated ruthenium porphyrin, to produce a polyethylene compound that sticks tightly to aluminum metal. By adding a relatively small percentage of alcohol to the polymer, researchers were able to boost adhesion by a factor of 20. Getting polyethylene to adhere to things promises many potential applications, including artificial hip sockets and knee implants, coating for electrical wire, glues that stick other polymers together and more durable composites of plastic and metal, as in toys.

While the process is not yet economical for industrial use, researchers believe that it can be improved and could be the starting point for adding other properties besides stickiness. The success also hints that other catalysts could work with different types of plastics — such as the polypropylene found in recycled plastic bottles — to produce higher-value products that are more profitable.

MATERIALS

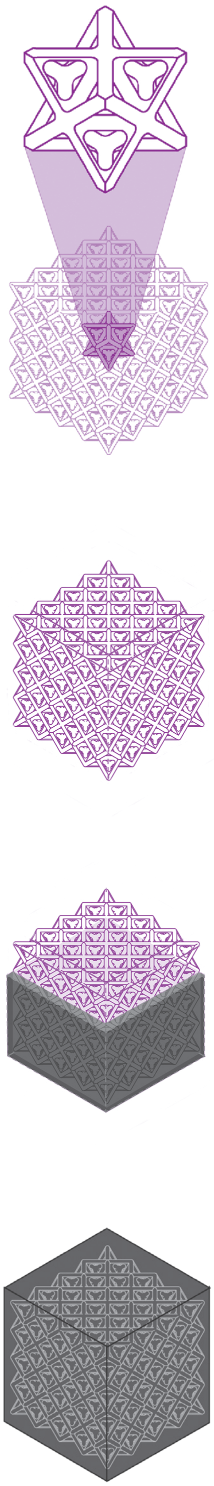
A new twist

By stacking layers of graphene on top of each other and twisting them, a research team led by associate professor of materials science and engineering **Jie Yao** has converted a common linear material into one with nonlinear optical capabilities crucial to everyday technology — from spectroscopy and material analysis to communications and computing.

In the study of optics, scientists distinguish between linear and nonlinear materials, which are rare. Unlike linear materials, nonlinear materials can combine multiple photons into one; for example, in the second-order nonlinear process, the frequency of the resulting photon is double that of the original, so it has twice the energy. But by twisting two single-atom-thick sheets of graphene in opposite directions, the team showed that it's possible to fine-tune a linear material's ability to combine photons, which practically converts a linear material into a nonlinear one.

To twist the layers of graphene, the researchers relied on a seemingly low-tech approach. **Fuyi Yang,** a Ph.D. student, used tape to peel layers of graphene off a large graphite crystal. She then used a piece of hexagonal boron nitride, which can attract sheets of graphene like a magnet, to lift and place the graphene layers on top of each other at an angle, producing samples of bilayer graphene at varying twist angles. By tuning the twist angles of the graphene samples, the team was able to achieve resonant second-harmonic generation, which combines photons into one with much greater efficiency.

While the research showed that graphene can be turned into a nonlinear material, Yao said it's just a milestone toward the ultimate goal: to make two layers of graphene twist on command. The discovery might one day be used to enhance the performance of the silicon microchips found in nearly all laptops, tablets and phones, as faster photonic circuitry is increasingly combined with traditional electronic circuitry.



Courtesy the researchers

STRUCTURAL ENGINEERING

Bring in the reinforcements

Since the mid-19th century, engineers have reinforced concrete with steel rebar. But today, engineers are exploring the potential to reinforce concrete with polymers, which are lightweight, don't corrode and, due to an abundance of recyclable materials, could be cheap to produce.

In a study led by **Hayden Taylor,** associate professor of mechanical engineering, researchers developed a new way to reinforce concrete by using a 3D printer to build octet lattices out of polymer and then filling them with ultra-high performance concrete (UHPC), which is four times stronger than conventional concrete in compression. The work was done with civil and environmental engineering professor **Claudia Ostertag's** lab, building upon a previous collaboration to create octet-lattice structures from UHPC by using 3D-printed molds.

In creating the octet lattices, the team tested two different polymers: polylactic acid (PLA), which is easy to 3D print but more brittle than other polymers, and acrylonitrile butadiene styrene (ABS), which is tougher than PLA and used in everything from Lego bricks and motorcycle helmets to whitewater canoes and car bumpers. Switching from PLA to ABS made no significant difference in compressive tests; all of the lattice-reinforced concrete samples scored high in strain energy density values, meaning they were able to absorb a lot of energy.

The engineers also experimented with the amount of lattice reinforcement used in the concrete. While increasing the amount of polymer in the samples slightly decreased their compressive strength, it actually increased their peak loads in bending tests. However, the samples with less polymer were just as tough as those with more. Increasing the amount of polymer — and reducing the amount of concrete — could also cut down on a structure's overall carbon emissions if recycled or bio-based polymers are used.

The next step, said graduate student and study lead author **Brian Salazar,** will be to determine if different concrete uses would be better served by different lattice shapes. In the future, engineers might determine the best reinforcement geometry for a given project with the help of topology optimization software.

Courtesy of the Rabaey Lab

BIOSENSORS

Read my hand

Imagine typing on a computer without a keyboard, playing a video game without a controller or driving a car without a wheel. This may soon be possible thanks to a device, developed by a team led by electrical engineering professor **Jan Rabaey,** that can recognize hand gestures based on electrical signals detected in the forearm. The system, which couples wearable biosensors with artificial intelligence (AI), could one day be used to control prosthetics or to interact with almost any type of electronic device.

The researchers — including lead authors **Ali Moin** and **Andy Zhou** — collaborated with **Ana Claudia Arias,** professor of electrical engineering and computer sciences, to design a flexible armband that can read electrical signals at 64 different points on the forearm.

The electrical signals from the armband are fed into an electrical chip, which is programmed with an AI algorithm capable of associating these signal patterns in the forearm with specific hand gestures.

To teach the algorithm how electrical signals in the arm correspond with individual hand gestures, each user wears the cuff while making hand gestures one by one. The algorithm can recognize 21 individual hand gestures including a thumbs-up, a fist, a flat hand, holding up individual fingers and counting numbers.

The device uses a hyperdimensional computing algorithm that can update itself with new information. For instance, if the electrical signals associated with a specific hand gesture change because an arm gets sweaty or a hand is raised above a user's head, the algorithm can incorporate this new information into its model.

All of the computing occurs locally on the chip. Not only does this speed up the computing time, but it also ensures that personal biological data remain private.

Q+A on the future of our cities

Marta González, associate professor of civil and environmental engineering and of city and regional planning, studies the intersections between people within social networks and the built and natural environments. Her research uses big data to understand behavior in such areas as transportation, energy and disease proliferation. We spoke with her about how the pandemic and climate change are affecting urban areas.

Adam Lau

What's the future of urban environments?

Short term, one of the biggest challenges for urban planning is likely to come from changes in the way we move around. Until COVID-19 is eradicated, people will be cautious of close proximity. They'll continue to avoid taking public transportation by walking, cycling or driving their own cars. What the new long-term normal will look like is still highly speculative. We could see more walkable cities, more working remotely from home, a decline in international travel and a move to localize manufacturing and healthcare. Alternatively, we could see more sprawl as people migrate from big cities to small towns, which could mean an increase in car travel and a decline in public transport.

What are some of the biggest challenges facing our cities, and how are we using technology to address them?

Continuous population growth creates a disparate quality of life and availability of services in urban populations, adversely impacting our natural and social environments. Unaffordable housing, acute pollution, power blackouts and congested travel are some of the current key challenges. In my research, I'm investigating how to promote and prepare for the adoption of engineered technologies — such as electric cars, photovoltaics, house sensors and smart phones — while remaining vigilant of the public good. Urban solutions are often a compromise between information systems and understanding human behavior. Challenges such as housing, mobility and energy have come with negative consequences like air pollution, congestion and sprawling.

What are some examples of projects that are finding positive solutions to these problems?

In Bogotá, Colombia, we used mobile phones and data from a local fitness app to learn that there are 4.1 million short- to medium-length trips made across the city every day that could be done by bicycle instead of by car. In response, the city built nearly 50 miles of temporary bike lanes to reduce crowding on public transport and help prevent the spread of COVID-19, as well as to improve air quality. In another project, we used optimization, data and modeling to pinpoint underserved neighborhoods in six cities. We found that accessibility to public facilities could be improved by as much as 50% if they were more optimally distributed. Such problems as the pandemic and climate change can actually be forces for improving the quality of life in our urban areas.

At the intersection of cities and climate change, what is our greatest obstacle?

To mitigate the current trends of our global environmental footprint, we need to better understand the sources of greenhouse gas emissions (GHGs) and develop more science-based policies. There are many data sources that we can use to model everyday human activities, but there's a disconnect between "ubiquitous computing" and the best practices proposed by those studying environmental sciences, urban planning and public policy. Until we improve that connection, we won't be fully able to solve the GHG problem.

What makes you optimistic about the future of cities?

Paris is exploring a new model for urban planning called "the 15-minute city," in which everything a resident needs can be found within 15 minutes of their home by foot or bike. We know that people are happier living in a village environment, and there are many European cities following this model. We've also learned from the pandemic that it's possible to dramatically reduce our miles traveled, particularly for work. Once the lockdown is over, we don't have to go back to peak-hour commute traffic. We now know that we can be more creative with our schedules and work environments. Finally, there's a global move toward making all government and commercial vehicles electric. China, France and Germany are leading the way on this effort, and it makes me very optimistic for the future.

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

Smooth operator

As the use of online shopping has skyrocketed, so have consumers' expectations for quick and accurate deliveries. This has led to a pace of activity in warehouses that is incredibly demanding on workers.

Assistance from robots could help ease the workflow and optimize output, but it's been a challenge to integrate them into these types of workspaces. In assembly lines, robots perform the same tasks repetitively. But in warehouses, robots need to grasp and move objects of varying shapes and sizes, requiring them to make many adjustments. If their movements are jerky, it can damage the object, as well as lead to wear and tear on the robot.

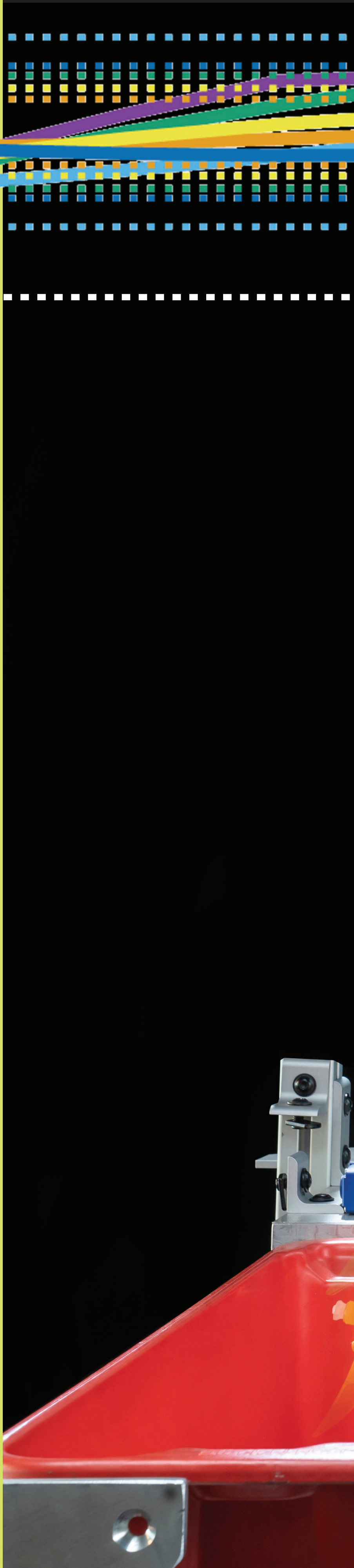
But a solution may be at hand. A research team led by **Ken Goldberg,** professor of industrial engineering and operations research and of electrical engineering and computer sciences, has developed artificial intelligence software that allows robotic arms to quickly grasp and move objects in a smooth and steady motion.

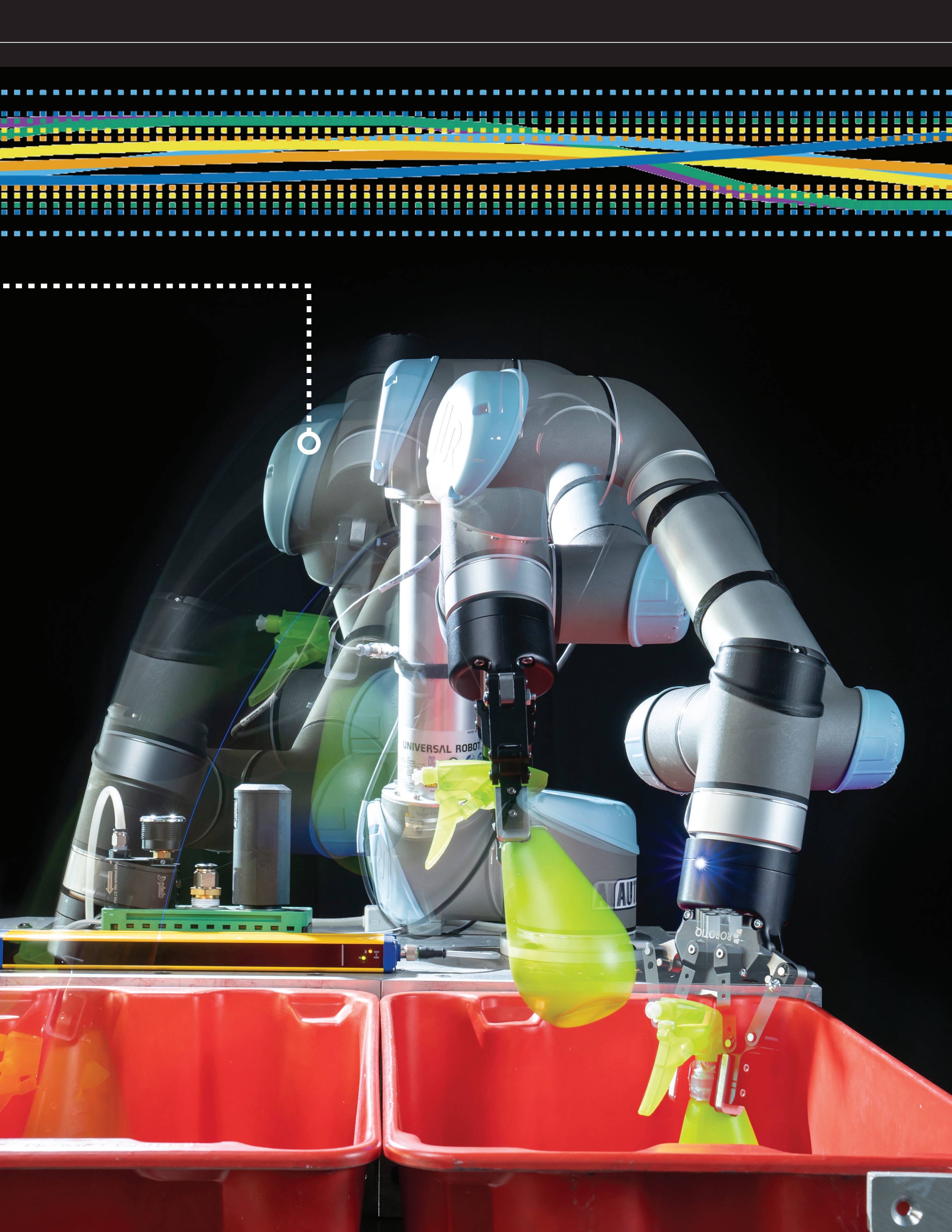
Previously, Goldberg and postdoctoral researcher **Jeffrey Ichnowski** had created a grasp-optimized motion planner that computed the most efficient way for robots to handle and move objects, but when they modified the software to smooth out the motions, it significantly slowed everything down, making the system impractical.

To address this challenge, the research team — including graduate student **Yahav Avigal** and undergraduate student **Vishal Satish** — combined a deep learning network with the motion planner. After sampling thousands of motions that a robot would likely make, they used them to train the deep learning network, which then proposed trajectories of varying lengths and selected the optimal one. The motion planner used that information to identify the best starting point for planning the smoothest trajectory to use. This integration proved to be key, allowing the team to cut the average computation time from 29 seconds to 80 milliseconds, or less than one-tenth of a second.

The researchers hope to expand this work to other robotic tasks in complex environments, as well as test new approaches to further speed up the deep learning process.

PHOTO BY ADAM LAU




UNIVERSAL ROBOT


GLADSTONE
INSTITUTES
OTT LAB

The Health Lab in Your Pocket

A COVID-19 test is Dan Fletcher's latest transformation of cell phones into mobile diagnostic tools

STORY BY ANN BRODY GUY • PHOTOS BY ADAM LAU

The actual virus detection takes as few as five minutes.
The reaction uses CRISPR, a technology that can locate specific genetic sequences inside cells, to send in specialized molecules to find the virus.

Swab your nose, plunge the sample into a reaction chamber, insert the chamber into a cellphone-based device, then press "go." In as little as 15 minutes, you'll likely know whether you're positive for COVID-19, with an unprecedented combination of speed and accuracy. If you're positive, you'll also learn how much viral load you're carrying — valuable information about the severity and transmissibility of an infection. Additional research is underway to make the same test identify which variant of the ever-mutating coronavirus you've got.

So where can you go to get this test?

"The point is, you wouldn't have to go anywhere," says bioengineering professor Dan Fletcher, who developed the test in partnership with Berkeley's Nobel Prize-winning biochemist Jennifer Doudna and UCSF professor of medicine Melanie Ott, director of the Gladstone Institute of Virology. "The whole goal is that it would be a point-of-care test — it would be right where people are."

The lack of widely available testing has been a major roadblock to containing a virus that people can spread without showing, or even feeling, any symptoms. Having a quick, affordable and accurate test to place at hyper-local community locations — schools, airports, churches or even large gatherings like concerts or weddings — would be a critical new tool in controlling the pandemic, enabling the identification and isolation of carriers before they have a chance to spread the disease, which has killed more than 2.5 million people worldwide and caused economic and social upheaval.

Several portable COVID-19 tests are in use or heading to market, but they are expensive, inconsistent and don't quantify viral load. The smartphone's advanced camera and processing abilities make the device uniquely suited to powering a mobile diagnostic lab. By adding some low-cost optical equipment, the Fletcher lab's COVID device converts the smartphone camera into a microscope, and the phone's powerful microprocessors support custom software that processes and analyzes results right on the phone instead of requiring a lab or computer to do so.

Standard-issue smartphone technology can geotag results, a potential aid in mapping the emergence of outbreaks and variants, and upload test data directly to a server. The ecosystem of apps and services promises even more connectivity in future iterations, Fletcher says, such as sending test data straight to an individual's electronic medical record or a county public health office.

Retrofitting a smartphone is far less expensive than building a custom device with these same advanced capabilities because consumer tech companies keep upping their game, packing in more processing power and better features to entice consumers to upgrade. Fletcher is simply leveraging the mass-production of these mini supercomputers to build a sophisticated, portable medical device. "It's really amazing — we're just riding the wave of what consumers want," he says.

The actual virus detection takes as few as five minutes. The reaction uses CRISPR, a technology that can locate specific genetic sequences inside cells, to send in specialized molecules to find the virus, as the project team documents in a study published in the journal Cell in January.

With support from the National Institutes of Health, Google.org and others, the team is preparing to scale up, making the components more manufacturing-friendly. A dedicated phone is the core of the device. "An app on that phone will run the whole system," Fletcher says.

Flipping on the light switch

And what, exactly, is that system? When coronavirus RNA, which carries the genetic information the virus needs to replicate, is present in a sample, the camera, outfitted with optics for microscopy, captures images of fluorescence in the reaction chamber that it's focused on. The result is quantitative — the more fluorescent the sample becomes across a series of time-lapsed images, the higher the viral load. No fluorescence, no virus. It sounds simple, but a lot of novel bioengineering is packed into that signaling mechanism.

In addition to co-developing CRISPR-Cas9 — the Nobel Prize-winning gene-editing technology that finds and cuts a specific sequence in the vast genetic material of DNA — the Doudna lab also demonstrated that another sequence-hunting enzyme, Cas13, has applications to virus detection. For their COVID test, the team sends in a Cas13 guide to look for coronavirus RNA in a sample. They prime the guide with a pair of molecules, configured by Doudna, that will fluoresce when the Cas13 enzyme snips them. The pair acts as a light switch set to the off position, programmed to flip on when Cas13 cuts the connection.

"We use that as a way of turning on a signal to say, 'Yep, I've found what you told me to look for,'" Fletcher explains — in this case, coronavirus.

Key to the test's speed and accuracy is a process called amplification — or rather, the lack of it. Standard COVID-19 laboratory tests convert viral RNA in a specimen into DNA, then copy it multiple times to make the DNA easier to find. However, amplifying a sample means the test doesn't look at the actual virus information, just a transcribed, magnified version of it. That's why current COVID testing can't provide precise viral-load quantities, while the Fletcher lab's direct-detection method — no transcription or amplification — can do so with great accuracy, and, Fletcher expects, it will significantly reduce the problem many tests have with false positives and negatives.

"Avoiding amplification avoids the problems with it — there's just less noise there," he says.

But skipping the amplification step requires a highly sensitive optical system to "see" the faint florescent light turning on. Fortunately, Sungmin Son, a postdoc in Fletcher's lab since 2013 and co-lead author of the Cell study, is an expert in precision measurement tools.

Son, who earned his doctorate in mechanical engineering from MIT, sidelined his work on basic biological problems to focus on the COVID device, assembling the optics, a laser and a mobile phone camera that illuminates and detects even an extremely dim signal from a positive sample. With the pandemic's urgency pressing on them, he and the team completed the task in about three months — lightning speed for research. The smartphone's ready-made components were key to this speed, Son notes, allowing prototyping without having to assemble a device with its own camera, circuits and processors.

María Díaz de León Derby, a doctoral candidate in the UC Berkeley-UCSF joint bioengineering program and co-lead author with Son and the Ott lab's Parinaz Fozouni, notes that while a few labs have used Cas13 to detect viral RNA, doing so without amplification is new. "We showed that we can get to a very sensitive level of detection without pre-amplification," she says.

She also felt intense time pressure, but notes that the project's payoff will extend well beyond COVID-19. "We now have this detection system we can use to find other diseases," she says. "One of the coolest things about our technique is that to switch to a different disease, you really just have to change the RNA sequence you're looking for."

An ethos of collaboration

The quick progress also reflects the Fletcher lab's culture of collaboration. In a typical hyperspecialized academic environment, Son says, he'd simply publish his method, then wait to see how it was applied. In Fletcher's lab, he says, "You can actually see the applications of your research within your own lab." And, he adds, it goes both ways. "The questions people are asking become my inspiration for developing a new technique."

Other specialties in the lab include nanotechnology, biomedical engineering, biophysics and chemistry. "As we try to answer basic questions and solve real problems, we need perspectives from different fields and life experiences," Fletcher says. He also values enthusiasm. "Much of the material — the facts, the systems — can be learned," he says. "But it's very hard to teach excitement."

Fletcher, who once imagined a career pursuing basic questions from the inside of a microscope room, says his work with the Ott and Doudna labs has convinced him that collaboration is central to solving big problems.

And, while he initially didn't set out to focus on public health, the real-world applications of his work have been exciting and also have brought intellectual rewards. "I'm finding that addressing practical problems can raise fundamental questions," he says. "How do we rapidly detect the presence of a virus? How do we identify the presence of other pathogens? They involve very basic questions about how enzymes work and how infectious diseases and their hosts try to outsmart each other. I find those questions fascinating."

The power of diagnosis

Fletcher, Ott and Doudna were able to get the COVID test moving as early as February 2020 because they already had been collaborating on an HIV test with the same components — a Cas13-based fluorescent light switch that avoids amplification.

The HIV-detection work was itself an outgrowth of Fletcher's dozen-plus years of cell-phone-based microscopy at UC Berkeley's Blum Center for Developing Economies. That work started, as many great discoveries do, accidentally — getting a cellphone camera to take microscopic images was a last-minute assignment for his Optics and Microscopy class. Working with his students on the project, Fletcher realized he was onto something,

"We now have this detection system we can use to find other diseases. One of the coolest things about our technique is that to switch to a different disease, you really just have to change the RNA sequence you're looking for."

and the work that would become the CellScope quickly developed into one of the major thrusts of his lab, together with basic biophysical research on pathogens and the immune system.

One major CellScope application detects, in minutes, the presence of the Loa loa worm in a simple finger-prick blood sample. The worm can cause dangerous, even deadly side effects to an otherwise safe treatment for river blindness, a devastating parasitic infection that is a leading cause of preventable blindness in the world and affects mainly developing countries in sub-Saharan Africa. In a 2015 pilot in Cameroon, local health workers used Fletcher's device, named the LoaScope, to clear more than 15,000 patients for immediate — and safe — river blindness treatment. The Gates Foundation is supporting a scale-up of the device, and the Fletcher lab is piloting the same the system to detect schistosomiasis, another parasite-transmitted tropical disease.

While the lab also is exploring CellScope modifications to detect malaria and tuberculosis, Fletcher's current priority is so-called neglected tropical diseases.

"Malaria and tuberculosis get more attention because they're killers," he says. "For neglected tropical diseases, the death toll is not as significant, but the impact on quality of life is tremendous." People don't generally die directly from river blindness, he says, "But if you're blind in a region where there's zero support for anyone with disabilities, and if you're a burden on your family and you can't work, these diseases reinforce poverty."

And because such diseases are treatable, there's potential for enormous progress. "Treatments can be provided if we know which patients need what," he says. "That's why the diagnostics are so important."

Decentralizing healthcare

Fletcher envisions a world where affordable, mobile diagnostic tools like his are ubiquitous and, eventually, even work on our personal phones. Such tools can help bring healthcare equity to perpetually underserved communities, from the 46 million Americans who live rurally to the under-resourced urban communities that have seen less care and more illness and death from COVID-19.

"I hope the silver lining of the pandemic is that we rethink the centralized clinical laboratory approach to taking a measurement and figuring out if someone is infected with something," Fletcher says.

In addition to diagnostic power, more far-reaching and efficient data collection could lead to research insights about how immune systems behave based on who we are, and where and how we live, he says — information that could help mitigate social disparities in health and efficiently document disease outbreaks.

Arguably, such technology-driven decentralization has already started, with the coronavirus's extreme transmissibility increasing the demand for telemedicine. Our cell phones have enabled decentralization in other fields — we flash e-tickets instead of lining up at airport counters and venue box offices; we deposit checks from home. Why not employ mobile phones for healthcare?

And, while tools like the LoaScope can help to disrupt entrenched cycles of poverty for some of the poorest and most remote populations in the world, "the pandemic has revealed many of the problems that plague all of us," Fletcher says, such as testing and treatment limitations. "We started working in developing countries because that's where the need seemed most urgent," he says, "but it's now become clear that the need is everywhere." BE

COMING

MONITORING INFRASTRUCTURE WITH ADVANCED SENSOR TECHNOLOGIES

STORY BY JAMES STEINBAUER

The East Bay Municipal Utilities District, or EBMUD, provides water for 1.4 million people in a roughly 332-square-mile area on the eastern side of the San Francisco Bay, operating more than 4,000 miles of water pipelines in one of the most seismically active places in North America. The Hayward Fault, which produced one of the most destructive earthquakes in California history and may be ready for another, runs right down the middle of the entire length of the utility's service area.

Until now, there's been no way for EBMUD to monitor its underground network of pipelines. By the time the utility knows a pipe is stressed, it's often too late to do anything about it. But new technology developed by Kenichi Soga, professor of civil and environmental engineering, has the potential to change that, allowing engineers to monitor for tension and compression in real time so they can fix stressed pipes before they break.

Distributed fiber optic sensing, or DFOS, is a system of fiber optic cables and sensors that has enormous potential for changing the way we monitor infrastructure, agriculture and a wide range of complex systems. DFOS uses standard fiber optic cables — the type used for high-speed internet connection — to detect potential vulnerabilities in large-scale structures and surfaces. When light is beamed through a fiber optic cable, a portion of that light bounces back toward the source, a phenomenon known as backscattering. Because the speed of light is constant, the time it takes for the light to return to its source can tell engineers where the backscattering was generated. Physical changes along the light's path — such as temperature and strain — alter the magnitude and frequency of the backscattered light.

Unlike other monitoring systems, DFOS can provide virtually seamless measurements over great distances. Most conventional strain measurement systems focus on a single point. They might offer some gauge length, but it tends to be on the order of just a few inches. This is fine if an engineer is looking to measure strain in a specific area, but when it comes to monitoring system-wide behavior, DFOS is hard to match.

"With DFOS, we can get information from every point along a fiber optic cable, and we can get it for tens of miles," Soga says.

TRACKING A TECTONIC TERRAIN

When David Katzev, a senior civil engineer for EBMUD, was first introduced to Soga's technology, he immediately recognized its potential to monitor the performance of EBMUD's underground pipes. The East Bay's tectonic terrain causes between 800 and 1,000 water main breaks every year, Katzev says. EBMUD currently replaces 20 miles of the pipeline a year, and they need to double that number to achieve the 1% replacement rate targeted by most utility companies.

TO LIGHT

Researchers install DFOS at the Crossrail's Liverpool underground station construction site in London to monitor movement of the tunnel during construction. The work was done by a team from the University of Cambridge's Center for Smart Infrastructure and Construction, which was established by professor Kenichi Soga and Cambridge professor Lord Robert Mair in 2011.

MATTHEW WILCOCK PHOTO

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"We can't double our staff to double pipe replacement," says Katzev, who helps lead the utility's Pipeline Rebuild program. "So we're constantly looking for innovative ways to improve our efficiency and create a sustainable long-term replacement strategy."

DFOS would also give EBMUD the ability to fix its pipes faster — and with fewer resources. Katzev laid out one potential scenario: Say a 1,000-foot-long water main breaks repeatedly in its center. Without a distributed sensing system, there's no way of knowing if the breaks occurred due to strain in just one area or if the entire pipe is compromised, so EBMUD might replace the whole thing. With DFOS, engineers would know how every inch of the pipe is responding to its environment and could target specific portions of the pipe that need to be replaced.

"We know that when that 7.0 magnitude earthquake on the Hayward Fault hits, there are going to be a lot of main breaks. This technology will help us get the system up and running faster," Katzev says. "It has tremendous potential. It could really work for us."

Katzev says EBMUD has pinpointed a few pipes that run adjacent to and across the Hayward Fault where he would like to incorporate DFOS. And as the utility begins to adopt the sensing technology more, it will gather data on not only its pipes but the landscape as well. It will get a clearer picture of the geographic distribution of earthquake damage and learn where the ground is subsiding or where soil corrosion poses the largest threat. The more EBMUD knows about ground movement in its service area, the better it can design its pipeline system for the future.

"Future infrastructure will need to be able to adapt to changes in its environment," Soga says. "With distributed fiber optics, we no longer have to suffer from aging infrastructure. We can transform it."

SEEING THE INNER WORKINGS OF INFRASTRUCTURE

For the California Department of Transportation, or Caltrans, DFOS isn't just a better system for monitoring existing infrastructure, but a superior tool for building it.

In 2016, during construction of the new 9,000-foot-long Gerald Desmond Bridge in Long Beach, California, Caltrans ran into a monitoring problem. Plans for the bridge's foundation consisted of 352 underground concrete shafts bolstered by base grouting, a process of injecting grout beneath a foundation pile to reduce settlement and improve stiffness.

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But during the base grouting process, engineers found they couldn't inject very much grout before the pressure started to skyrocket. "Everyone had an expert opinion on what that meant," says Tom Shantz, a senior research engineer at Caltrans. "But it wasn't clear if those shafts should be accepted."

Caltrans determined it could not approve a base grouted shaft for future projects unless it could verify that the grouting process transferred a sufficient load up into the shaft. The question, then, was: How?

Typically, engineers will measure the flow rate and pressure of grout as it is injected into the ground below a shaft — a method that, at best, produces an educated guess. Short of conducting

1 Postdoctoral student James Chien-Chih Wang tests DFOS technology at a San Francisco Public Utilities Commission construction site. DFOS cables buried underground monitored changes in the surrounding sediment as a drill rig (seen at right) ran over a prescribed track.

2 Graduate student Peter Hubbard sits atop a water pipe, sourced from EBMUD for testing. DFOS allows researchers to monitor any changes in shape or potential cracks in the pipe itself.

3 Civil and environmental engineering professor Kenichi Soga holds a length of fiber optic cable.

ADAM LAU PHOTOS

a load test on each shaft, which would be prohibitively expensive, there's no way of knowing if the pressure from the grout is pushing against the base of the shaft.

So Shantz turned to Soga, who told him that DFOS could provide a relatively inexpensive and scalable way to measure strain during base grouting.

"As engineers, it's important for us to understand how the infrastructure we are designing really performs," Soga says. "This technology can give us the information we need to make better decisions and design safe and cost-effective buildings."

During a base grouting study in 2019, Soga and one of his Ph.D. students, Andrew Yeskoo, wove fiber optic cables through the steel rebar cages of 12 test shafts and connected each end to a fiber optic analyzer, about the size of a desktop computer tower, called an interrogator. Once the shafts were poured and base grouting began, the interrogator pulsed a beam of light through the fiber optic cables and gathered the data that returned, giving researchers the ability to look down into the inner workings of the shaft.

"We found that there was definitely load being put into the shaft during grouting, but that load was not necessarily uniform," Yeskoo says. "In some shafts, we would see it more concentrated on one side. We would also see the distribution vary depending on the method of grout delivery."

There are a few different ways to base grout a shaft. Before the study, Caltrans used an open system, where grout is injected directly into the soil. But with Soga's measurements, Schantz was able to see that a closed system, where the grout fills a rubber bladder attached to the base of the shaft, was better at transferring pressure up into the shaft.

"We were really flying blind without these measurements," Shantz says. "This technology will give us a clearer picture — and, in some cases, a surprising picture — of system behavior in walls, bridges and foundations. I can see the day when we start putting fiber optic cables in all of our infrastructure projects."

MINIMIZING GREENHOUSE GAS EMISSIONS

Far from seismically active California, in the southern English countryside, the Rothamsted Research Center lays nestled among a patchwork quilt of centuries-old farm fields. Here, Soga is partnering with researchers in the hope of leveraging DFOS to study how land management affects the release of major greenhouse gases — such as carbon dioxide, nitrous oxide and methane — into the atmosphere.

Globally, agriculture contributes between 10–12% of all greenhouse gas emissions, and 40% of those emissions are estimated to come directly from soils. Plants absorb CO_2 from the atmosphere during photosynthesis and store carbon in their roots. When plants die and decay, some of that carbon is released back into the atmosphere, but part of it lies buried in damp, oxygen-poor soil and stays there as organic matter.

A study at Rothamsted that began in the 1940s found that unplowed fields maintain a higher level of organic matter over time. Intensive plowing decreases organic matter in the soil by exposing it to oxygen and creating CO_2. Researchers estimate that plowing since the dawn of agriculture has unearthed about 133 billion tons of carbon — an amount equal to more than a decade of global emissions at current levels.

Drought also exacerbates the release of carbon. When soil dries out, it shrinks, forming cracks that allow oxygen to seep in. Linqing Luo, a former postdoctoral student in Soga's research group, said DFOS can detect the strain caused by cracking soil in the same way it monitors compression and tension caused by base grouting or an earthquake. In a preliminary test at the Colorado School of Mines, Soga's research team buried fiber optic cables at different levels of soil in a wind tunnel set up to simulate a drying field. DFOS successfully monitored strain as cracks formed at the surface and spread deeper into the soil.

Luo is now testing custom designs for fiber optic cables that can measure greenhouse gasses as they escape into the atmosphere. One allows gas to infiltrate the fiber optic cable through a special porous cladding, or skin. Different gasses absorb different wavelengths of light. By monitoring how much of a specific wavelength is absorbed as light pulses through the cable, Luo hopes he can detect concentrations of greenhouse gasses in the surrounding soil. A second design calls for coating the porous cladding with a chemical indicator that will combine with gasses in the soil to generate different colored light. The intensity of the colored light corresponds to the concentration of gas along the cable.

"Right now, the intensity of light that's produced when the fibers absorb different amounts of gas is very small," said Luo, now a research scientist at Berkeley Lab. "The signal is very sensitive. Somehow, we need to figure that out."

Eventually, Soga and Linqing will bury the cables in different fields at Rothamsted to study how certain farming practices alter soil structure. Linqing and others said they hope the data DFOS provides will not only help farmers keep more carbon in their fields, but conserve water and prevent the damage caused by over-fertilization, such as harmful algal blooms.

"By telling us how soil structure is changing in time and space, this sensing technology could help minimize the effects of agriculture on the environment," says Richard Whalley, a soil scientist at Rothamsted Research and the study's principal investigator. "It could substantially improve our understanding of how to manage land — and reduce emissions of major greenhouse gases." BE

The Department of Electrical Engineering and Computer Sciences' professor emeritus **Manuel Blum,** professor **Shafi Goldwasser** (M.S.'81, Ph.D.'84 CS), professor **Stuart Russell** and alumnus **Scott Aaronson** (Ph.D.'04 CS) were named to Academic Influence's list of "Top Influential Computer Scientists" from 2010–20.

Mechanical engineering professors **Alice Agogino** (M.S.'78 ME) and **Oliver O'Reilly** are co-recipients of the 2021 Berkeley Faculty Award, which honors their outstanding and dedicated service to the campus.

Zakaria Al Balushi, assistant professor of materials science and engineering, and **Jelani Nelson,** professor of electrical engineering and computer sciences, were named to Cell Mentor's list of "100 More Inspiring Black Scientists in America."

Civil and environmental engineering professor **Lisa Alvarez-Cohen** is part of a team that received the 2020 Strategic Environmental Research and Development Program Project of the Year Award for Environmental Restoration from the Department of Defense.

Cecilia Aragon (M.S.'87, Ph.D.'04 CS) has written a memoir titled "Flying Free," which describes how she became the first Latina pilot to win a spot on the United States Unlimited Aerobatic Team that competed at the World Aerobatic Championships in 1991.

Professor **Alper Atamturk** is the new chair of the Department of Industrial Engineering and Operations Research, replacing the outgoing chair, professor **Zuo-Jun "Max" Shen.**

Christopher Ategeka (B.S.'11, M.S.'12 ME), founder and managing partner at UCOT, Inc., has been awarded UC Berkeley's Mark Bingham Award for Excellence in Achievement by Young Alumni.

Alexia Aubault (M.S.'05 Ocean Engineering), **Christian Cermelli** (M.S.'90, Ph.D.'95 Naval Architecture) and **Dominique Roddier** (Ph.D.'00 Naval Architecture) were awarded the prestigious 2020 Elmer A. Sperry Award for their discovery, design, fabrication and commercialization of Principle Power's WindFloat, a floating platform supporting a large wind turbine.

Electrical engineering and computer sciences professor **Ruzena Bajcsy** has won the IEEE Medal for Innovations in Healthcare Technology for "pioneering and sustained contributions to health-care technology fundamental to computer vision, medical imaging and computational anatomy."

Electrical engineering and computer sciences professors **John Canny** and **Sanjit Seshia** have been elected to the 2020 class of fellows of the Association for Computing Machinery in recognition of their fundamental contributions to computing and information technology.

Senior electrical engineering and computer sciences student **Steven Cao** has won a Computing Research Association 2021 Outstanding Undergraduate Researcher Award. Other award-winning Berkeley Engineering students include **Stephen Tian** (runner-up), **Ryan Lehmkuhl** (finalist) and **Joey Hejna** (honorable mention).

Gerbrand Ceder, professor of materials science and engineering, has been named an American Physical Society fellow for his "extensive contributions to the fundamental understanding of energy storage materials, and for pioneering the materials genome approach for computational materials design."

Civil and environmental engineering graduate student **Amber Chau** (B.S.'20 CE) was selected by the American Society of Civil Engineers, San Francisco Section, for its 2020 Outstanding Civil Engineering Student Award. The award recognizes a civil engineer under the age of 35 who has exhibited professional achievement and has made significant impact to the field of engineering.

Robert Chen (B.S.'13 BioE), **Joshua Nixon** (B.S.'16 BioE) and **Joshua Yang** (MTM'16 BioE) were all named to Forbes' "30 Under 30" list for 2021.

Assistant professors **Alvin Cheung** and **Jonathan Ragan-Kelley** of electrical engineering and computer sciences are among the winners of Intel's 2020 Outstanding Research Awards for their work in developing ARION, a system for compiling programs onto heterogeneous platforms.

Assistant professor of electrical engineering and computer sciences **Alessandro Chiesa** has been selected as a 2021 Alfred P. Sloan Research Fellow in Computer Science.

Jonathan Colby (B.S.'02 ME) is the resident engineer on Verdant Power's Roosevelt Island Tidal Energy project, which aims to convert energy from marine tides into electricity, recently installing tidal turbines in New York's East River.

Rafael Davalos (M.S.'95, Ph.D.'02 ME), professor of biomedical engineering at Virginia Tech, has been named winner of the American Society of Mechanical Engineers' 2021 Van C. Mow Medal in honor of his contributions to the field of bioengineering.

James Dietrich (M.S.'66 CE) has published a book, "Too Much by Half: The Coming Cut in Proved Oil Reserves," that describes his career as an international consultant as well as his take on the coming end of the oil age.

Fiona Doyle, professor emeritus of materials science and engineering and former dean of the Graduate Division, is among eight new 2021 fellows of the Minerals, Metals and Materials Society.

Assistant professor of electrical engineering and computer sciences **Anca Dragan** has won the 2021 IEEE Robotics and Automation Society Early Career Award for her work in pioneering algorithmic human-robot interaction.

An infant-warming device developed by civil and environmental engineering professor **Ashok Gadgil** and Berkeley Lab's **Vi Rapp** (Ph.D.'11 ME) was recently recognized with an honorable mention in the 2020 Patents for Humanity Awards.

Civil and environmental engineering professor **Allen Goldstein** has been elected Fellow of the American Association of Aerosol Research.

Shafi Goldwasser (M.S.'81, Ph.D.'84 CS) professor of electrical engineering and computer sciences and director of the Simons Institute for the Theory of Computing, has won the L'Oréal-UNESCO for Women in Science International Award for her work in computer science and cryptography.

Mechanical engineering assistant professor **Kosa Goucher-Lambert** was named as one of the reviewers of the year by the Journal of Mechanical Design.

Paul Grigas, assistant professor of industrial engineering and operations research, was selected as winner of the 2020 INFORMS Junior Faculty Interest Group Paper Competition for his work with Columbia University's **Adam Elmachtoub** on a new prediction and optimization framework.

Tim Guertin (B.S.'72 EECS), CEO emeritus of Varian Medical Systems, has received UC Berkeley's 2021 Campanile Excellence in Achievement Award.

Alex Horne, professor emeritus of civil and environmental engineering, and co-authors — including **Marc Beutel** (M.S.'94, Ph.D.'00 CEE) and **Rodney Jung** (M.S.'77 CEE), among others — were awarded the Best Paper Award by the North America Lake and Reservoir Management Journal for their work on the use of deep-water pure oxygenation to solve water quality and fish kills in the Mokelumne River salmon hatchery and the Camanche Reservoir.

Civil and environmental engineering professor **Arpad Horvath** is the founding editor-in-chief of Environmental Research: Infrastructure and Sustainability, a multidisciplinary journal devoted to addressing important challenges relevant to infrastructure.

Hayley Iben (M.S.'05, Ph.D.'07 CS), director of engineering at Pixar, earned a Technical Achievement

Award from the Academy of Motion Picture Arts and Sciences for her work with Pixar colleagues to create the Taz Hair Simulation System, which brought realistic movement to the hairstyles of hundreds of characters in animated films, including "Brave" and "Inside Out."

Michael Jordan, professor of electrical engineering and computer sciences and of statistics, has been awarded the 2021 American Mathematical Society Ulf Grenander Prize in Stochastic Theory and Modeling.

Ramzi Jreidini (M.S.'12 CEE) is the founder and CEO of Handiss, a market network for freelancers and small firms in architecture and engineering.

Associate professor of electrical engineering and computer sciences **Boubacar Kanté** has been selected as a Moore Inventor Fellow.

Sanjay Kumar, professor of bioengineering, **Robert Ritchie,** professor of mechanical engineering and of materials science and engineering, and **Peidong Yang,** professor of materials science and engineering and of chemistry, have been elected fellows of the American Association for the Advancement of Science.

Electrical engineering and computer sciences professor emeritus **Kam Lau** has won the 2021 IEEE Microwave Theory & Techniques Society Microwave Power Award.

Negar Mehr (Ph.D.'19 ME), assistant professor of aerospace engineering at the University of Illinois Urbana-Champaign, won the 2020 IEEE ITS Best Dissertation Award, given for work in any ITS area that is innovative and relevant to practice.

Mechanical engineering Ph.D. student **George Moore** was honored with the 2020 Birgeneau Recognition Award for Service to Underrepresented Students.

Richard Morales (M.S.'86 CE) was honored with the 2020 Whitney M. Young Jr. National Service Award from the Boy Scouts of America in

Cultivating female coders in Africa

When **Gloria Tumushabe** (B.S.'20, M.S.'21 EECS) returned to her native Uganda in 2017 after her freshman year at Berkeley, she was disheartened — but not surprised — to see the great disparity between the number of male and female computer programmers. "In my country, there's still a big stigma around girls being as smart as boys in science," she said. "Very few homes have computers or WiFi. And if money is tight, it's the boy who'll be sent to college."

That inequity stuck with her until last year, when COVID-19 hit and the Mastercard Foundation Scholar found herself sheltering in place. As the world quickly shifted to working remotely, Tumushabe decided to teach coding to Ugandan girls from her home in Walnut Creek, in a program she called Afro Fem Coders.

Remote learning is uncommon in Uganda, so many girls had to put their educations on hold during the shutdown. Tumushabe reached out by word-of-mouth and social media, and within two weeks she'd heard from more than 40 girls who had completed high school and were eager to join the semi-weekly classes. Unfortunately, only 13 of them had access to computers, and the classes were held at night after work, when going to a cybercafé isn't safe for women. So Tumushabe began sending money, often from her own pocket, to buy laptops and pay for internet service. She also formed a network of female professionals worldwide — largely from the networks Sista Circle: Black Women in Tech and Zawadi Africa — to mentor the girls one-on-one.

In the year since the program was founded, it has already spread to other African countries. In May, a new cohort will begin with 120 girls from Kenya, Tanzania, Namibia, Botswana and Ethiopia as well as Uganda. Every girl has her own mentor, and there is an international waiting list of potential mentors.

After receiving her master's degree in electrical engineering and computer sciences this spring, Tumushabe has a job as a software engineer awaiting her in Silicon Valley. She hopes to acquire several years of hands-on experience in the industry and possibly pursue her Ph.D. before returning to Uganda to run Afro Fem Coders full time.

"The more of us women in this space, the better," she said.

STORY BY KIRSTEN MICKELWAIT | PHOTO BY ADAM LAU recognition of his outstanding service as chairman of the Exploring Engineering STEM Academy, which introduces low-income high school students in Atlanta to the engineering profession.

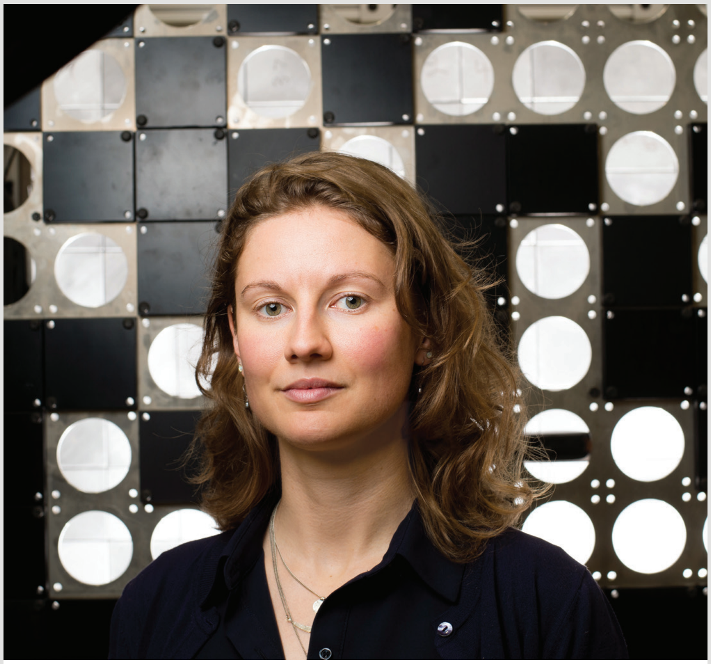
Assistant professor of electrical engineering and computer sciences **Rikky Muller** (Ph.D.'13 EECS) has won the 2021 IEEE Solid-State Circuits Society New Frontier Award for her work in designing and building a high-speed holographic projector that can stream 3D light into the brain at neural speeds.

Ali Niknejad (M.S.'97, Ph.D.'00 EE), professor of electrical engineering and computer sciences, has won the University Research Award by the Semiconductor Industry Association and the Semiconductor Research Corporation.

Grace O'Connell, associate professor of mechanical engineering, has been named a 2021 fellow of the American Institute for Medical and Biological Engineering.

David Patterson, professor emeritus of electrical engineering and computer sciences, has won the Frontiers of Knowledge Award in Information and Communication Technologies from the BBVA Foundation.

Lily Peng (Ph.D.'10 BioE), product manager at Google Health, and **Kate Rosenbluth** (Ph.D.'09 BioE), founder and CEO of Cala Health, have been named to Fortune's "40 Under 40" list.



Rachel Slaybaugh, associate professor of nuclear engineering, has been named director of Berkeley Lab's Cyclotron Road Division, which has supported leading entrepreneurial scientists since 2015. Innovators in the division's fellowship program spend two years developing transformative technologies for advanced manufacturing, clean power and electronics. Most recently, Slaybaugh served as program director for the Department of Energy's Advanced Research Projects Agency-Energy.

PHOTO BY NOAH BERGER

Kristin Persson, professor of materials science and engineering, has been named director of Berkeley Lab's Molecular Foundry.

Dorsa Sadigh (B.S.'11, Ph.D.'17 EECS) has been recognized with the IEEE Technical Committee on Cyber-Physical Systems Early Career Award for "contributions to the theory, design, and implementation of human cyber-physical systems.'' She is currently an assistant professor of computer science and electrical engineering at Stanford University.

Industrial engineering and operations research assistant professor **Barna Saha** was selected as the 2020 recipient of the Young Alumnus Award by the Indian Institute of Technology, Kanpur.

David Schaffer, professor of bioengineering and of chemical and biomolecular engineering, is the 2020 recipient of the Andreas Acrivos Award for Professional Progress in Chemical Engineering from the AIChE Foundation.

Maryann Simmons (M.S.'97, Ph.D.'01 CS), senior staff software engineer at Walt Disney Animation Studios, was honored with a Technical Achievement Award from the Academy of Motion Picture Arts and Sciences for her work on the Walt Disney Animation Studios Hair Simulation System, which allows artists to manipulate hair in realistic ways and was used in animated features including "Tangled."

Electrical engineering and computer sciences professor **Dawn Song** (Ph.D.'02 CS) has won the ACM SIGSAC Outstanding Innovation Award for her "contributions to systems and software security, in particular, dynamic taint analysis for vulnerability discovery and malware detection."

Electrical engineering and computer sciences professor emeritus **Michael Stonebraker** has won the prestigious NEC Computers and Communications Prize for his contributions to relational database systems.

Gitanjali Swamy (M.S.'93, Ph.D.'96 EECS), managing partner at IoTask, has been named one of the most Influential Women in Technology in 2020 by Analytics Insight.

PROVEN, the world's first microbial biofertilizer for cereal crops, has been named one of the 100 Best Inventions of 2020 by Time Magazine. The product was developed by PivotBio, founded by **Karsten Temme** (Ph.D.'10 BioE).

Mechanical engineering professor **Masayoshi Tomizuka** was awarded the 2020 IEEE ITS Lifetime Achievement Award, as well as an American Society of Mechanical Engineers' Honorary Membership.

Laura Waller, associate professor of electrical engineering and computer sciences, has been elected a Fellow of the American Institute for Medical and Biological Engineering. She was also selected as the 2021 recipient of the Optical Society of America Adolph Lomb Medal.

Peidong Yang, professor of materials science and engineering and of chemistry, received the 2020 Global Energy Prize in the non-conventional energy category for the invention of the nanoparticle-based solar cell and artificial photosynthesis.

Electrical engineering and computer sciences professor **Katherine Yelick** has won The Berkeley Lab Citation, the LBNL Director's Award for Exceptional Achievement, for her role in developing Department of Energy strategy in exascale and quantum computing, big data and artificial intelligence.

Mechanical engineering professor emeritus **Ronald Yeung** (B.S.'68, M.S.'70, Ph.D.'73 Naval Architecture) has been awarded the 2020 Offshore Technology Conference Distinguished Achievement Award for Individuals.

Mechanical engineering professor **Tarek Zohdi** is the new academic director for the Sutardja Center for Entrepreneurship and Technology.

M.E.T. program celebrates first graduating class

Completing a Berkeley bachelor's degree in engineering or business is already a great achievement. Now imagine finishing both in just four years. That's exactly what 32 students are accomplishing as part of the inaugural cohort in the Management, Engineering, & Technology (M.E.T.) program — a collaboration between Berkeley Engineering and the Haas School of Business. This spring, those students will represent M.E.T.'s first graduating class.

Launched in 2017, the M.E.T. program has attracted students from more than 10 countries who aspire to create new companies or become innovative leaders within existing ones. The program, entirely donor-funded, has grown from two academic tracks to seven, offering simultaneous bachelor of science degrees combining business with a wide range of engineering disciplines.

One of the leading forces behind M.E.T.'s creation was **Michael Grimes** (B.S.'87 EECS), managing director and co-head of Global Technology Investment Banking at Morgan Stanley. Asked why he felt the need to establish M.E.T. at Berkeley, Grimes sums up the problem succinctly: "There's a shortage of leaders who code and coders who lead. As undergrads, these students are now graduating with everything they need to get them to the C suite and stay there."

Take **Leah Kochendoerfer** (B.S.'21 IEOR/Business), who will be working as a business analyst at Activate Consulting. M.E.T.'s Entrepreneurial Fellows Program, which offers students a stipend for summer internships at affiliated startups, gave her the chance to work as a user experience research and strategy intern at Dispatch Goods. "Because of the startup environment, I was faced with several ambiguous and complex business problems, but I quickly learned that the root of the solution to nearly all of them was the consumer," she said.

Or **Aditya Ganapathi** (B.S.'21 EECS/Business), who will stay at Berkeley for a fifth-year master's program. He has spent the past two years doing research in the Berkeley Automation Lab (AUTOLab) working in deformable object manipulation — a subfield of robotics. Ganapathi will intern with Google this summer, and his fifth year will be focused on a collaboration between the AUTOLab and Google Brain. "I hope that one day I can apply this research in the real world as an entrepreneur," he said, "and my M.E.T. degree will help me get there."

The program continues to grow and evolve, attracting a steady increase of applicants each year. "We're reimagining M.E.T. offerings to promote the true integration of engineering and business, including a redesign of the freshman and senior courses, new capstone experiences and new entrepreneurship opportunities," said **Saikat Chaudhuri,** the program's inaugural faculty director. "Another priority is to create a summer program for high school students, which will provide a pipeline of talent and further our goal of promoting diversity, equity and inclusion."

Grimes hopes that all M.E.T. alumni will look back on the program as the single best career decision they ever made. "I expect that, by age 30, they'll all have careers that are unrecognizable to where they'd otherwise have been," he says. "They'll be the founders and CEOs who are going to help change the world."

STORY BY KIRSTEN MICKELWAIT | PHOTO BY NOAH BERGER

Ara Bagdasarian (M.S.'72 MSE) died in January at the age of 75. He started out working at the National Iranian Oil Company and then returned to the United States, where he had a long career focused on improving environmental outcomes in the American oil industry, including a role as chief materials engineer at Chevron.

Charles Bucher Sr. (B.S.'60 CE) died in November at the age of 90. He had a 43-year career as an engineer with the California Department of Transportation, starting as a surveyor of U.S. Highway 101 through San Francisco, and later with key roles in the design of Interstate Highway 280 and other regional projects.

Anne-Louise Guichard Radimsky (M.S.'67, Ph.D.'73 EECS) died in July at the age of 79. She was one of the first women to earn a doctorate in electrical engineering and computer sciences from UC Berkeley, later becoming the first female faculty member in computer science at UC Davis. In 1979, she joined the computer science department at California State University, Sacramento, where she taught for nearly three decades and served as department chair. She also spent 20 years as a program evaluator and later as a commissioner for the Computing Accreditation Commission.

David Jenkins, professor emeritus of civil and environmental engineering, died in March at the age of 85. A faculty member since 1964, he was known as a superb teacher and world-renowned expert on the chemistry and microbiology of wastewater. He was a member of the National Academy of Engineering, won the Fair Distinguished Engineering Educator Medal and received the Water Pollution Control Federation's Outstanding Publication Award for an archival journal publication that has stood the test of time.

Robert Kaifer (B.S.'50 EECS) died in November at the age of 93. He was a radio operator for the U.S. Merchant Marines, then served in the U.S. Army during the Korean War. Later, he worked as an engineer at Lawrence Livermore National Laboratory for 37 years.

Robert Lyss (B.S.'58 ME) died in December at the age of 84. After graduating, he served in the U.S. Army, attended medical school at UCSF and then resumed his service at a military hospital. He later completed his dermatology residency at UCSF and embarked on a long career as a physician, including roles as physician-in-chief and regional medical director for Kaiser Permanente. He also chaired the Kellerman Foundation Board, where he helped design a community hospital and nursing school in Uganda.

Alaa Mansour (M.S.'62, Ph.D.'66 Naval Architecture), professor emeritus of mechanical engineering, died in January at the age of 83. He joined the Berkeley faculty in 1975 and was an internationally recognized expert in structural reliability and safety, probabilistic dynamics of marine structures and the strength of ship and offshore structures. He also made notable contributions to offshore wind energy development with his research on wind turbines.

Ahmad Moghaddas (B.S.'65, M.S.'66 CE) died in September at the age of 82. After graduating, he worked in the City of Berkeley's civil engineering department. He later ran his own engineering and land surveying company in Berkeley.

David Pelz (B.S.'59 CE) died in March 2020 at the age of 83. He worked as a highway engineer for the Federal Bureau of Public Roads, then had a 35-year career with the City of Davis' public works department, where he served as director for 27 years.

Gail Preston (B.S.'53 CE) died in November at the age of 92. He worked for the United States Steel Corporation, where he was a senior engineer for the bridge division, and later for the State of California as a staff engineer. He also served in the U.S. Army in World War II and again in the Korean War.

Leslie Robertson (B.S.'52 CE) died in February at the age of 92. He was the lead structural engineer of the original World Trade Center, and he also designed the structural systems of notable skyscrapers including the U.S. Steel Tower in Pittsburgh, Shanghai World Financial Center and the Bank of China Tower in Hong Kong. Among his many honors, he was a member of the National Academy of Engineering.

William Schick (B.S.'57, M.S.'58 ME) died in August at the age of 88. Over the course of his 40-year engineering career, he worked at Philco-Ford and GTE Sylvania, designing custom communications equipment.

Kilian Schindler (MEng'16 IEOR) died in May 2020 at the age of 30. He was a Ph.D. student at École Polytechnique Fédérale de Lausanne and had recently completed his dissertation on scalable stochastic optimization. In September, he was awarded his doctoral degree posthumously.

Daniel Tellep (B.S.'54, M.S.'55 ME) died in November at the age of 89. After graduating, he worked on groundbreaking space and missile technologies at Lockheed. There, he rose through the ranks, eventually becoming chairman and chief executive; orchestrating the merger with Martin Marietta to form the world's largest military contractor, Lockheed Martin; and becoming Lockheed Martin's first chairman and chief executive. He was also a member of the National Academy of Engineering.

Frank Walter (B.S.'60 CE) died in December at the age of 91. During his 51-year career as a civil engineer in Tuolumne County, he designed and engineered numerous shopping centers, industrial parks, water and sewer systems, parcel and subdivision maps, roads and bridges.

Keegan Houser

With flexibility comes possibility

When the pandemic put the world into lockdown, academic classes across campus had to shift quickly to remote learning. This posed particular challenges for hands-on lab courses, including three core classes in Berkeley's mechanical engineering department.

Faculty and students solved the problem by creating a microcontroller and electronics kit that provided everything students would need to build and test circuits, as well as a companion website with collaboration tools. Within three weeks, kits had been delivered to 270 students worldwide.

Such flexibility to adapt to adversity was made possible through discretionary resources like the Berkeley Engineering Fund. Contributions to this annual fund can be put to use immediately in support of the college's greatest needs. With your support, anything is possible.

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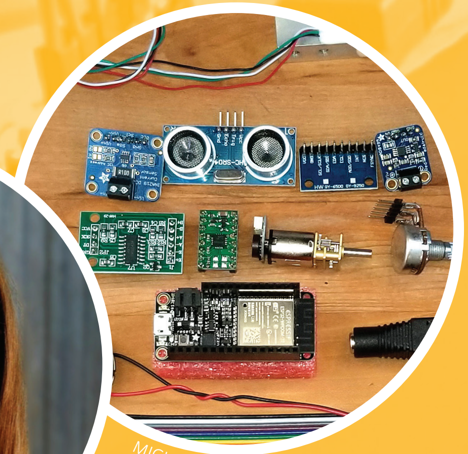
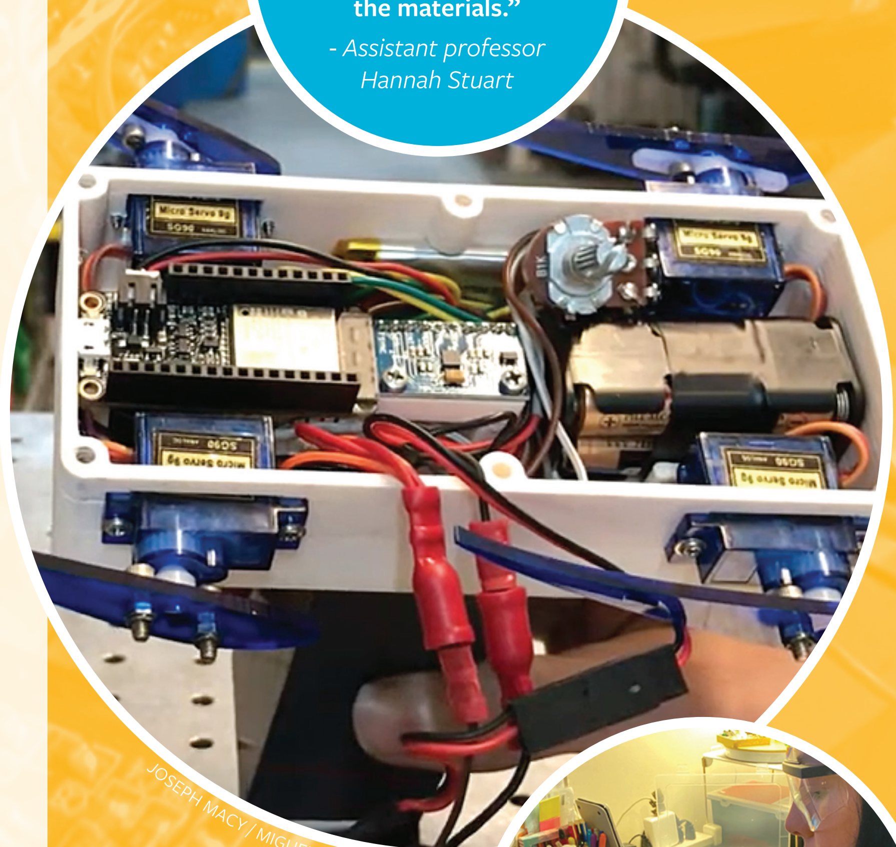


MICHAEL NEUFER

HANNAH STUART

"Practicing theory on real hardware at home elevated engagement and retention of the materials."

- Assistant professor Hannah Stuart



JOSEPH MACY / MIGUEL NEPOMUCENO

NATALIA PEREZ

"I've been able to test my understanding on controls, linkages and electronics while learning how to utilize new parts."

- Undergrad student Natalia Perez

Berkeley Engineering

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ALEX GREENSPAN PHOTO

The power of one professor

Ask any Berkeley Engineering alum for the key factor that put them on their path to success, and chances are they'll name a single professor who lit the flame of inspiration. Professors like Björn Hartmann (above), faculty director of the Jacobs Institute for Design Innovation, who holds the Paul and Judy Gray Alumni Presidential Chair in Engineering Excellence. Creating a faculty endowed chair can honor a favorite professor while funding a new generation of inspiration.

To learn more about ways you can support our faculty, visit: **engineering.berkeley.edu/give.**

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