

UCDAVIS



Research IN ACTION

2019-2020

# Reframing

WHAT IS POSSIBLE

## Greetings,

This has been a year that none of us will likely ever forget! Our world struggled through a global pandemic, devastating wildfires and a social reckoning on racial disparities. These very complex and multifaceted issues brought to light — more than ever — the importance of research. At UC Davis, we have always leaned in to confront these challenges, bringing together experts from different disciplines to provide insight and solutions that reframe what is possible. Many examples of these contributions are captured throughout this annual report.



Early in 2020, we experienced something unlike ever before in our times (for most of us, at least), with the emergence of the COVID-19 outbreak that quickly turned into a global pandemic. I have never witnessed such an eagerness and commitment from our researchers, staff and clinicians to be part of the solution, all at a time when we had to close many of the campus operations due to the shelter-in-place order. Deemed essential, all research focused on COVID-19 continued, and new collaborations were spurred through a virtual platform and emergency seed-funding grants. This research quickly provided critical insights into transmission, detection, social implications and vaccines.

Although this was one of the most challenging years for many of us, we also recognized some exciting progress on many fronts. In fiscal year 2019–2020, we set an all-time record for research funding, bringing in a total of \$941 million, an increase of

\$95 million from the previous year. We also licensed foundational technology to 15 emerging startups, recorded 141 invention disclosures and were awarded 89 domestic and foreign patents. These innovations not only offer solutions to address needs, but they also play an important role in contributing to our economy.

I would like to thank you for taking the time to learn more about our work and its impact in California and around the world, and encourage you to reach out to us to discuss opportunities for collaboration or support.

Prasant

**Prasant Mohapatra**  
VICE CHANCELLOR FOR RESEARCH

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\$941m IN RESEARCH FUNDING

115 STARTUPS LICENSED  
FOUNDATIONAL INTELLECTUAL  
PROPERTY IN LAST TEN YEARS

950+ PATENTS ON RECORD

\$12.9m IN ROYALTY INCOME

# Impact AT A GLANCE

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## Zika vaccine found to protect fetus in pregnant monkeys

Researchers at the California National Primate Research Center revealed that a new vaccine for the Zika virus reduces the rate of fetal loss and protects full-term fetuses. The study mimicked a real-world scenario in which women could be vaccinated months or years before becoming pregnant.



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## Cause of California's kelp forest decline uncovered

Marine biologists at the Bodega Marine Laboratory chronicled the catastrophic shift leading to the death of the kelp forest, showing how disease, warming waters and ravenous sea urchins led to the destruction and how interventions could help the recovery.



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## Zero-emission vehicles will eventually save costs with supportive policies

A study by researchers at the Institute of Transportation Studies at UC Davis found that California's transition to zero-emission vehicles could begin to save the state money by as early as 2030. The report finds that reaching very low greenhouse gas emissions from road vehicles by 2050 appears feasible and ultimately cost-effective.



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## Developing a breath test to detect opioids

UC Davis researchers have developed a method for detecting opioid drugs and drug metabolites in breath. The test could be useful for management of patients with chronic pain, as well as for detecting illegal opioid use.



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### **Agricultural innovations help Cambodian farmers thrive**

Cambodian farmers have been working with researchers from UC Davis and Cambodia's Royal University of Agriculture to test new methods for growing and selling produce locally. These innovations are helping farmers grow and sell horticulture crops amid rising recognition that fruits and vegetables are not only critical to meet human nutrition needs, but also can help farmers in developing countries lift themselves out of poverty.



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### **Synthetic version of CBD treats seizures in rats**

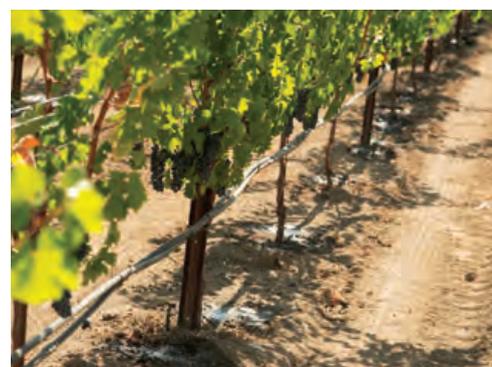
UC Davis chemists have come up with a way to make a synthetic version of CBD and showed that it is as effective as herbal CBD in treating seizures in rats. The synthetic CBD alternative is easier to purify than a plant extract, eliminates the need to use agricultural land for hemp cultivation, and could avoid legal complications with cannabis-related products.



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### **Maximizing use of water stored in soil could result in savings for farmers**

Researchers at UC Davis looking at using a “free” resource — rain water stored in the soil — found that optimizing its use could go a long way to help meet demand for five California perennial crops.



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### **Removing tiny shrimp may help climate-proof Lake Tahoe**

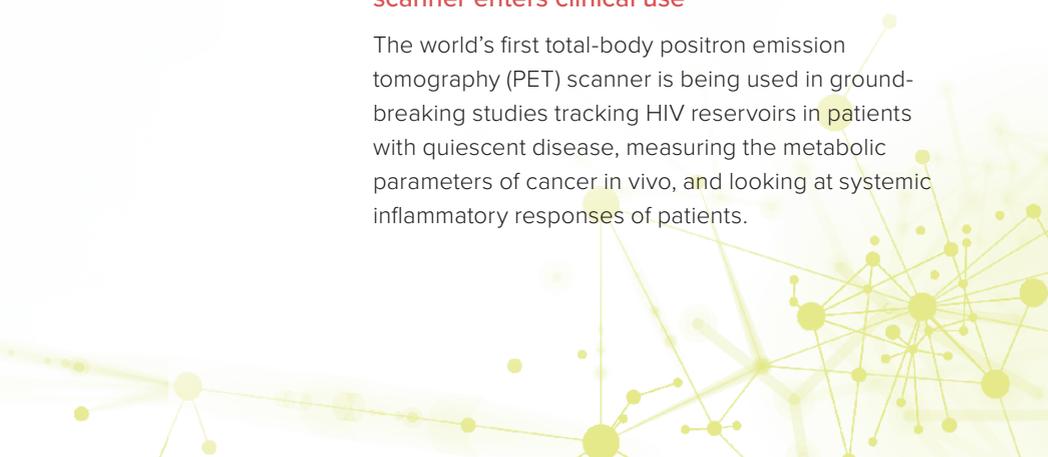
Billions of invasive Mysis shrimp, introduced into Lake Tahoe in the 1960s, persist in the lake, where they eat native zooplankton that historically helped keep the lake blue and clear while also serving as a food source for native fish. Researchers found that when Mysis shrimp mysteriously disappeared from Emerald Bay in 2011, native zooplankton rebounded almost immediately. Within two years, clarity had increased by almost 40 feet.



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### **World's first-of-its-kind whole body scanner enters clinical use**

The world's first total-body positron emission tomography (PET) scanner is being used in groundbreaking studies tracking HIV reservoirs in patients with quiescent disease, measuring the metabolic parameters of cancer in vivo, and looking at systemic inflammatory responses of patients.



## Developing 'Anti-Solar' Panels

### THAT GENERATE ELECTRICITY IN THE DARK

**Solar panels** have emerged as an effective technology to provide energy, particularly in homes, but their contributions are limited to daytime generation. Jeremy Munday, professor in the Department of Electrical and Computer Engineering at UC Davis, is working to change that by designing a photovoltaic cell that generates up to 50 watts of power per square meter in the dark of night, adding roughly 25% to what a conventional solar panel can generate in a day.

The process is similar to the way a normal solar cell works, but in reverse. Instead of pointing a cool object at a hot sun to absorb light and generate power during the day, the new device points a warm panel to the cold night sky, which will radiate heat as infrared light that can be captured as energy.

Munday further explained, "A regular solar cell generates power by absorbing sunlight, which causes a voltage to appear across the device and for current to flow. In these new devices, **light is emitted instead and the current and voltage go in the opposite direction, but you still generate power.** You have to use different materials, but the physics is the same."

The device would work during the day as well, if you took steps to either block direct sunlight or pointed it away from the sun. Because this new type of solar cell could potentially operate around the clock, it is an intriguing option to balance the power grid over the day-night cycle.



# Racing to Respond TO COVID-19

UC Davis Researchers and Clinicians  
LEAN INTO THE CHALLENGE



When UC Davis announced the first case of community transmission of COVID-19 in the U.S. on Feb. 26, it solved a medical mystery at the hospital and led to important changes to the U.S. Centers for Disease Control and Prevention (CDC) guidelines for novel coronavirus testing.

UC Davis Health physicians and medical staff members who treated the severely ill patient provided a detailed case study of her condition and the medical steps and challenges they experienced before arriving at a diagnosis and treatment. The case study also reveals how her symptoms matched — and sometimes varied from — published studies of COVID-19 infection at the time.

UC Davis' role in the fight against coronaviruses was not new. The PREDICT Project, led by the UC Davis School of Veterinary Medicine's One Health Institute and part of USAID's Emerging Pandemic Threats Program, was initiated in 2009 to strengthen health security and global capacity for the detection and discovery of viruses of pandemic potential that can move between animals and people.

Over the past 10 years, surveillance teams in Asia and Southeast Asia collected more than 57,000 animal and human samples and identified bat families that are likely to carry viruses in the SARS group. They have provided insight into potential animal host or hosts of SARS CoV-2.

As the COVID-19 outbreak grew, researchers from various disciplines across UC Davis quickly leaned in to the challenge. The Office of Research launched a collaborative virtual platform in partnership with the School of Medicine, providing a forum for researchers to engage with others and share their work. The initiative also provided grants for researchers to quickly launch their studies.

Researchers from across campus started producing insight into transmission, testing, genetic analysis, social implications, treatments and vaccines over the next several months.

Their work has leveraged the unique combination of resources at UC Davis that include the School of Medicine, the School of Veterinary Medicine, the Center for Immunology and Infectious Diseases and the California National Primate Research Center, where researchers have made tremendous advancements related to HIV/AIDS, Zika and other infectious diseases.

"UC Davis is well-positioned to lead the world in responding to the pandemic," said Allison Brashear, dean of the UC Davis School of Medicine. "We have been able to leverage our history in monitoring viral threats and developing responses through our unique resources and comprehensive range of expertise."



Assistant professor Priya Shah combines chemical engineering and virology to produce COVID-19 proteins using mammalian cells and plants for serological tests for antibodies.

# COVID-19 COLLABORATION IN ACTION

## MARCH

With the goal of **MAKING DIAGNOSTIC TESTS IN-HOUSE**, a UC Davis team isolated, characterized and cultured the novel coronavirus from a patient treated at the UC Davis Medical Center.

UC Davis Health launched **TWO CLINICAL TRIALS FOR HOSPITALIZED PATIENTS WITH SEVERE COVID-19**, evaluating the antiviral remdesivir and inflammatory blocker sarilumab.

Researchers published findings on **NEW INSIGHTS GAINED FROM BLOOD ANALYSIS** of an early COVID-19 patient noted non-typical results commonly seen in disorders with bone marrow disease.

PREDICT program provided **EMERGENCY SUPPORT TO OTHER COUNTRIES** for outbreak response, including technical support for the early detection of the virus that causes COVID-19.

## APRIL

Researchers analyzed the **GENOMES OF 150 SARS-COV-2 STRAINS** in combination with epidemiology and transmission information to gain insight into the spread.

UC Davis economists reported that **THE ECONOMY COULD SUFFER THE EFFECTS OF THE PANDEMIC FOR DECADES**, based on research going back to the 14th century.

Aerosol scientists suggested that **RESPIRATORY PARTICLES THAT TRAVEL THROUGH THE AIR** from ordinary speech could be large enough to carry viruses such as influenza and coronavirus.

The Road Ecology Center reported that traffic accidents and **CRASH-RELATED INJURIES AND DEATHS WERE REDUCED BY HALF** during the first three weeks of California's shelter-in-place order.

The UC Davis School of Veterinary Medicine's One Health Institute published a study that indicated infectious diseases can be connected to **ENVIRONMENTAL CHANGE**.

**RESEARCHERS IN THE SCHOOL OF VETERINARY MEDICINE** developed a web application for tracking COVID-19 cases and testing worldwide.

Scientists and engineers analyzed how building **LAYOUT, VENTILATION AND LIGHTING** can contribute to the transmission of infectious diseases, including COVID-19.

Communication researchers found that tracking social media "sick posts" could give public health officials a head start on identifying and **RESPONDING TO EMERGING DISEASE OUTBREAKS**.

Preliminary results of the first **CLINICAL TRIAL OF THE ANTIVIRAL THERAPY REMDESIVIR** conducted at UC Davis Health and other hospitals show positive impact in severely ill patients.

**A COVID-19 VACCINE WITH PATCH DELIVERY TECHNOLOGY** from the biopharmaceutical company Verndari Inc. entered preclinical testing at the UC Davis Mouse Biology Program.

Two UC Davis Health patients with COVID-19 received **PLASMA TRANSFUSIONS FROM A BLOOD DONOR WHO RECOVERED** from the virus, in an effort to boost the ability of the sick patients to fight the disease.

## MAY

The Road Ecology Center reported that as Americans drove less during the early months of the pandemic, **PRODUCTION OF GREENHOUSE GASES DECLINED** by millions of metric tons.

Researchers launched a pilot study to evaluate an intranasal compound, chitosan, for the **PREVENTION OF SARS-COV-2 INFECTION**.

A team of chemical engineering researchers collaborated to find **NEW WAYS TO PRODUCE COVID-19 PROTEINS** using mammalian cells and plants for serological tests for antibodies.

Computer scientists developed a **WEB-BASED CONTACT-TRACING APPLICATION** that can notify a user if a person who tested positive for COVID-19 was in the same location within a certain time frame.

## JUNE

Three major initiatives in biodiversity genomics — BIOSCAN, the Earth BioGenome Project and the Global Virome Project — joined forces to deliver a **"PANDEMIC INTERCEPTION SYSTEM."**

Researchers adapted technology to make self-assembling protein scaffolds that could be used in diagnostic tests or for **VIRUS-NEUTRALIZING MASKS** to combat coronavirus.

## JULY

UC Davis Health tested new **MONOCLONAL ANTIBODY COCKTAIL** as a prevention and treatment for COVID-19.

The Center for Poverty Research launched a study to evaluate the **IMPACT OF THE COVID-19 PANDEMIC ON STUDENTS** in California community colleges.

Researchers found that **INDIVIDUALS IN POORER COMMUNITIES** were less likely to remain at home, adding to risks of higher levels of pre-existing health conditions and less access to health care.

## AUGUST

UC Davis Health began enrolling participants as part of a **GLOBAL CLINICAL TRIAL** of an investigational vaccine against COVID-19.

A new study looking at **MODES OF TRANSMISSION** found that influenza viruses can spread through the air on dust, fibers and other microscopic particles — suggesting implications for COVID-19.

Genomic analysis of 410 animal species revealed **VULNERABILITY TO SARS-COV-2 INFECTION** and identified several critically endangered primate species at very high risk.

Survey results showed that COVID-19 has severely affected people's daily **EMOTIONAL LIVES AND MENTAL HEALTH**, increasing their stresses, fear of getting sick and financial strains the longer that lockdowns persist.



(COURTESY USAID PREDICT).  
NOTE, PROTECTIVE EYEWEAR  
REQUIRED IN UC DAVIS LABS.

Interns of the USAID PREDICT program conducted lab work at Sokoine University of Agriculture in Tanzania. The PREDICT program **provided emergency support to other countries for outbreak response**, including technical support for early detection of SARS CoV-2, the virus that causes the disease COVID-19.

## NEW WINE GRAPE VARIETIES

### Resistant to Deadly Pierce's Diseases Released

**Researchers at UC Davis** released five new varieties of wine grapes that are highly resistant to Pierce's disease, which costs California grape growers more than \$100 million a year. The new, traditionally bred varieties also produce high-quality fruit and wine. Of the varieties, three are red and two are white.

**To create the new varieties**, Andrew Walker, geneticist and professor of viticulture and enology, **crossed a grapevine species from the southwestern U.S. and northern Mexico, *Vitis arizonica*** — which carries a single dominant gene for resistance to Pierce's disease — with *Vitis vinifera* over four to five generations, roughly 20 years.

Pierce's disease is caused by a bacterium spread by a group of insects called sharpshooters. It causes grapevine leaves to yellow or "scorch" and drop from the vine. The grape clusters also dehydrate, and infected vines soon die. Rising temperatures from climate change could increase the spread of the disease, which is thought to be limited by cold winters. Growers in the Southeast usually can grow only Pierce's disease-resistant varieties that don't have the same wine quality as the European wine grape species, *Vitis vinifera*, which is typically grown in California.

"These varieties will hopefully make viticulture much more sustainable and provide a high-quality wine that the industry will welcome," said Walker. "So far there has not been tremendous interest in new wine grape varieties, but climate change may encourage growers to reconsider wine grape breeding as we work to address future climates and diseases."



## Why Our Brains Get Stuck in the Negative, AND HOW WE CAN SHIFT THAT PATTERN

**Our brains are hardwired** to remember insults and attacks — which explains why so many political campaigns go negative. Research by UC Davis psychology professor Alison Ledgerwood also finds a bright side: You can train your brain to flip the script.

Ledgerwood studies framing effects, or how people process information based on how it's presented to them. She and her colleagues have found that a negative frame is much more persistent, or “stickier,” than a positive one.

**“Our minds are built to look for negative information** in the environment and to hold on to it,” Ledgerwood says. “In many situations, we want our minds to be grabbed by the negative **so that we can fix problems** when they are presented.”

She suggests that we can train our brain to tilt the balance in favor of the upside. But doing so takes work. Spending a few minutes each day thinking about things for which you are grateful can turn into a habit that will change the negative bias over time.

Ledgerwood says that noticing this shift over time as we age is easy. Children often react to little things as if they are the end of the world, but her research found that stickiness of the negative frame seems to disappear entirely by the time people reach their 70s, allowing them to flow back and forth between positives and negatives much more easily.

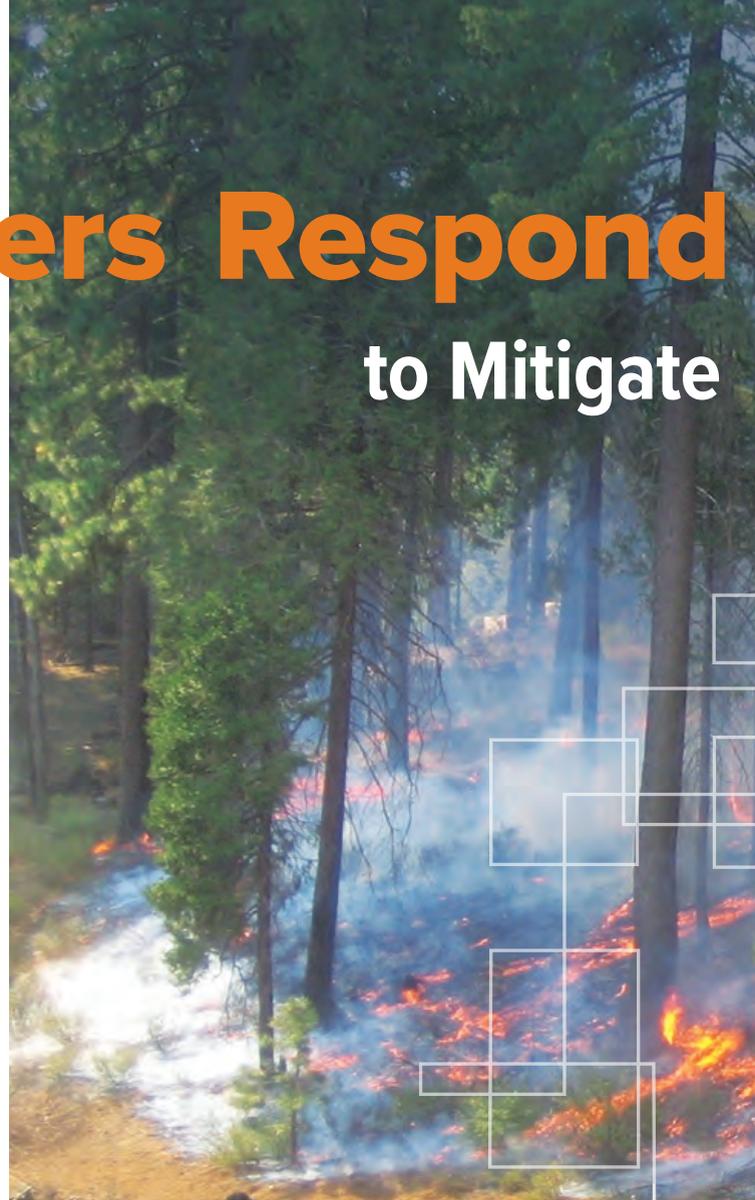


# Researchers Respond to Mitigate

**THE CAMP FIRE IN 2018** was the deadliest and most destructive wildfire in California's history, killing 85 and burning over 150,000 acres and 18,000 structures. It came just a little over a year after the devastating Tubbs Fire, signifying an alarming new reality in the state. And now in 2020, the skies are once again filled with smoke, streets have a new layer of ash, and over 250,000 people have evacuated their homes.

The rise in the destructiveness of California's wildfires raises questions about what the future holds for the state. But what's clear is that the problems surrounding California's wildfires are myriad and complex — and research has an important role to play in solving them.

At UC Davis, scientists and researchers are responding to the accelerating crisis with a broad range of research studies and innovations. Driven by the growing impact, they are narrowing in on ways to reduce the severity of wildfires, evaluate the toxicity of the smoke, document the environmental factors, treat the affected wildlife and understand the long-term impacts on health in order to mitigate the toll of wildfires on our lives and the planet.



With low-intensity prescribed burns, smaller trees and brush are thinned out, leaving larger, more established trees. (PHOTO: NORTH LAB)

## Evaluating Strategies for Fuel Reduction

The lack of proper forest management has been blamed as one of the reasons for California's deadly wildfires.

Malcolm North, who has been a forest ecologist with the USDA Forest Service, Pacific Southwest Region, for 25 years — and an adjunct professor at UC Davis for 20 years — has focused his research on the ecological consequences of suppressing fire in forests as well as identifying the factors that make forests more resilient to fire and drought. His studies have revealed that the right kind of fires can be healthy for forests.

“Many types of dry forests are much healthier when they regularly have low-intensity surface fires. Most of the Native American practices with cultural burns were along these lines. It's very beneficial,” he said.

A photograph of a forest fire with a white grid overlay. The fire is intense, with bright orange and yellow flames rising from the ground and consuming the lower parts of the trees. The smoke is thick and grey, filling the air. The trees are tall and thin, with green needles. The grid is composed of white lines forming a series of overlapping rectangles of various sizes, some of which are partially obscured by the fire and smoke.

# California's Wildfire Crisis

With low-intensity burns, smaller trees and brush are thinned out, leaving larger, more established trees. North explained that without regular low-intensity burns or thinning, a wildfire will end up burning at a very high severity, leaving very little alive in its wake.

North also has studied the amount of carbon that is lost in high-intensity versus low-intensity wildfires. Capturing carbon to reduce carbon dioxide in the atmosphere is a key strategy for mitigating climate change.

"When you see a wildfire burning, and all that gray smoky material going up into the sky, it is quite a bit of carbon going up there. The Rim Fire put out the equivalent of what automobiles put out for one year in California and did it in three weeks," North said.

**But not all fires are the same, he explained. A high-intensity fire that incinerates practically everything has a high carbon cost, but a low-intensity fire can make the forest more resilient, retaining more carbon in the long run.**

North's research has shown that a key calculation in the impact of a wildfire is how many of the largest trees were killed. "A huge portion of the carbon is concentrated in the big trees," he said. His research shows that once you reduce the density of the forest, the carbon that remains is much more stable.

"The simple take-home is what works best for carbon sequestration also works best for the forest, which is removing the small trees and letting the big trees bask in the sunshine and grow and become healthy," said North.

## Revealing the Long-Term Effects of Wildfire Smoke Exposure

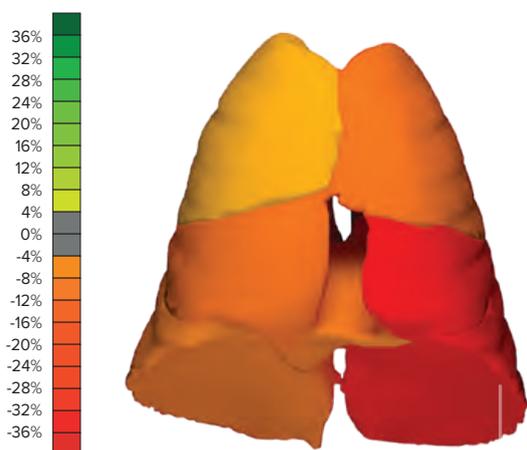
UC Davis Professor Lisa Miller, associate director of research for the California National Primate Research Center, has been studying the effects of wildfire smoke for more than a decade — essentially by chance.

In the summer of 2008, wildfires in Humboldt and Trinity counties, in the northern part of the state, burned thousands of acres, creating a thick blanket of smoke in the Central Valley.

“Based on the monitor two miles down the road, the air quality was pretty similar to what we experienced during the Camp Fire,” said Miller.

For about 10 days in the summer of 2008, the monkeys living in outdoor pens year-round were exposed to levels of very small atmospheric particulate matter, known as PM2.5, that exceeded national air quality standards set by the Environmental Protection Agency.

### TLC Lobar Volume change between Non-Exposed and Exposed



Computed Tomography (CT) image of rhesus monkey lung showing in color the areas of the lung that are most affected in wildfire smoke exposed animals. Areas with more red equal smaller volume. (IMAGE: LISA MILLER, CNPRC)

Miller thought it was an interesting air pollution event and began a study to assess the smoke’s impact on health.

Monkeys that were adults during the 2008 wildfires did not show any lingering effects from the wildfire smoke. “They were affected during the event because of the irritation, but three years later there was no difference in those animals relative to their unexposed counterparts,” said Miller.

When researchers evaluated the monkeys that had been exposed to smoke as babies, however, the differences were significant. The lungs of the three-year-old, smoke-exposed monkeys were smaller, stiffer and had less capacity than those of monkeys born a year later that weren’t exposed to smoke. The smoke-exposed monkeys also produced less of an immune-related protein that triggers inflammation to fight pathogens. The monkeys are now adults and are showing evidence of early interstitial lung disease.

When Miller began the study, she expected the monkeys exposed as babies to have something resembling asthma. But instead, she said the effects more closely resemble pulmonary fibrosis.

And other impacts appear to extend to the next generation. “The animals that were born from moms exposed to smoke show a reduced immune response. That means they aren’t able to mount as robust a response as their unexposed counterparts,” said Miller.

“Wildfires have **changed my perspective on what air pollution can do. Everyone has an acute response to wildfire smoke, whether you are a youngster or an adult,**” said Miller. “**But the long-term health impacts for the young can be severe.**”

### Developing New Treatments to Heal Burns

For UC Davis Veterinarian Jamie Peyton, it was the 2017 Thomas Fire in Ventura and Santa Barbara counties — at that time the largest wildfire in California history — that radically changed how she treats animal burns.

A five-month-old mountain lion and two adult female black bears were brought to the California Department of Fish and Wildlife (CDFW) Investigations Lab in Rancho Cordova suffering from burns from the Thomas Fire. The available treatment options were poor — burns are very painful and take months to heal, requiring frequent dressing changes.

Peyton had read about clinical studies in Brazil in which researchers used sterilized skin from a tilapia fish to treat burns on animals and humans. Working with CDFW and a team from UC Davis, she decided to try this novel approach, obtaining farmed tilapia skin that she sterilized and then sutured onto the paws of the mountain lion and bears.

The results of the “fish mittens” were dramatic: One of the bears was able to put weight on her injured paws almost immediately. In addition to covering the burned tissue, the fish skin helped with healing because it is rich in collagen. New skin grew back on their paw pads in a matter of weeks, instead of months.



UC Davis veterinarian Jamie Peyton applies tilapia skin to the foot of a five-month-old mountain lion that was burned in the Thomas Fire. Peyton received Venture Catalyst’s STAIR™ grant in 2019 to validate and optimize the approach and was awarded the UC Davis Chancellor’s Innovator of the Year award for the application of her work.

Peyton and her team have since gone on to use the tilapia skin treatment on more than 13 different species. She is now taking the technology to help veterinarians in Australia who are coping with animals that have been injured in the country’s devastating wildfires. She hopes that healing animals with fish skin can be a game changer for treating burns because of the low cost and widespread availability of tilapia.

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In addition to covering the burned tissue, **the fish skin helped with healing because it is rich in collagen.** New skin grew back on their paw pads in **a matter of weeks,** instead of months.

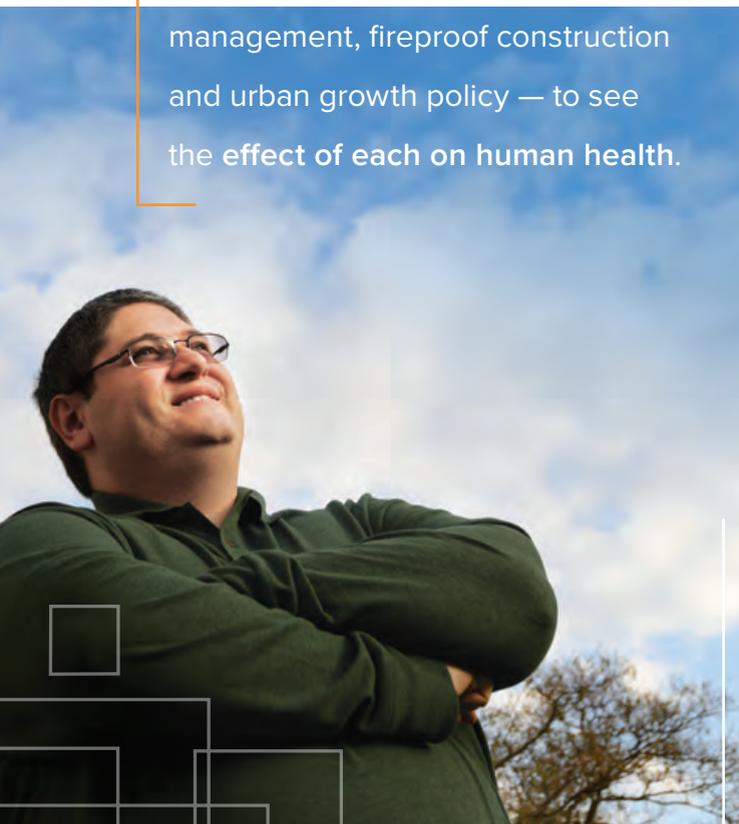


## Modeling Wildfire Mitigation Strategies

Michele Barbato, a professor of civil and environmental engineering, had been teaching at UC Davis for only a few months at the time the Camp Fire broke out. Barbato's core research focuses on hazards, analyzing how earthquakes, hurricanes, tornadoes, fires and other events affect the load on structures — houses, buildings, offices, bridges, skyscrapers.

"Working on wildfire was something I thought about even before moving to California," said Barbato. "The idea was to develop fireproof material for construction in rural areas, the wildland-urban interface."

The team also plans to look at **four wildfire mitigation strategies — controlled burns, vegetation management, fireproof construction and urban growth policy — to see the effect of each on human health.**



Professor Michele Barbato has received \$4.8 million in grants to develop a state-of-the-art scalable framework for assessment and mitigation of wildfire-induced air pollution.

During the Camp Fire, as smoke levels trended for days into the hazardous range, he had the idea of extending his research to include creating models for air pollution.

"What makes this wildfire smoke different from just burning wood? That was the core of the research idea. We need to investigate what is in the wildfire plume that makes it different from what's coming from your fireplace," said Barbato.

**"The problem is a little bit bigger than just housing, so I started putting together people that had other expertise that I didn't have myself."**

The team he gathered includes scientists from UC Davis, UC Davis Health, UC Merced, UCLA, UC Irvine, UC Berkeley, Lawrence Livermore National Lab, Los Alamos National Lab and the Electric Power Research Institute.

In November, the team's proposal, "Assessment and Mitigation of Wildfire-Induced Air Pollution," received a \$3.75 million grant from the UC Office of the President and an additional \$1.05 million from Lawrence Livermore National Lab, Los Alamos National Lab and the Electric Power Research Institute.

"What we hope is to create a framework that allows us to investigate the effect of wildfire on health in different parts of the state, and to also project it under different climate scenarios," said Barbato.

The team also plans to look at four wildfire mitigation strategies — controlled burns, vegetation management, fireproof construction and urban growth policy — to see the effect of each on human health.

"That way, we will have a quantitative way of comparing different approaches that can be transformed into policy because you can actually compare what each strategy is doing," said Barbato.

## Wildfires Research Work Group

The Office of Research at UC Davis recently launched an initiative to enhance interdisciplinary collaborations among researchers and connect stakeholders through a Wildfires Research Work Group. The group, which consists of more than 30 campus scientists, provides a monthly forum to identify new opportunities in research, connect specialists to build upon each other's work and act as a central conduit for engaging with policymakers and external partners.

## REDUCING CHILD MORTALITY BY 27%

With the Use of Nutrient Supplements

**More than half** of child deaths worldwide stem from preventable causes, such as adverse effects from malnutrition. A recent study led by researchers at UC Davis' Institute for Global Nutrition found that child mortality significantly drops when children receive nutritional supplements rich in vitamins, minerals and essential fatty acids. It found that supplements may decrease mortality among children 6 to 24 months old by as much as 27% in low- and middle-income countries.

The analysis included 18 trials conducted in 11 countries with 34,051 children.

Nutrient supplements typically consist of a mixture of a legume — peanut, lentil or chickpea paste — plus milk powder, oil and a full complement of the vitamins and minerals children need.

“Picture a tiny package of fortified peanut butter that has only 100 calories,” said Christine Stewart, a professor in the Department of Nutrition and director of the Institute for Global Nutrition. “It’s enough to spread on a single piece of bread or it can be mixed with other foods.” The packets are designed to be added to the child’s diet daily as they make the transition from breastfeeding to complementary foods or family foods.

The work was supported by a grant from the Bill & Melinda Gates Foundation and funding from the Consultative Group for International Agricultural Research (CGIAR) Program on Agriculture for Nutrition and Health, led by the International Food Policy Research Institute.



K. Ryan Wessells, project scientist; Christine Stewart, professor of nutrition; Charles Arnold, statistician; and Kathryn Dewey, distinguished professor emerita of nutrition.

A study from UC Davis shows that **receiving lipid-based nutrient supplementation** for a minimum of 6 months among children aged 6 to 24 months of age **may reduce the risk of mortality by as much as 27 percent.**

# Gene Therapy Center

## DEVELOPING LIFELONG CURES

**Precision medicine**, an approach that uses information about an individual's unique variations to treat or prevent disease, is changing the future of medicine.

Rather than tackling symptoms, precision medicine looks at the root cause of illnesses. Information used to determine treatment can include genetic variations and mutations, lifestyle, the environment, or even a person's unique microbiome.

Personalized medicine is not new, but research momentum for individualized cures is growing.

Close to half of the new molecular entities approved by the FDA in 2018 are considered personalized or precision medicine treatments.

A report by BIS Research estimated the precision medicine market at \$79 billion in 2018 and expects it to grow to \$216 billion by 2028. Companies involved in developing precision medicine treatments include Roche, Novartis, Pfizer and other industry icons.

**Gene therapy is one type of precision medicine that uses several mechanisms to insert a gene into a patient's cells to treat medical disorders caused by mutated, defective or missing genes.**

Gene-editing technologies, including CRISPR-Cas9 and other techniques, allow scientists to alter, add or remove parts of a genome. The experimental therapy can replace a disease-causing gene with a healthy copy, inactivate a malfunctioning gene or introduce a new gene to help fight disease.

Scientists use "vectors" to insert new genes directly into cells. Viruses can be modified to not cause diseases and instead carry therapeutic genes that deliver the desired genetic material into cells. Multiple types of stem cells can also be vectors that deliver genetic material targeted at treating various diseases.

Gene therapy is being explored for the treatment of inherited disorders and other diseases, including cancer, rheumatoid arthritis, diabetes, Parkinson's disease and Alzheimer's disease.

### Gene therapy research at UC Davis

UC Davis' commitment to stem cell and gene therapy research dates back more than a decade.

In 2010, with major support from the California Institute for Regenerative Medicine (CIRM), UC Davis launched the UC Davis Institute for Regenerative Cures, which includes research facilities and a Good Manufacturing Practice (GMP) facility.

In 2016, led by Fred Meyers, a professor in the School of Medicine, UC Davis launched the Center for Precision Medicine and Data Sciences.



Heather Dahlenburg, staff research associate; Jan Nolta, director of the Stem Cell Program; Jeannine Logan White, advanced cell therapy project manager; Sheng Yang, graduate student, Bridges Program, Humboldt State University.



Gene therapy is being explored for the treatment not only of inherited disorders but also a variety of other diseases,

including cancer, rheumatoid arthritis, diabetes, Parkinson's disease and Alzheimer's disease.

Last year, the university launched the Gene Therapy Center, part of the IMPACT Centers program.

**Led by Jan Nolta, professor of cell biology and human anatomy and director of the UC Davis Institute for Regenerative Cures, the new center leverages UC Davis' network of expert researchers, facilities and equipment to establish a center of excellence aimed at developing lifelong cures for diseases.**

Nolta began her career at the University of Southern California, working with Donald B. Kohn on a cure for a condition in which babies are born without an immune system. The blood stem cell gene therapy has cured more than 50 babies to date.

Work at the UC Davis Gene Therapy Center targets disorders that potentially can be treated through gene replacement, editing or augmentation.

"The sectors that make up the core of our center stretch out across campus," said Nolta. "We work with the MIND Institute a lot. We work with the bioengineering and genetics departments, and with the Cancer Center and the Center for Precision Medicine and Data Sciences."

A UC Davis stem cell study shows a potential breakthrough for healing diabetic foot ulcers with a bioengineered scaffold made up of human mesenchymal stem cells. Another study revealed that blocking an enzyme that is linked with inflammation enables stem cells to repair damaged heart tissue.

A stem cell gene therapy study demonstrated restored enzyme activity in Tay-Sachs disease-affected cells in humanized mouse models.

Several cell and gene therapies have progressed to the point that clinical trials are being conducted at UC Davis for diseases including sickle-cell anemia, retinopathy, muscle injury, dysphasia, advanced cancer, and Duchenne muscular dystrophy.

"Some promising and exciting research right now at the Gene Therapy Center comes from work with hematopoietic stem cells and viral vector delivery," said Nolta.

Hematopoietic stem cells give rise to other blood cells. A multi-institutional Phase I clinical trial using hematopoietic stem cells to treat HIV-lymphoma patients is underway at UC Davis.

"We are genetically engineering a patient's blood stem cells with genes that block HIV infection," said Joseph Anderson, an associate professor in the UC Davis Department of Internal Medicine. The clinical trial is a collaboration with Mehrdad Abedi, the lead principal investigator.

“When the patients receive the modified stem cells, new immune system cells derived from these stem cells will contain the HIV-resistant genes and block further infection,” said Anderson.

Kyle Fink, an assistant professor of neurology at UC Davis, is leveraging institutional expertise to bring curative therapies to rare, genetically linked neurological disorders.

“We are developing novel therapeutics targeted to the underlying genetic condition for diseases such as CDKL5 deficiency disorder, Angelman, Jordan and Rett syndromes, and Juvenile Huntington’s disease,” said Fink.

His lab is using DNA-binding domains to modify gene expression in therapeutically relevant ways. The team is also creating novel delivery platforms to allow these therapeutics to reach the brain.

The lab is developing therapies to target the underlying genetic condition using DNA-binding domains to modify gene expression in therapeutically relevant ways. They are also creating novel delivery platforms to allow these therapeutics to reach their intended target: the brain.



“The hope is that these **highly innovative methods** will **speed up the progress of bringing therapies** to these rare neurodegenerative disease communities,” said Fink.

### Developing potential lifetime cures

Among Nolta’s concerns is the expense of gene therapy. “Some of the therapies cost half a million dollars, and that’s simply not available to everyone. If you are someone with no insurance or someone on Medicare, which reimburses about 65 percent, it’s harder for you to get these life-saving therapies,” said Nolta.

To help address this challenge for cancer patients at UC Davis, Nolta has set up a “CAR T Team.”

Chimeric antigen receptor (CAR) T-cell therapy is a type of immunotherapy in which a patient’s immune cells are reprogrammed to attack a specific protein found in cancer cells.

“We can develop our own homegrown CAR T-cells,” said Nolta. “We can use our good manufacturing facility to genetically engineer treatments specifically for our UC Davis patients.”

Developing stem cell treatments can be painfully slow for patients and their families, but Nolta sees progress every day. She envisions a time when gene therapy treatments are no longer considered experimental, and doctors simply prescribe them for patients.

“And the beauty of the therapy is that it can work for the lifetime of a patient,” said Nolta.

## UC Davis Startup USES ADVANCED IMAGING TECHNOLOGY AND MACHINE LEARNING TO SORT SEEDS

**Christian Nansen**, an associate professor in the UC Davis Department of Entomology and Nematology, has launched a startup, Spectral Analytix, to apply machine vision and machine learning to the classification and sorting of seeds.

“The idea is to **combine machine vision, robotics and machine learning** so you have an automatic eye, an automated arm and an automated brain,” said Nansen. “If you automate those three components you **end up with a system that can automatically classify or sort whatever you are working with.**”

For the machine “vision,” Nansen works with hyperspectral cameras, which collect data at very high spectral resolution. “The camera on your phone divides light into three wavelengths — red, blue and green,” said Nansen. “You can think of it like a cake with three layers — for each pixel you have three values. With a hyperspectral camera you have 250 bands, so the ‘cake’ now has 250 layers.”



UC Davis startup Spectral Analytix applies machine vision, robotics and machine learning to automatically classify or sort seeds and insects.

The first target market for Spectral Analytix is the seed industry, sorting dead seeds from those that are alive. “Crop breeders and vendors of crops seeds need fast and non-destructive methods to eliminate non-viable seeds,” said Nansen.

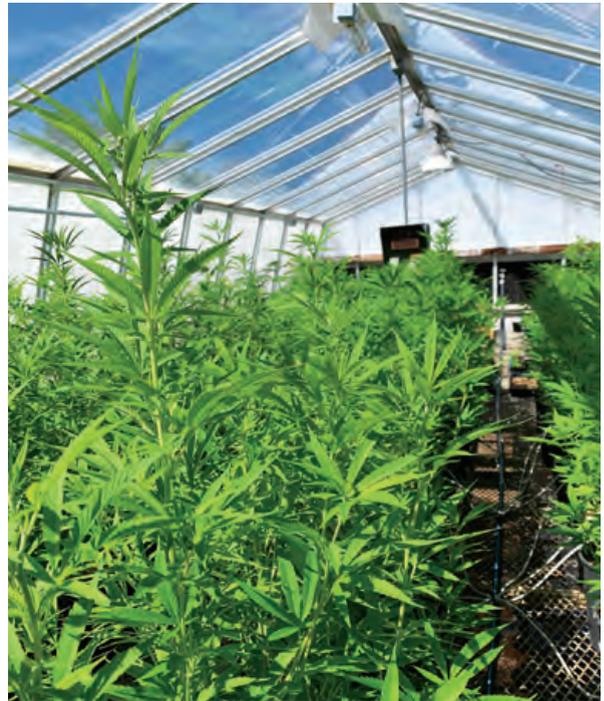
In addition to viability, his system also will be able to recognize the chromosomal makeup of seeds, sorting for desirable genetic features. “Typically, to find out whether a seed is triploid, diploid or tetraploid, it would have to be looked at by a specially trained person,” said Nansen. Triploid seeds, for example, are used to create seedless fruits, such as seedless watermelons. “The goal is to develop classification algorithms that can separate seeds based on ploidy.”

## Taking a Global Leadership Role to

## ADVANCE CANNABIS AND HEMP RESEARCH

**UC Davis launched** the Cannabis and Hemp Research Center in 2020 to serve as the university's hub, bringing together scientists, engineers, scholars and clinicians involved in research related to cannabis and hemp.

As a leader in agriculture, plant science and veterinary medicine, with a top-ranked medical center and law school, UC Davis has an extensive research infrastructure in place to pioneer advancements in the knowledge of production, environmental and health impacts, testing, and applications for use of cannabis and hemp as well as to provide insight for social implications and public policy.



Cameron Carter and Li Tian, co-directors of the Cannabis and Hemp Research Center at UC Davis.

In 2019, UC Davis entered into an agreement with Biopharmaceutical Research Company (BRC), which is registered with the U.S. Drug Enforcement Administration, to analyze the chemical and biological profiles of cannabis for the benefit of law enforcement, health care providers and scientific professionals. Together, the researchers analyze legally acquired cannabis materials in BRC's labs to understand the chemical composition of tetrahydrocannabinol (THC), cannabidiol (CBD) and other cannabinoids.

Researchers believe that **with a better scientific understanding of cannabis**, government authorities will be able to **more effectively regulate** the substance, and health care providers will be able to **uncover potential new treatments** and improve its prescribing practices.

The center is led by Cameron Carter, director of the UC Davis Behavioral Health Center of Excellence, and Li Tian, associate professor in the Department of Plant Sciences. It is designated as a Special Research Program under the administration of the Office of Research.

## Development of a Noninvasive Fetal Oxygen Monitor FOR SAFER DELIVERIES

**Soheil Ghiasi**, a professor in the UC Davis Department of Electrical and Computer Engineering, has launched a startup, Storx Technologies, to commercialize a noninvasive pulse oximeter that can measure a baby's blood oxygen saturation while it is still in the womb. His innovation may lead to safer deliveries and enable new fetal research.

With current fetal monitors, fetal health is inferred from the baby's heart rate and the mother's uterine contractions, but the baby's exact level of oxygen is not known. Ghiasi began to think about a non-invasive way to determine the fetal blood oxygen levels in utero, rather than solely relying on cardiac patterns, to know when a fetus was truly in distress and in need of delivery by C-section.

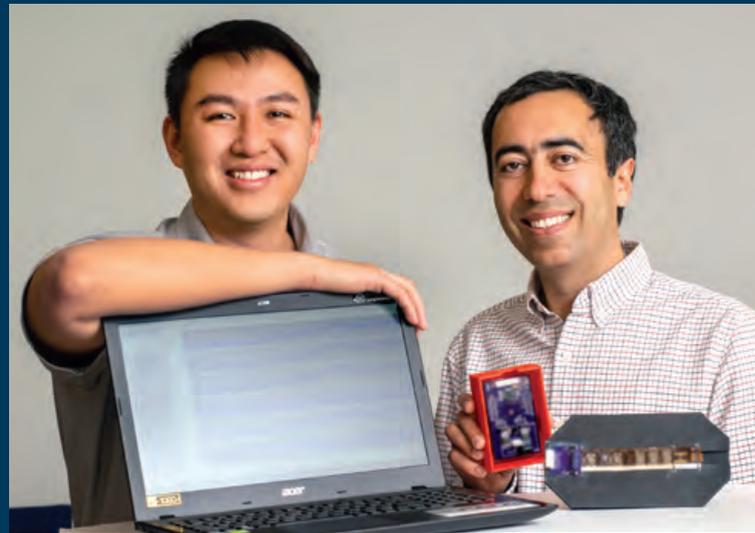
Along with Daniel D. Fong, a Ph.D. student in his lab, Ghiasi designed a noninvasive transabdominal fetal oximeter that transmits near-infrared light through the mother's abdomen.

The small amount of tissue-diffused light is sensed on the maternal abdomen; the measurements are subsequently **analyzed to remove the contributions of mother's tissue layers** and to infer measurements that are strictly due to the fetal tissue. Such measurements are then utilized, similar to conventional pulse oximeters, **to compute the baby's blood oxygen** saturation.

They collaborated with Diana L. Farmer, a renowned fetal and neonatal surgeon at UC Davis, to successfully test and validate the trans-abdominal fetal oximeter on pregnant ewes. Their results, published in *IEEE Transactions of Biomedical Engineering*, show that the new device could accurately measure oxygen levels in the fetus.

Next up is testing the novel fetal monitoring system with humans.

"We have approval to test patients who are at least 36 weeks pregnant and are coming in for routine checks. If that goes well, the next phase will be to test this during labor. That would be the ultimate application," said Ghiasi.



Daniel Fong (left) an electrical and computer engineering Ph.D. student, and Soheil Ghiasi (right), a professor of electrical and computer engineering, have invented a patented device that can measure blood oxygen saturation in a fetus through the maternal abdomen.

# Reaching Into Space

## UC DAVIS BECOMES A RISING STAR IN SPACE ENGINEERING

If space is the final frontier, UC Davis is taking giant leaps to reach it. With expertise in human-machine cooperation, control systems and materials under extreme conditions, the university is becoming a rising star in space engineering, playing a crucial role in the next generation of space exploration.

“We humans are just taking baby steps in space,” said mechanical and aerospace engineering (MAE) professor Stephen K. Robinson, a former astronaut and alumnus. “Research is the enabler for moving beyond the baby steps. That’s why we’re so passionate about it.” Engineering for space requires collaboration at every step. Researchers work with neuroscientists, medical doctors, psychologists, computer scientists, physiologists and other engineers to design the tools that then need to work in sync with humans to keep missions afloat and people alive in the solar system’s most uninhabitable places.

“The notion of working together is ingrained in the philosophy of UC Davis,” said MAE professor Sanjay Joshi. “In space engineering, nothing is completely independent — all of the subsystems of the spacecraft have to be designed concurrently, so you have to work in interdisciplinary groups to solve problems.”

The best example of this is the UC Davis-led Habitats Optimized for Missions of Exploration Space Technology Research Institute, a \$15 million NASA-funded multi-institution project to develop technology for human habitats in deep space.

### Human-machine teamwork

Robinson’s Human/Robotics/Vehicle Integration Performance Lab (HRVIP) works on projects ranging from human-machine collaboration to small satellites

to atmospheric entry vehicles to get people to work seamlessly with engineering systems and each other.

One example is a small device that fits atop a spacewalk helmet that reads and displays radiation information for astronauts to protect them from hazardous radiation in space. The device, Robinson’s contribution to NASA’s \$5.5 million Radiation Effects on Volatiles



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and Exploration of Asteroids and Lunar Surfaces (REVEALS) project led by Georgia Tech, is being tested at NASA’s underwater training facility at the Johnson Space Center in Houston.

Another example is a space ambulance — a repurposed Air Force uncrewed spacecraft that accommodates a pilot, a medic and a patient. The ambulance can leave the International Space Station, survive atmospheric entry and land like an aircraft at any regulation airport to get care that the patient needs.

### Controlling spacecraft

Human-machine cooperation goes both ways, so making spacecraft safer for humans to control is equally important. Robinson and Joshi work with 10 cm<sup>3</sup> satellites known as CubeSats, which are

popular because they can be launched into orbit as cargo and deployed directly from space. Robinson focuses on building CubeSats that can search for defects or leaks and monitor existing problems, which is critical to the integrity of the craft and the safety of the crew. These satellites make inspection easier, faster and safer, because their use puts fewer astronauts in harm's way on spacewalks. The UC Davis Space and Satellite Systems Club is developing the REALOP (Remote Experimentation and Analysis of Low Orbit Phenomena) CubeSat — UC Davis' first satellite. REALOP was selected in 2018 by NASA's CubeSat Launch Initiative (CSLI) to

be launched in early 2022. It will provide continuous data from a variety of environmental and remote sensors while downlinking this data to a ground-based server that students can access through online API and independently investigate various phenomena that are unique to low-earth orbit.

“The West Coast has traditionally had a lot of **aerospace innovation** and we feel like we're continuing that tradition,” said Robinson. “**UC Davis is an excellent place to develop teams** and to **push the boundaries of space research.**”

## CURRENT FUNDED RESEARCH EFFORTS INCLUDE:

“Radiation Effects on Volatiles and Exploration of Asteroids and Lunar Surfaces,” sponsored by NASA and partnering with Georgia Tech.

“Habitats Optimized for Missions of Exploration (HOME) Space Technology Research Institute for Deep Space Habitat Design,” sponsored by NASA and partnering with USC, CU Boulder, Georgia Tech, Carnegie Mellon University, Howard University and Texas A&M.

“Enabling Autonomous Crew Task Performance with Multimodal Electronic Procedures Countermeasures,” sponsored by NASA and partnering with Ames Research Center, University of Wisconsin, University of Michigan, MIT, Texas A&M, TraCLabs Inc. and CU Boulder.

“Aerodynamic Tabs for Control of Hypersonic Atmospheric Entry Trajectories,” sponsored by NASA.

“Modeling Individual & Team Problem-Solving Skills for the Establishment of Training Metrics, Standards, & Guidelines for Long-Duration Space Missions,” sponsored by NASA and partnering with Harvard University and Massachusetts General Hospital.

“Investigation of User-Interface and Human-Robot Performance for Supernumerary Robots,” sponsored by the National Science Foundation and partnering with Professor Sanjay Joshi (director, UC Davis Center for Neuroengineering).

“NCS-FO: Identification and Control of Neural Cognitive Systems,” sponsored by NSF and partnering with Professor Jochen Ditterich from the Center for Neuroscience.

“Zero-G Technology Demonstration of Low-Cost Three-Axis CubeSat Attitude Control with Hard Disk Drive Reaction Wheels,” sponsored by NASA.

“Capturing Human Adaptations in Novel Gravitational Environments in Space,” sponsored by NASA.



# IMPACT

## CENTERS PROGRAM LAUNCH

In the fall of 2019, the Office of Research announced a \$4 million investment in the creation of four new inter- and multidisciplinary research centers that align campus strengths with unique opportunities for global impact. Through these IMPACT (Inter & Multidisciplinary Program to Accelerate Convergence & Translation) research centers, UC Davis will enhance intellectual strengths in multidisciplinary areas and the collaborative research culture to establish itself as a leader in these emerging areas. The outcome of the research will have a significant social impact locally and globally while enhancing the quality of planetary health.

The four centers were selected from a pool of 64 applicants following a peer review process by a panel of experts consisting of faculty members from UC Davis and other institutions.

“Multi- and interdisciplinary research enables breakthroughs in resolving some of the world’s most intractable problems and opens up entirely new and exciting research fields,” said Prasant Mohapatra, vice chancellor for research at UC Davis.

“By building on synergies between individuals and organizations, the IMPACT Program will harness the power of complementary knowledge and capabilities to accelerate and amplify impact from research.”



### Perinatal Origins of Disparities Center

CENTER LEADERS: **Leigh Ann Simmons**, professor and chair of the Department of Human Ecology; **Janine LaSalle**, professor, Department of Medical Microbiology and Immunology, and associate director of the Genome Center

The Perinatal Origins of Disparities (POD) Center will investigate why and how some groups of people are more likely to be sicker than others, and then develop ways to prevent those disparities when they often begin — pre-conception to infancy.

### Center for Data Science and Artificial Intelligence Research

CENTER LEADER: **Thomas Strohmer**, professor, Department of Mathematics

The UC Davis Center for Data Science and Artificial Intelligence Research (CeDAR) will facilitate breakthroughs in research and innovation to address societal challenges by advancing data science foundations, methods and applications in a concerted effort.

### Gene Therapy Center

CENTER LEADER: **Jan Nolte**, professor, Department of Cell Biology and Anatomy

The UC Davis Gene Therapy Center will create a center of excellence to target genetic diseases through multidisciplinary research, education and manufacturing.

### Global Migration Center

CENTER LEADER: **Giovanni Peri**, professor, Department of Economics

The Global Migration Center will utilize a multi-disciplinary approach to understanding the new challenges of global migration that affect climate migrants, refugees, and vulnerable and at-risk migrants, and developing research-based action.

# Innovation AWARDS

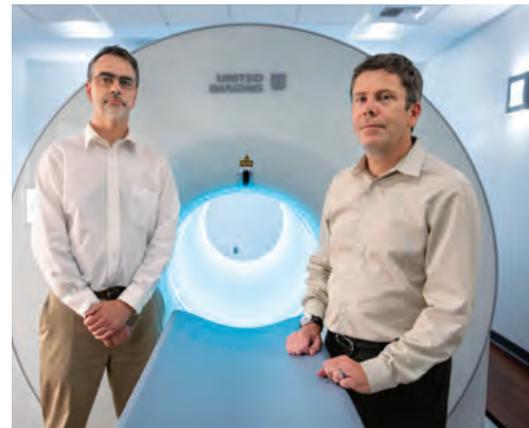
## The UC Davis Chancellor's Innovation Awards

recognize faculty members, community partners and industry leaders for their work, dedication and success in improving the lives of others and addressing the needs of our global society through innovations in technology or innovative societal engagement.

Venture Catalyst, a unit of the Office of Research, manages the awards program as part of its broader mission to foster an effective innovation ecosystem within and outside the university.

### Innovator of the Year

Professors **Ramsey Badawi** and **Simon Cherry** received an Innovator of the Year award for the development of EXPLORER, the world's first total-body positron emission tomography, or PET, scanner. Traditional PET scanners use short-lived radioactive tracers to show how organs and tissues are functioning in the body, only scanning approximately 20-centimeter segments at one time. In contrast, the EXPLORER can image the entire human body all at once, revealing system interactions that were previously undetectable.



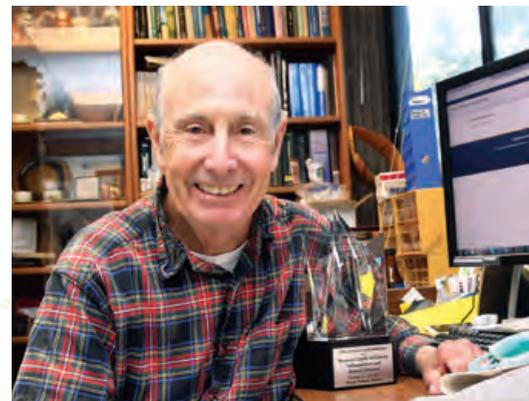
### Innovator of the Year

**Daniela Barile, Bruce German, Carlito Lebrilla, David Mills, Jennifer Smilowitz** and **Mark Underwood** also received the Innovator of the Year award for their collaborative work in advancing infant health through microbiome restoration. The team was able to develop a novel probiotic intended to enhance the health of premature and full-term infants through a sequence of discoveries that identified the important role of complex oligosaccharides in human milk and their role in supporting growth of a specific strain of bacteria (*Bifidobacterium longum* ssp. *infantis*) which promotes a protective and nourishing environment within the intestine of infants.



### Lifetime Achievement Award in Innovation

Distinguished Professor **Bruce Hammock** in the Department of Entomology and Nematology was awarded the Lifetime Achievement Award in Innovation. Hammock founded the field of environmental immunoassay using antibodies and biosensors to monitor food and environmental safety, and human exposure to pesticides. His laboratory developed the first recombinant virus for insect control and, extending from his insect research, he discovered a human enzyme termed soluble epoxide hydrolase that regulates a new class of natural chemical mediators, which in turn regulate inflammation, blood pressure and pain. This discovery led to a new drug now in human trials for neuropathic pain as well as a version in development for treating painful conditions in companion animals.



## Researcher Profile SATYA DANDEKAR

**Satya Dandekar**, professor of microbiology and the chairperson of the Department of Medical Microbiology and Immunology at UC Davis, has received a prestigious MERIT award from the NIH National Institute of Allergy and Infectious Diseases (NIAID) for her critical work on mechanisms of HIV and viral persistence.

MERIT stands for Method to Extend Research in Time. The National Institutes of Health (NIH) presents MERIT awards to outstanding investigators for their superior competence and stellar records of scientific achievement.

“Dr. Dandekar has been a pioneer in cutting-edge HIV research for decades. All of us at the UC Davis School of Medicine are very proud that her extraordinary work and significant contributions to understanding and treating infectious diseases have been recognized by the NIH,” said Allison Brashear, dean of the UC Davis School of Medicine.

Dandekar holds a joint appointment in the Department of Internal Medicine and the Division of Infectious Diseases in the UC Davis School of Medicine. Her research identified molecular mechanisms by which HIV exploits and rapidly impairs gut mucosal immune defense and establishes persistent infection in the host. The new NIH-funded research study will investigate mesenchymal stem cells, primarily found in bone marrow, as a potential therapy for eradicating HIV infection.

She began studying disease mechanisms of HIV, the virus that causes AIDS, in the early 1990s when contracting the disease was considered a death sentence. With the development of highly active antiretroviral therapies, AIDS has become a chronic, rather than fatal illness. But a cure — a treatment that completely eradicates the virus — remains elusive.



Dandekar’s research uncovered the direct and devastating **impact of HIV on the gut** and its ability to establish permanent residence. Within just a few days to weeks of infection, the **virus damages the gut epithelial lining and impairs the gastrointestinal mucosal lymphoid tissue**, which are critical for generating the body’s immune response for defending against infections.

The findings from her laboratory were the first to show the benefit of initiating antiretroviral therapy in early stages of HIV infection, leading to rapid immune recovery and better control of the viral infection. The findings changed treatment protocols for HIV.

# Research Funding

TRENDS AND  
BREAKDOWN BY SOURCE

5-YEAR TREND



2019-20 FUNDING SOURCE



# Innovation

## BY THE NUMBERS

### RECORDS OF INVENTION

(breakdown by category below)

141

#### BIOMEDICAL AND HUMAN HEALTH

- 24 Human Therapeutics
- 17 Human Diagnostics & Medical Devices
- 9 Bioscience-Related

#### ENGINEERING, SCIENCE & TECHNOLOGY

- 26 Engineering & Physical Sciences
- 4 Computer Science & Software

#### AGRICULTURE AND ANIMAL HEALTH

- 14 Veterinary
- 20 Agriculture & Food Science

#### OTHER

- 27 Platform Tools and Technologies, Tangible Research Property and "Know-How"

182 PATENT APPLICATIONS FILED

89 PATENTS ISSUED

40 LICENSES EXECUTED (PLANT & UTILITY, EXCLUSIVE & NON-EXCLUSIVE)

24 OPTIONS AND LETTER AGREEMENTS EXECUTED

937 MATERIAL TRANSFER AGREEMENTS EXECUTED

72 COPYRIGHT LICENSES EXECUTED

152 DATA TRANSFER AGREEMENTS EXECUTED

\$12.92m IN ROYALTY INCOME

## STARTUPS

Technologies developed at UC Davis enabled the foundation of 15 startup companies during the fiscal year 2019–2020.

### ALPHACAIT

Novel leukemia stem cell-targeted ligand and nanotherapeutics for human leukemia treatment

### AMCYT

Automated rapid onsite evaluation (ROSE) device that mitigates the 20% sampling error in fine needle aspiration biopsies, saving health care providers valuable time, money and resources

### BCD BIOSCIENCE

Natural carbohydrate structures to efficiently create and commercialize novel prebiotics, synbiotics and immunomodulatory therapies for human and animal health

### BREEZE BIOSCIENCES

New method for targeting nuclear receptor ROR-gamma in tumor cells for prostate cancer treatment

### CARRISAN TECHNOLOGIES

Novel antimicrobial solutions to prevent the spread of food-borne illnesses and to minimize food losses due to pathogens

### HISTOLIX

Rapid slide-free tissue imaging and decision-support tools that provide real-time results to address critical needs in cancer care and medical diagnostics

### INSTATIN

Lung-targeted inhaled therapies to treat chronic respiratory diseases such as asthma and COPD

### MATRUBIALS

Novel and selective antimicrobial therapies to treat bacterial infections based on antimicrobial peptides found in milk

### NANOELEMENTS TECHNOLOGIES

Revolutionary nano technology-based IP to remove lung-penetrating sub-0.3 micron air pollution particles and viruses

### OROX BIOSCIENCES

Dual inhibitors of soluble epoxide hydrolase (seh) and cyclooxygenase-2 (COX-2) for the treatment of inflammation, pain and cancers

### SARYA

ALPHA-4 BETA-1 integrin ligands for imaging and treatments of cancer, autoimmune diseases and inflammatory diseases

### SPECTRAL ANALYTIX

Advanced imaging tools that drive improved crop yields through purity, quality and proactive disease detection

### STORX TECHNOLOGIES

Solutions to reduce unnecessary cesarean section deliveries

### TENDEL THERAPIES

Next generation of immunomodulatory vaccines for HIV, infectious diseases, and cancer

### THE VACCINE GROUP (TVG)

Herpes virus-based vaccine vectors for use in animals with the ability to “plug and play” pathogen immunological target proteins in response to new pathogen threats



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