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RESEARCH

Fall 2019

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GROUND FOR
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SATELLITE**

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HURRICANE DORIAN

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ENTERPRISE HITS
RECORD YEAR

ENERGY INSTITUTE
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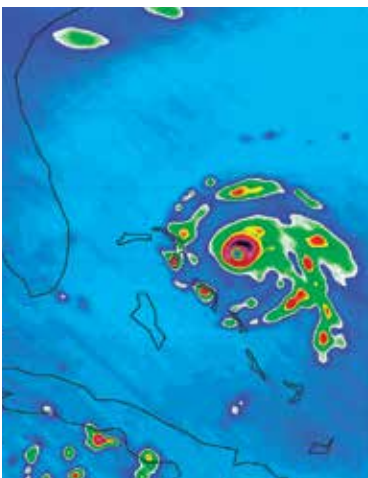
The 2019 AgInnovation Summit is part of the Sesquicentennial Colloquium Series – a celebration of Colorado State University's academics, research, and impact.

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ON THE COVER

TEMPEST-D, a weather-observing satellite the size of a cereal box, captured an image of Hurricane Dorian 250 miles above the coast of Puerto Rico on Aug. 28, 2019. The satellite used its miniaturized radio wave-based instrument to see through the clouds and reveal areas with heavy rain and moisture being pulled into the storm. For more information, see Page 15.



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Send comments, news, or story tips to:
 Office of the Vice President for Research
 Colorado State University
 2001 Campus Delivery
 Fort Collins, CO 80523-2001
 Or email us at
vpr_office@mail.colostate.edu

COLORADO STATE UNIVERSITY RESEARCH

Publisher:

Alan Rudolph, Vice President for Research

Guest Publisher:

Joyce McConnell, President, Colorado State University

Senior Editor and Writer:

Lauren Klamm, Director of Communications, Office of the Vice President for Research

Writers:

Mary Guiden, Science Writer and Senior Public Relations Specialist, CSU Public Relations

Jenna Gallegos, Postdoctoral Research, Chemical and Biological Engineering

Shelby Condit, Interim Communications Coordinator, CSU Energy Institute

Dell Rae Ciaravola, Public Safety and Risk Communications Manager, CSU Public Relations

Kate Jeracki, Executive Editor and Content Manager, CSU Public Relations

Design and Production:

Lisa Schmitz, Designer, CSU Creative Services

Production Editor:

Carly Ross, Project Manager, CSU Creative Services

Doug Garcia, Communication Coordinator/Designer, CSU Creative Services

Copy Editor:

Betty Grace Mickey, Assistant Director of Communications, University Advancement

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A Historic Year for CSU Discoveries



When I first began to get to know the faculty, staff, and students of Colorado State University, I was absolutely blown away by their achievements,

their engagement, and their energy. Why hadn't I known how extraordinary this campus community was earlier, even as an outside observer?

The answer seems clear: Like many land-grant and public institutions that truly embrace their service mission, CSU has a habit of hiding our light under the proverbial bushel basket.

In doing so, we sell ourselves short – but more than that, we do a disservice to our community, our state, and our world, which need to know just how much we have to offer to improve lives now – today – and to truly shape and improve our future.

So as the new president of CSU, this is my message for our entire campus community: *Embrace your brilliance.*

As a land-grant university, our mission is clear: set the standard for public research universities in teaching, research, service, and Extension for the benefit of the citizens of Colorado, the United States, and the world.

The research done here at CSU reflects the brilliance of our faculty, our staff, our graduate students, and our undergraduates. As an institution, we can create an environment through our research infrastructure that amplifies this brilliance.

CSU has a vibrant ecosystem of discovery and innovation that makes significant economic impacts in our Colorado communities. We translate our ideas into partnerships that carry this impact deep into our state with demonstrated gains to communities in our region. This past year has been a historic year for our impact, one in which we have broken records for productivity. Notable accomplishments from the year include:

- Election of Dr. Sue VandeWoude to the

National Academy of Sciences for her international recognition in One Health and wildlife disease management.

- A \$155 million NOAA award to the Center for Research in the Atmosphere, the premier site for weather prediction in Colorado, including national impacts with the recent Hurricane Dorian prediction using the new GOES-R satellite.
- Zoetis, the largest animal health company, invested in a Zoetis incubator, locating 20 new discovery scientists in our Foothills incubator to work on increasing sustainability of agriculture and food systems.
- We increased investments in existing core facilities and established new shared research facilities aligned with research opportunities, including the new Drone Core and the Institute for Research in the Social Sciences.
- We implemented a new Research Safety Culture Program that works collaboratively across the University to ensure productive, synergistic relationships within our research community.
- Our Energy Institute has established broad recognition for creating an ecosystem with social venture, corporate, and government partners. This year, we have established new ARPA-E sites for testing new innovations in methane leak detection and continued international work in access to energy, including work in Africa, South America, and India.

We are consistently impressed with and often amazed by the brilliance Colorado State University researchers deliver in and across multiple disciplines, and the creative and thoughtful ways in which they seek to address and solve the most pressing challenges of our time. As you read their stories here, I am confident that you will agree with me that this incredible institution truly needs to own our brilliance.

Sincerely,


Joyce McConnell
President

COUNTERMEASURES FOR PANDEMIC PREPAREDNESS: A conversation with BioMARC's John Wyckoff

by Mary Guiden

On July 17, Colorado State University received an award worth up to \$9.5 million to develop a human vaccine against the Rift Valley Fever virus. John Wyckoff, the University's principal investigator for the project, which is funded by the Coalition for Epidemic Preparedness Innovations, spoke recently about what it means for CSU and global health.

Wyckoff is the director of the Biopharmaceutical Manufacturing and Academic Resource Center, a nonprofit contract development and manufacturing operation owned and operated by CSU to produce vaccines, therapeutics, diagnostics, and other biopharmaceutical products. BioMARC is part of the Infectious Disease Research

Center administered through the Office of the Vice President for Research at CSU, headed by Alan Rudolph.

How did CSU decide to take on this vaccine development project?

At BioMARC, we help biotech companies, large pharmaceutical companies, and government agencies develop products that require specialized biological containment. BioMARC's function is to serve as a stepping stone between discovery and development. Our team helps generate vaccine or diagnostic material that goes into preclinical studies in the lab. We also work toward manufacturing material for clinical studies when products are tested in people.

CEPI had a call for proposals early this year. When that call came out, it was a great fit for what BioMARC does. Around 10 years ago, when I was working at Merial, a global animal health company, I was aware of this particular vaccine candidate, which is also why this project was appealing to me. A 'vaccine candidate' means that it has promise to be safe and to be effective, but it has not yet been approved by a regulatory agency for use in people.

How long have you been interested in infectious disease research and how did that start?

I'm an immunologist who has been focusing on development of vaccines against infectious diseases for animals

(continued on next page)

Vaccination is the most cost-effective avenue for reducing infectious diseases that we know.

CSU has a long-standing international reputation of excellence for work in mycobacterial diseases.



John Wyckoff is the director of BioMARC, which is part of the Infectious Disease Research Center at Colorado State University. *Photo: John Eisele/CSU Photography*

and people my entire career. I had one professor in graduate school who not only was able to identify a fascination or ‘hot button’ I had for immunology, but he also stomped on it regularly, which challenged me, in a good way.

It remains a fact to this day that vaccination is the most cost-effective avenue for reducing infectious diseases that we know. It doesn’t matter whether you’re talking about animals that are raised for food, pets, or people.

Who are the partners CSU will be working with on this project?

BioMARC is leading this research project, and we have about 20 people involved at our facilities. We are also working with two faculty members at CSU who have both experience and interest in Rift Valley Fever virus: Assistant Professor Rebekah Kading and Professor Dick

Bowen. They are both in the College of Veterinary Medicine and Biomedical Sciences and were natural additions to the team.

The vaccine that we will be testing was developed by the Viral Special Pathogens group at the Centers for Disease Control and Prevention. Stuart Nichol, who was the head of that group, and Brian Bird, also one of the inventors who is now at University of California, Davis, are also part of the project team at this point. There will be several phases to this project and new partners to announce moving forward.

How would you describe CSU’s expertise in infectious disease research?

CSU has a long-standing international reputation of excellence for work in mycobacterial diseases, in particular

tuberculosis. We have a lot of scientists who have really strong reputations in the infectious diseases research realm, not only in veterinary medicine but also in zoonotic diseases – ones that cross between humans and animals, like Rift Valley Fever – and vector-borne diseases – those that are transmitted by mosquitoes and ticks as well as other arthropods.

What should people know about Rift Valley Fever virus?

We do not yet have Rift Valley Fever in the United States. However, the virus is endemic throughout sub-Saharan Africa, and outbreaks usually occur in pastoral communities in lower-income countries. These rural communities have reduced access to public health services and their livelihoods are often closely linked to their livestock, which also happen to be

a main amplifier for the Rift Valley Fever virus and exposure risk for people.

There is an urgent need to develop a vaccine for humans to mitigate this emerging epidemic threat, protect these vulnerable communities, and strengthen global health security in the process.

Rift Valley Fever is a fairly mild disease in most people. It causes a flu-like illness and most people recover in a week or two. However, there are a couple of serious forms of RVF infection, in particular one known as a hemorrhagic form, where the fatality rate can be as high as 50 percent.

For most cases of Rift Valley Fever, the overall fatality rate is about 1 to 2 percent.

In the United States, we do actually have mosquitoes that are capable of transmitting RVF virus, mostly through the *Aedes* and *Culex* species, as well as a few other species. There are similar species also found in continental Europe,

so there is a risk of Rift Valley Fever spreading to other countries outside sub-Saharan Africa.

Over the last 20 years, the virus has expanded in its reach. In the last 10 years, it has moved into the Arabian Peninsula, northeast of Africa, and Madagascar.

In 2019, the island of Mayotte, which is northwest of Madagascar, has an ongoing outbreak of Rift Valley Fever among people and livestock.

There is an urgent need to develop a vaccine for humans to mitigate this emerging epidemic threat.

Why are zoonotic diseases particularly worrisome in terms of public health?

Zoonotic diseases are particularly worrisome because most of our livestock enterprises in the U.S. are intense, meaning that we have large numbers of highly susceptible animals confined in close proximity. You couldn't ask for a better situation for a pathogen to come in, sweep through a barn full of broiler chickens, egg-producing hens, swine, or dairy cattle or feedlots for beef cattle. Diseases can potentially just sweep through situations like this.

If it's a zoonotic disease, the people who take care of the animals can be at risk, and vice versa.

What draws you to work with vaccines? And is there a difference working in a university or industry setting?

Starting in graduate school, my interest was in immunology, and the big accomplishment of immunology that has done the most good is vaccine development. As I advanced in my career, I saw that in academia, to get a product developed and into the field where it did something good, was exceptionally difficult and time-consuming.

In industry, everything is about generating products. BioMARC is very much like a small company embedded in the University. I would describe us as 5 percent academic and 95 percent company-oriented, and that's pretty unique.

That's how I can give back to society, to develop things that benefit society in a large way. ■



Rebekah Kading, assistant professor in the Department of Microbiology, Immunology, and Pathology, has been studying Rift Valley Fever for years. *Photo: John Eisele/CSU Photography*

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Photo: Christopher Robertson, CSU Drone Core Facility



EYE IN THE SKY: A new drone research center

by Dell Rae Ciaravola

The possibilities of using a drone to assist research are endless: from mapping erosion or tree diseases in forests to monitoring wildlife populations and activity to measuring substances in the atmosphere, drones enable faster, easier, and better research strategies. But, that is true only for those who can navigate complicated FAA regulations and flight authorizations and the complexity of the drone itself. That's why Colorado State University launched a center aimed at making drones – as well as professional drone pilots – more accessible to University researchers.

Already assisting with several University projects, the CSU Drone Center, housed in the Vice President for Research Office, will help researchers access equipment, professional drone pilots, and permission to fly in University and non-University airspace.

“Our goal is to remove barriers and increase access to drone and drone expertise so that drone-based research can flourish at CSU,” said CSU Police Department Sgt. Christopher Robertson, who is the coordinator for the center. “We’re already seeing researchers use the center to successfully access information and data that would otherwise be difficult to

access without a drone, such as measuring air pollution at varying altitudes and gathering detailed images of bridges for early detection of possible failures.”

Through the center, CSU students, faculty, and staff can:

- Check out drones and related equipment for research projects.
- Gain permission to fly in University airspace or assistance with requesting permission to fly in non-University airspace.
- Work with a professional drone pilot or receive training to fly the drone themselves.
- Get assistance with adhering to FAA flight regulations and University drone policy.
- Access the University’s Chrisman Airfield for research.

Robertson hopes that the center can eventually expand to support research on drones themselves and how drones can be safely integrated into air traffic corridors. One current CSU research project accessing services through the center is looking at how drones may be kept out of areas where they don’t have authorization to fly, such as over people or protected airspace. ■

FOR MORE INFORMATION, PLEASE GO THE DRONE CENTER’S WEBSITE, OR CONTACT SGT. ROBERTSON AT CHRISTOPHER.ROBERTSON@COLOSTATE.EDU.

DNA has gone digital – *what could possibly go wrong?*

by Jeanna Gallegos

Biology is becoming increasingly digitized. Researchers like us use computers to analyze DNA, operate lab equipment, and store genetic information. But new capabilities also mean new risks – and biologists remain largely unaware of the potential vulnerabilities that come with digitizing biotechnology.

The emerging field of cyberbiosecurity explores the whole new category of risks that come with the increased use of computers in the life sciences.

University scientists, industry stakeholders, and government agents have begun gathering to discuss these threats. We've even hosted FBI agents from the Weapons of Mass Destruction Directorate at Colorado State University and previously at Virginia Tech for crash courses on synthetic biology and associated cyberbiosecurity risks. A year ago, we participated in a U.S. Department of Defense-funded project to assess the security of biotechnology infrastructures. The results are classified, but we disclose some of the lessons learned in our new *Trends in Biotechnology* paper.

Along with co-authors from Virginia Tech and the University of Nebraska-Lincoln, we discuss two major kinds of threats: sabotaging the machines biologists rely on and creating dangerous biological materials.

Computer viruses affecting the physical world

In 2010, a nuclear plant in Iran experienced mysterious equipment failures. Months later, a security firm was called in to troubleshoot an apparently unrelated problem. They found a malicious computer virus. The virus, called Stuxnet, was telling the equipment to vibrate. The malfunction shut down a third of the plant's equipment, stunting the development of the Iranian nuclear program.

Unlike most viruses, Stuxnet didn't target only computers. It attacked equipment controlled by computers.

The marriage of computer science and biology has opened the door for amazing discoveries. With the help of computers, we're decoding the human genome, creating organisms with new capabilities, automating drug development, and revolutionizing food safety.

Stuxnet demonstrated that cybersecurity breaches can cause physical damages. What if those damages had biological consequences? Could bioterrorists target government laboratories studying infectious diseases? What about pharmaceutical companies producing lifesaving drugs? As life scientists become more reliant on digital workflows, the chances are likely rising.

(continued on next page)

Messing with DNA

The ease of accessing genetic information online has democratized science, enabling amateur scientists in community laboratories to tackle challenges like developing affordable insulin.

But the line between physical DNA sequences and their digital representation is becoming increasingly blurry. Digital information, including malware, can now be stored and transmitted via DNA. The J. Craig Venter Institute even created an entire synthetic genome watermarked with encoded links and hidden messages.

Twenty years ago, genetic engineers could create new DNA molecules only by stitching together natural DNA molecules. Today, scientists can use chemical processes to produce synthetic DNA.

The sequence of these molecules is often generated using software. In the same way that electrical engineers use software to design computer chips and computer engineers use software to write computer programs, genetic engineers use software to design genes.

That means that access to specific physical samples is no longer necessary to create new biological samples. To say that all you need to create a dangerous human pathogen is Internet access would be an overstatement – but only a slight one. For instance, in 2006, a journalist used publicly available data to order a fragment of smallpox DNA in the mail. The year before, the Centers for Disease Control used published DNA sequences as a blueprint to reconstruct the virus responsible for the Spanish flu, one of the deadliest pandemics of all time.

With the help of computers, editing and writing DNA sequences is almost as easy as manipulating text documents. And it can be done with malicious intent.

First: Recognize the threat

The conversations around cyberbiosecurity so far have largely focused on doomsday scenarios.

The threats are bidirectional.



Neil Adans, research scientist, works in the Peccoud Lab in the Scott Bioengineering Building, Walter Scott, Jr. College of Engineering. *Photo: John Eisele/CSU Photography*

Jenna E. Gallegos, postdoctoral researcher in chemical and biological engineering, and Jean Peccoud, professor and Abell Chair in Synthetic Biology at Colorado State University, wrote this piece for *The Conversation* in December 2017. Colorado State is a contributing institution to *The Conversation*, an independent collaboration between editors and academics that provides informed news analysis and commentary to the general public.

On the one hand, computer viruses like Stuxnet could be used to hack into digitally controlled machinery in biology labs. DNA could even be used to deliver the attack by encoding malware that is unlocked when the DNA sequences are translated into digital files by a sequencing computer.

On the other hand, bad actors could use software and digital databases to design or reconstruct pathogens. If nefarious agents hacked into sequence databases or digitally designed novel DNA molecules with the intent to cause harm, the results could be catastrophic.

And not all cyberbiosecurity threats are premeditated or criminal. Unintentional errors that occur while translating

between a physical DNA molecule and its digital reference are common. These errors might not compromise national security, but they could cause costly delays or product recalls.

Despite these risks, it is not unusual for researchers to order samples from a collaborator or a company and never bother to confirm that the physical sample they receive matches the digital sequence they were expecting.

Infrastructure changes and new technologies could help increase the security of life science workflows. For instance, voluntary screening guidelines are already in place to help DNA synthesis companies screen orders for known pathogens. Universities could

institute similar mandatory guidelines for any outgoing DNA synthesis orders.

There is also currently no simple, affordable way to confirm DNA samples by whole genome sequencing. Simplified protocols and user-friendly software could be developed, so that screening by sequencing becomes routine.

The ability to manipulate DNA was once the privilege of the select few and very limited in scope and application. Today, life scientists rely on a global supply chain and a network of computers that manipulate DNA in unprecedented ways. The time to start thinking about the security of the digital/DNA interface is now, not after a new Stuxnet-like cyberbiosecurity breach. ■



Aubrey Ibele, lab manager of the Peccoud Lab, works with Jean Peccoud, Abell Endowed Chair in Synthetic Biology, Chemical and Biological Engineering, in the Scott Bioengineering Building. *Photo: John Eisele/CSU Photography*



Concussion test wins virtual reality hackathon

by Lauren Klamm

Fifty participants from Colorado State University, Front Range Community College, and Florida International University worked in 10 teams to develop virtual reality experiences from scratch in one weekend at the third annual CSU virtual reality hackathon, last fall. At the end of the event, one team went home with a check for the \$3,000 first-place prize.

"I thought the hackathon was an interesting opportunity to test myself. I had some basic game development and rapid prototyping skills, but I had never put them to the test before," said Alex Malott, CSU computer science senior and member of the winning team, VR-oom VR-oom.

Teams not only faced technical challenges, but also a looming time limit.

"The hardest part of our project was the time constraint. We had to make a fully functioning demo by the end of the 48 hours," said Kareem Youssef, CSU computer science senior and member of VR-oom VR-oom. "I think a lot of

"A big problem with a lot of concussion tests is that they are just question tests being administered and taken by people who are motivated to get back out on the field."

Team VR-oom VR-oom won first place with their concussion assessment tool project. Pictured from left to right: Rick Hotta, Kareem Youssef, Alex Malott, Ariana Mims, Alan Rudolph.

the other teams struggled, but we figured it out with a bunch of Red Bull and other snacks."

How it works

Team VR-oom VR-oom won first place with a virtual reality program designed to evaluate an athlete's readiness to return to sports after a concussion. The experience includes a base test looking at sensory abilities, focus, balance, and memory to objectively measure levels of cognitive impairment.



During the course of the hackathon, participants receive mentorship from virtual reality experts.
Photos: John Eisele/CSU Photography



Teams spent 40 hours developing their projects at the 2018 Virtual and Augmented Reality Symposium at Colorado State University, Oct. 20, 2018.

“A big problem with a lot of concussion tests is that they are just question tests being administered and taken by people who are motivated to get back out on the field,” said Malott. “With this experience, we have an objective measurement of the level of impairment that you can’t handwave or just say ‘oh, I feel fine.’”

The idea for the project was submitted by Jaclyn Stephens, assistant professor in occupational therapy.

Collaborative ideas

Last year, campus faculty and staff were invited to submit ideas for the virtual and augmented reality projects developed during the Create-a-thon. Fifteen ideas from the College of Liberal Arts, College of Health and Human Sciences, College of Veterinary Medicine and Biomedical Sciences, and College of Natural Sciences were submitted to the event idea board and seven were chosen. Teams that chose a faculty-submitted idea and placed first, second, or third in the competition won an additional \$500, and faculty who submitted the idea will receive funding to continue working on the virtual project.

“We are looking forward to carrying out this project a little further. One thing we are missing right now is that we have never tested this on someone with a concussion – just some severely sleep-deprived computer science students,” said Malott. “It will be interesting to get some actual, valid data past the program and make some tweaks based on that.”

(continued on next page)



Other honors

The second-place prize went to The Climate Changers, who developed “The Path We’re On: 2020,” which places the user in different scenarios affected by climate change. One scenario included a coastal town in Louisiana slowly being engulfed by rising sea levels. The idea for this project was submitted by political science Professor Michael Hamilton.

Team ProteVisus won third place and created an app modeling 3-D protein structures found in the Protein Data Bank. The project idea was submitted by Aaron Sholders in the

“The Path We’re On: 2020” places the user in different scenarios affected by climate change. One scenario included a coastal town in Louisiana slowly being engulfed by rising sea levels.

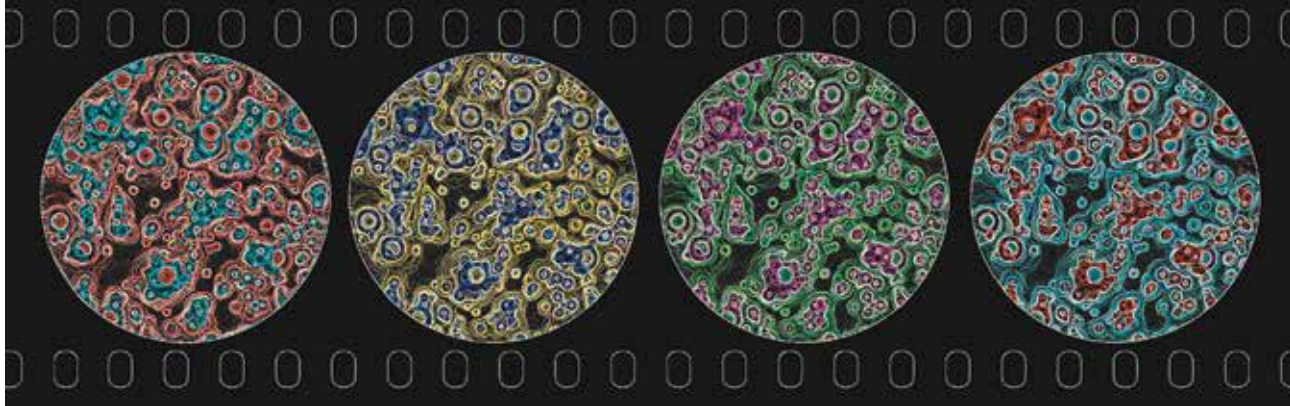
biochemistry and molecular biology department to be used as a teaching tool. The experience was developed on a Google Cardboard platform so it can be viewed on a smartphone or in a virtual reality headset.

The Hello World! team received the Outstanding Artistry Award for creating realistic 3-D models of several different types of eyes, including a dog eye, a healthy human eye, and a human eye clouded with cataracts. Kathryn Wotman in the ophthalmology department in the James L. Voss Veterinary Teaching Hospital submitted the idea for this virtual experience.

The Outstanding Technical Award went to the FBI Surveillance Van team, which created an interactive visualization of a home assistant’s network traffic.

Team Manipulation Hertz won the Land Grant Prize for their project “Making Waves.” This project idea, submitted by Sarah Sloane in the English department, included a virtual soundboard with interactive sound waves that created different frequencies and music.

To read about all the teams, participants, and projects developed during the weekend, visit the RamReality website. ■



Why Colorado State University is investing in **MICROBIOME SCIENCE**

by Anne Manning

Our bodies are brimming with invisible bugs – microscopic organisms, or microbes – such as bacteria, fungi, protozoa, and viruses that inhabit our guts, our ears, our skin. This community of 100 trillion microbes regulates our immune systems, helps us digest food, and even plays a role in our mental health.

Under our feet, the soil in which we grow food teems with microbial life, including bacteria and fungi that regulate plant health and longevity. In just one cup of lake water, you'll find thousands of bacterial species that quietly manage the functioning of a healthy waterway.

With apologies to Madonna, we are living in a microbial world – and we're only just beginning to understand it.

The combined genetic material of all the microbes living in a particular environment – be that the human gut, the soil on a farm, or the bottom of a lake – is called a microbiome. And over the last two decades, microbiome science, and the federal funding that makes it possible, has made its grand entrance into the university research world. Thanks in large part to DNA sequencing technologies that allow researchers to get up close and personal with whole swaths of organismal communities, it is increasingly clear that our health, the health of animals, the longevity of our soils, and our very destinies, are tightly linked to microbes and their wider microbiomes.

Like the microbes living in our guts, microbiome science at Colorado State University is thriving. Building on a legacy of excellence in microbiological science and scholarship, several years ago the University's leadership chose

microbiome science as one of three strategic initiatives in which to invest significant resources. (The others were aging research and air quality.) The University has hired six faculty members who all specialize in the study of microbiomes, and together with other colleagues, they are part of CSU's Microbiome Network.

Microbes matter

"One thing we all know is that microbes matter," said Ed Hall, assistant professor in the Department of Ecosystem Science and Sustainability, one of the six Microbiome Initiative faculty hires and a member of the Microbiome Network. "Yet we have been struggling to connect all of this information into usable system-level insights. The Microbiome Network is a strategic answer to the question of why microbes matter and how we can use those insights to improve humans, animals, and ecosystem sustainability."

First hooked on microbes through a faculty mentor while an undergrad at UMass Amherst, Hall now leads a lab examining the causes and consequences of microbial biomass, particularly in aquatic ecosystems such as streams and lakes. He and his students are looking at nitrogen and phosphorus cycling in Lake Yojoa in Honduras, and how the presence of metals influences the watershed's bacterial communities.

Researchers in the CSU Microbiome Network work in several colleges and disciplines – from microbiology to ecosystem science, and soil and crop sciences to animal sciences. They are connected by a common thread –

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BREAKING NEW GROUND FOR GLOBAL IMPACT

tailoring their scientific endeavors to a systems-level understanding of the microbiomes of their chosen disciplines.

Kelly Wrighton, assistant professor in soil and crop sciences, came to CSU from The Ohio State University to join the Microbiome Network. She and graduate student Kayla Borton are examining a specific microbe-mediated metabolism that occurs in the human gut.

“The question we are trying to answer is why certain people who have a high-protein, high-fat diet are susceptible to atherosclerosis, while other people who eat the same diet aren’t impacted,” Wrighton said. “One of the answers belongs in your host genome – your own DNA – but the other component could be the microbial component – how microbes in your gut convert those same chemicals differently than the microbes in another person’s gut.”

This, coming from a soil scientist? Wrighton calls herself and her students “ecosystem agnostics”; they look at fundamental metabolisms of microbe species, regardless of where they live. She’s examined soils, watersheds, and much more. For example, Wrighton and Borton have previously studied the methylamine metabolism they’re looking at in the human gut, but in a very different context: inside fractured shales in the Earth’s crust.

“We don’t really care what the ecosystem is,” Wrighton said. “Instead, we think about the functions and the chemical reactions that microorganisms catalyze. Then we can look across systems, and at how those microorganisms have these huge ecosystem-level consequences, and to track those differences across ecosystems.”

The network

The other faculty hired into the Microbiome Network illustrate the vastly different disciplines microbiome science can influence.

- Jessica Metcalf, associate professor of animal sciences, studies microorganisms that inhabit the gastrointestinal tracts of vertebrates. One of her projects looks at the effects of captivity and domestication on animal health. She also is researching decomposition ecology and applying it to better understand meat shelf life and spoilage.
- Pankaj Trivedi, assistant professor in bioagricultural sciences and pest management, explores interactions between microbiome and plant environments, including plant-microbe-insect interactions.
- Joshua Chan, assistant professor in the Department of Chemical and Biological Engineering, focuses on modeling and engineering microbiomes. He considers such microbiomes as potential solutions to global challenges ranging from food security to climate change to human disease.
- And Mike Wilkins, assistant professor in soil and crop sciences, is investigating the impacts of microbiomes on biogeochemical cycling in the environment.

Together with the larger web of microbiome and microbiology expertise across campus, these new faculty members are helping steer the direction of microbiome research and bringing new ideas to the table. ■





Top honors

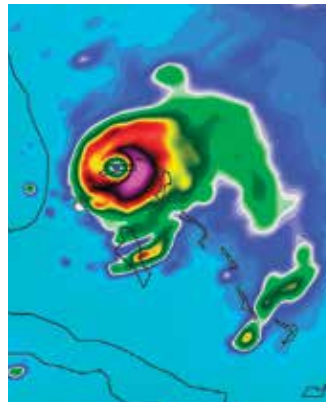


Sue VandeWoude

Colorado State University is proud to recognize Dr. Sue VandeWoude, a newly elected National Academy of Sciences member.

VandeWoude is a professor of comparative medicine and serves as associate dean for research and graduate education in the College of Veterinary Medicine and Biomedical Sciences at CSU. ■

TEMPEST-D provides storm coverage



TEMPEST-D – short for Temporal Experiment for Storms and Tropical Systems Demonstration – is an experiment in shrinking weather satellites to a size that makes them inexpensive enough to produce in larger quantities.

In this Aug. 28, 2019, image of Hurricane Dorian, the satellite used its miniaturized radio wave-based instrument to see through the clouds and reveal areas with heavy

rain and moisture. The green colors show moisture spiraling into the storm's center, and the yellow to pink colors correspond to the most intense rainfall.

The TEMPEST-D mission is funded by NASA's Earth Venture Technology Program and led by Colorado State University, in partnership with NASA/Caltech Jet Propulsion Laboratory in Pasadena, California, and Blue Canyon Technologies in Boulder, Colorado. The TEMPEST-D principal investigator is Professor Steven C. Reising of electrical and computer engineering, with co-investigators Professors V. Chandrasekar (electrical and computer engineering) and Christian Kummerow (atmospheric science). CSU's CIRA, directed by Professor Kummerow, hosts the TEMPEST-D data processing center, building on its strong heritage from NASA's CloudSat mission. The TEMPEST-D research team aspires to create real-time storm coverage with many small satellites that can track storms around the world. ■

Campus faculty now have access to SOCIAL SCIENCE RESEARCH ASSISTANCE

by Jeff Dodge

Faculty who need to conduct focus groups, design a survey for a research project, or carry out other types of social science research now have a place on campus to turn for help. An institute at Colorado State University offers a host of services related to all types of social science data collection, from program evaluation and interviews to social network surveys. The Institute for Research in the Social Sciences, or IRISS, was started in July 2017 by faculty from the Department of Political Science and the Department of Sociology. One of the co-founders, Associate Professor Jeni Cross of sociology, says it's an institute that faculty from many other disciplines have requested.

"Faculty from across the social sciences have been asking for this for a long time," Cross says. "By no means is it our idea; faculty across campus have been expressing the need for years. Most of CSU's peer institutions have a similar institute."

Historically, some faculty have contracted with similar institutes at other colleges and universities when they needed assistance with social science research, according to Cross. But now that CSU has IRISS, faculty can pay less for the services, and the institute's offerings are conveniently located on campus.

VARIETY OF SERVICES

Cross, who directs the institute, says that in addition to survey design and consulting, IRISS offers services for social

network analysis, program evaluation, and the "science of team science," a national effort to improve interdisciplinary scholarly work.

"It's about helping the members of a multidisciplinary team achieve something bigger than they can do on their own," Cross says.

The institute can be especially valuable for faculty outside the social sciences who may not be familiar with the best way to design a survey or when focus groups might be a better choice than a survey.

So far, IRISS clients have included on-campus and off-campus partners, including Larimer County Extension, where IRISS is conducting a community needs assessment. In another case, IRISS was contacted by a faculty member in the Department of Psychology who needed trained Spanish-speaking interviewers for a research project. The institute can be especially valuable for faculty outside the social sciences who may not be familiar with the best way to design a survey or when focus groups might be a better choice than a survey, for instance.

FOR MORE INFORMATION, VISIT IRISS.COLOSTATE.EDU.

GROWING FACILITY

IRISS is funded as an “emerging innovations core facility” by the Office of the Vice President for Research and has also received financial support from the College of Liberal Arts dean’s office.

Plans call for expanding facilities to accommodate things such as video interviewing, a computer lab with analytics software, and coding equipment.

While it currently has some office space in the General Services Building, Cross says plans call for expanding its facilities to accommodate things such as video interviewing, a computer lab with analytics software, and coding equipment.

Cross says the institute is expected to see its volume of work triple in its third year, and IRISS could eventually become established by the Office of the Vice President for Research as a “foundational core research facility” as its value to all CSU faculty grows. The institute’s projects are handled predominantly by social science faculty, graduate students, undergraduates, postdoctoral students, and social science research staff.

“IRISS aligns with many of the college’s areas highlighted for strategic investment – for example, interdisciplinary team science,



Sociology Ph.D. student Hannah Love specializes in the growing field called the “science of team science.”

data analysis, data collection, data visualization, student involvement in the research enterprise, and the like,” said Michael Carolan, the College of Liberal Arts associate dean for research and graduate affairs. “It will also help catalyze collaborative efforts that will

bring further visibility to the type of scholarship and methodological tools that are to some degree unique to the liberal arts.”

The institute’s rates vary by service but are lower for CSU faculty than for off-campus clients. ■

Luce Foundation awards Public Lands History Center \$225,000

The Henry Luce Foundation has awarded the Public Lands History Center \$225,000 over three years to fund a project called “Telling Untold Stories.”

The center plans to use the funding to identify two underserved communities that have untold stories, conduct research to help those communities claim a voice, incorporate them into American West Program events, and expand the center’s Parks as Portals to Learning program.

The first American West Program event funded by the grant will feature a lecture by Kent Blansett, author of *A Journey to Freedom: Richard Oakes, Alcatraz, and the Red Power Movement*. His talk marks the 50th anniversary of the 1969 takeover of Alcatraz Island by the activist organization Indians of All Tribes.

The event, which will be held from 7 to 9 p.m. on Nov. 7 in the Lory Student Center North Ballroom, is free and open to the public and will be followed by a reception with an audience question-and-answer period. The event is funded in part by the Lilla B. Morgan Memorial Endowment for the Arts.

Jared Orsi, faculty director of the Public Lands History Center, said the center will replicate the Parks as Portals to Learning program at another national park. For the past seven years, it’s been based at Rocky Mountain National Park, where history students spend a week working with staff to address park management issues.

Good impression

Orsi said Luce Vice President Sean Buffington became interested in the work of the PLHC when he came across



Members of the Public Lands History Center use a Luce Foundation grant to tell stories of marginalized communities in Colorado. Photo: Public Lands History Center

the center’s website while on a visit to Colorado. The PLHC hosted a visit with Buffington in July 2018, and he encouraged them to apply for the grant.

“He was intrigued enough to stop by,” Orsi said. “I think we made a good impression.”

“The Luce Foundation seeks to make humanistic scholarship accessible to broad and diverse publics,” Buffington said. “The Public Lands History Center’s ‘Telling Untold Stories’ initiative will bring the history of America’s public lands – in

all its complexity – to wider scholarly and public attention. The Luce Foundation is proud to support this project and the innovative work of the PLHC.”

Plans call for using the first year of grant funding to identify candidates to become the two community partners. All of the initiatives associated with the grant will feature significant student involvement, according to PLHC program manager Ariel Schnee. Additional American West Program events funded by the grant will be announced as they are scheduled. ■

FOR MORE INFORMATION, VISIT PUBLICLANDS.COLOSTATE.EDU.



Colorado State University Energy Institute researchers work to **BROADEN ACCESS TO ELECTRICITY IN RURAL RWANDA**

by Lauren Klamm



In America, it is easy to take access to reliable electricity for granted. Yet, according to the United Nations, 1.2 billion people around the world still live without power, and in developing countries, access to electricity is a luxury primarily available to those in metro areas. In the African nation of Rwanda, for example, the government estimated only about 20 percent of the country has access to electricity, and this figure was as low as 5 percent in rural areas in 2013.

The Rwandan government recently launched an ambitious goal to electrify the entire country by 2024 to bolster its economy and improve the health and incomes of its nearly 12 million residents, many of whom live in remote rural areas, some hours from paved roads.

Running power lines from a national electric grid is not only costly but would provide electricity to only roughly half of the population. Instead, the Rwandan government is looking at smaller, community-based microgrids and small household systems that generate electricity on-site and distribute solar power to the end consumers.

(continued on next page)

MICRO



GRIDS

Researchers at Colorado State University, in collaboration with the University of Rwanda and energy startup MeshPower, are helping the nation reach its electrification goals through a large-scale project to design, build, and install microgrids in rural villages.

Decentralized microgrids

“Microgrids are grids we build from the ground up and don’t require a connection to the central grid,” said

Bryan Willson, executive director of the Energy Institute at CSU. “In much of the developing world, we can’t afford to extend the grid because of far distances, and the amount of power we are supplying is relatively small. So, in those cases it makes sense to use things like solar, batteries, wind, or engines to supply the power and distribute it within a village.”

Decentralized microgrids allow areas without access to bypass the national

electricity network electric grid.

Microgrids, in general, consist of an energy generation source and energy storage. Historically, both functions have been performed by loud and dirty diesel generators, but the Smart Village Microgrid team is using solar power and battery storage.

While solar power can be more expensive than retail grid-connected power, it is cheaper than extending the grid to households that are not currently



Rwandan woman uses the innovative microgrid technology to bring electricity to her and her daughter in the rural countryside.



Rwandan locals gaze at new outdoor lighting feature, powered by microgrid technology developed by Colorado State University, University of Rwanda, and MeshPower.

connected. This makes microgrids an attractive option for the millions of people without electricity who have modest power demands.

Socio-technical implementation

However, technology isn't the only answer to the challenge of rural electrification. Dan Zimmerle, senior research associate in the Energy Institute, says the key question is how to have socio-technical implementation of sustainable microgrids. Therefore, the Smart Village Microgrid team is incorporating sociology and economic impacts into their research and working with Rwandan schools and companies like MeshPower.

"I think the approach we have taken at CSU to microgrids is different than what most universities have done," said

Zimmerle. "At most universities the microgrid work is entirely in the technical department. Our approach has always been cross-disciplinary."

The Smart Village Microgrid team has been supported, in part, by the Catalyst for Innovative Partnerships, a program of the CSU Office of the Vice President for Research that funds cross-disciplinary science. Through CIP, Zimmerle has collaborated with engineers, social scientists, industrial technology designers, and others from the colleges of Liberal Arts, Agricultural Sciences, and Health and Human Sciences.

Global partnership

The CSU team has also partnered with the University of Rwanda to replicate laboratory facilities and methods and is working to duplicate the design

and development of engineering course work.

"Colorado State was named as the strategic partner with the University of Rwanda in this African Center of Excellence, which is funded by the World Bank," said Willson. "In that role we have helped them to design the curriculum, lay out the research programs, and create the laboratories, including training of University of Rwanda staff at Colorado State."

The program has also expanded to 10 additional countries in southeast Africa to continue training and education in areas that have significant electrification needs. ■

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RESEARCHERS PROTOTYPE A NEW TEST FOR **Viral Infections**

by Mary Guiden

Professors Chuck Henry, Brian Geiss, and David Dandy began a research collaboration in 2015 through the Office of the Vice President for Research at CSU.

A team of Colorado State University researchers has developed technology that can detect extremely small amounts of antibodies in a person's blood. Antibodies develop to infect cells or kill pathogens, essentially fighting off a bacteria or virus. The levels of antibodies in the blood can tell whether that person is sick.

Using a small wire that is one-fourth the size of a human hair, the researchers developed a sensor that can detect as few as 10 antibody molecules within 20 minutes. Standard medical testing requires billions or trillions of antibody molecules for detection and can take up to a day to process.

This type of cost-effective instrument could help clinicians treat diseases sooner in people and could be used in low-resource settings.

Results from the team's research were published in *Biosensors and Bioelectronics* under the title "An ultrasensitive capacitive microwire sensor for pathogen-specific serum antibody responses."

The limitations of standard medical testing

Currently, most U.S. medical offices and hospitals use the ELISA test to determine whether or not a person has a viral infection. ELISA stands for enzyme-linked immunosorbent assay.

It's a common test, but ELISA's sensitivity is relatively low, said Brian Geiss, a senior author on the study and an associate professor in the Department of Microbiology, Immunology, and Pathology. This means that clinicians need a fairly high number of antibodies in a person's blood to get a positive test result. It also often takes seven to 10 days after an infection for the test to register.

Down to the wire

Using what Geiss described as very simple technology, the research team chemically attached proteins related to Zika and chikungunya viruses to inexpensive small gold wires. These particular viruses, along with West Nile and dengue, are transmitted by infected mosquitoes. Medical laboratories use these proteins in ELISA tests to look for antibodies that have developed to fight infections.



Next, they ran an electrical current through the wire, creating a charge on the wire similar to that of a battery.

The researchers then added antibodies to bind to the viral proteins on the wire, which increased the mass on the outside of the wire. This also increased the ability of the wire to hold the charge. They then measured the change in mass to quantify the number of antibodies on the surface of the wire.

Brian Geiss holds a wire that is one-fourth the size of a human hair. Photo: John Eisele/CSU Photography



Three researchers, three different colleges

The research builds off work from the lab of Professor Chuck Henry in the Department of Chemistry. Henry, a co-author on the paper, and his lab have developed several simple, inexpensive electrochemical devices over the last 10 years.

Professor David Dandy, also a senior author on the paper and head of the Department of Chemical and Biological

Engineering, said he was surprised by the device's sensitivity.

"We found that we could get very high specificity for confirming a viral infection," Dandy said. In addition, the research team did not see any reaction or reactivity from antibodies targeting other viruses, which can sometimes lead to false positive test results.

The scientists each brought unique skill sets and expertise to the table for this project, which led to the group's success.

"This type of research project is something that none of us could do on our own," said Geiss, adding, "we synergized our efforts to come up with new solutions to problems we're hoping will eventually be used in clinical settings."

The research team now hopes to combine this discovery with viral detection research they previously published to create a single system that can detect both viruses and antibodies against the viruses in patient samples.

"We hope that it can be used for point-of-care diagnostics and that it can be developed into a compact handheld system that can be used in the clinic or in resource-limited areas," said Geiss.

This type of device could also be used in agricultural settings for livestock disease surveillance and environmental sensing.

Lei Wang, who recently received a doctorate from CSU through the School of Biomedical Engineering and is now a postdoctoral fellow at the Massachusetts Institute of Technology, is the lead author of the study.

Jessica Filer, who recently received a doctorate from CSU through the Cell and Molecular Biology program, and Meghan Lorenz, an undergraduate research assistant, also are co-authors of the study. ■

WHERE IT BEGAN

Brian Geiss, David Dandy, and Chuck Henry began a research collaboration in 2015 through the Catalyst for Innovative Partnerships program, sponsored by the Office of the Vice President for Research at CSU. Their team, the Coalition for Development and Implementation of Sensor Systems, got its start through a two-year \$200,000 seed grant.

The program nurtures faculty with similar goals but different scientific interests and know-how, and encourages them to synergize their expertise to come up with new solutions to important problems, said Geiss.

The interdisciplinary team was formed at a time when Geiss wanted to switch gears in his research. "At that point, my lab's research was focused a lot on drug development, and I was interested in changing directions," he said.

Tom Chen, professor in the Department of Electrical Engineering, also was involved in this team.

Collectively, they developed several different types of diagnostic sensing systems that can be used for detecting bacteria, nucleic acids, and antibody responses to infections.

Dandy applauded Geiss's collaborative spirit and the gains the team has made.

"Brian is very interested in combining his knowledge of molecular biology and infectious diseases with engineering solutions to apply that knowledge to problems of societal importance," he said. "He works on very fundamental questions in biology, which has helped me and others on the team work on problems we probably wouldn't have tried to tackle."

3-MINUTE CHALLENGE

by Lauren Klamm



Winners become 2019-2020 research fellows

Fifteen participants in the Vice President for Research 3-Minute Challenge were selected to become the next VPR Graduate Student Fellows. Each winner receives \$4,000 in scholarship and travel support. Fellows will also participate in professional development workshops, mentorship, leadership, and engagement opportunities over the 2019-20 academic year.

Last spring, 39 graduate students vied for fellowships as they explained their research in three minutes for a panel of judges.

As students quickly summarized their research, judges scored on the content and comprehension of the presentations, as well as students' effective engagement and communication skills.

2019-20 VPR Fellows:

Kaytee Ankrom, Biology

- 3-Minute Challenge Presentation "Global Warming"

Heather Deel, Cell and Molecular Biology

- 3-Minute Challenge Presentation "Solving Crimes with Microbes"

Kimberly Dolphin, Biology

- 3-Minute Challenge Presentation "Why Can't He Take A Hint! The Evolution and Mechanisms of Male Guppy Mating Strategies"

Magda Garbowski, Graduate Degree Program in Ecology

- 3-Minute Challenge Presentation "Do Differences Make All the Difference? Targeting Functional Trait and Genetic Variability for Ecological Restoration"

Gretchen Kroh, Biology

- 3-Minute Challenge Presentation "Building Better Crops: Tackling Iron Deficiency in Plants"

Blaine McCarthy, Chemistry

- 3-Minute Challenge Presentation "Growing Green Plastics Using the Sun"

Afnan Shazwan Nasaruddin, Bioagricultural Science and Pest Management

- 3-Minute Challenge Presentation "The Chemical Radar: Bacterial Chemotaxis"

Michael Nguyen-Truong, Biomedical Engineering

- 3-Minute Challenge Presentation "Preparing Stem-Cells in their Fight Against Heart Failure: What is their Ideal Niche?"

Peter Olayemi, Soil and Crop Sciences

- 3-Minute Challenge Presentation "Lactobionate: A Soil Health Genie?"

MJ Riches, Chemistry

- 3-Minute Challenge Presentation "A Plant's Role at the Crossroads of Climate Change"

Evan Sproul, Mechanical Engineering

- 3-Minute Challenge Presentation "Engineering a Solution to the Greenhouse Gas Problem"

Ray Sumner, Anthropology

- 3-Minute Challenge Presentation "The Days After Colorado's Darkest Day"

Clayton Swanson, Health and Exercise Science

- 3-Minute Challenge Presentation "Turning on Your Brain: Age Matters"

Robert Wimbish, Biochemistry and Molecular Biology

- 3-Minute Challenge Presentation "Attachment Issues: Uncovering the Molecular Basis for Chromosome Movement in Cells"

Scott Wrigley, Food Science and Human Nutrition

- 3-Minute Challenge Presentation "The Gut Microbiome: The Missing Link" ■

Fellows will also participate in professional development workshops, mentorship, leadership, and engagement opportunities.

UNDER YOUR NOSE

How response to natural gas leaks could change through new research

by Shelby Condit

Have you ever caught a whiff of something like rotten eggs and realized there might be a gas leak nearby? That smell is a component added to natural gas, something that is normally colorless and odorless, to help people recognize leaks. However, it's a bit more complicated than that to effectively detect harmful leaks of natural gas.

There are many factors in how natural gas leaks and where it goes from there.

Now, in the first phase of a two-year project, a team of researchers at Colorado State University, in collaboration with the University of Texas at Arlington, are performing experiments to understand the degree to which environmental conditions affect natural gas migration below the surface, as well as what happens once it leaks into the air. The project is sponsored in part by the U.S. Department of Energy's Advanced Research Projects Agency—Energy, the Pipeline and Hazardous Materials Safety Administration, and five major industry distributors: PG&E, Con Edison, Southern California Gas, Xcel Energy, and Dominion Energy.

This kind of research is important, because natural gas leaks can be dangerous. Daniel Zimmerle, director of the Methane Emissions Testing and Evaluation Center and senior research associate at the Colorado State University Energy Institute, said these issues should matter to everyone. "Gas pipes are running underneath your street, and if natural gas accumulates in a confined space, that can be dangerous. What's more, methane is 25 times more powerful than CO₂ in terms of driving climate change. So you want to keep it in pipes," he said. In a more practical sense, leaks are a hazard to landscaping. "When you need to repair a leak, you want to minimize how much they dig up your street or front yard. Knowing more about where the leak is, how urgently it needs to be repaired, and how it should be monitored has a direct impact on the consumer."

Engineering and public health are combined in this issue. Kathleen Smits, associate professor in the Department of Civil Engineering at the University of Texas at Arlington and principal investigator on the study, said she is motivated by engineering research that connects to environmental health and safety. "I have been studying gas migration through soils for many years as applied to landmine detection and environmental remediation, like contaminant vapors migrating into residential structures," Smits said. "In terms of natural gas, which is predominantly composed of methane, we really don't understand how the environmental conditions both above and below ground affect the methane behavior."

Smits said a better understanding of those conditions will allow for improvement in the ability to respond to leaks. "Repairing leaks is something that everyone can rally around – climate benefits, safety improvements, better PR, and ultimately a better bottom line," Smits said.

This kind of information is essential for natural gas distribution companies to be able to address leaks effectively within their service areas. Richard Trieste, department manager for research, development and demonstration at Consolidated Edison Company of New York (Con Edison), said in an email that they are always looking for ways to enhance the safety and environmental impact of their natural gas distribution system. "Enhancing our understanding of how natural gas migrates serves as a means to enhance our leak repair process in order to continually improve and achieve these objectives," Trieste said.

The METEC facility, located at the CSU Foothills Campus, provides a space that models natural gas facilities, so that researchers can test low-cost methane sensing technologies and evaluate their performance. Part



Dan Zimmerle and his research team use the METEC test site to develop leak detection solutions under more natural conditions.
Photo: Ty Betts

of this setup includes an underground pipeline testbed. This gives researchers the chance to test how different conditions under the surface, such as soil type and moisture level, affect natural gas leaks, as well as how different surfaces such as pavement or vegetation affect the leak.

Clay Bell, a research scientist at the CSU Energy Institute, has helped coordinate this project and run experiments at the METEC pipeline testbed. “Gas distribution pipelines are under our city streets and supply gas to our homes,” he said. “They are much closer to the public than much of the other natural gas infrastructure, and therefore, a leak is a significant safety concern.”

Collaboration is key on these kinds of issues. “For us to actually go after interesting problems, we need diverse expertise – in house or at universities. That’s why we work closely with UT Arlington,” said Zimmerle.

Bell will also be working with industry partners to develop and implement a measurement protocol for field measurements. “Our team will go to leak locations with our industry partners to measure the extent of gas migration and the emission rate of leaks,” Bell said. “This data will help validate the models developed under this project, and ultimately help us understand how gas migrates and saturates soil in the event of an underground leak.”

The ultimate goal of the research is to provide guidelines for gas company employees and first responders when they arrive at a leak location.

George Smith, supervisor of gas operations at Dominion Energy, said the company was motivated to join the effort because there are currently no standard protocols that consider all of the

factors in gas migration. Smith said they hope the information collected in this study will help them develop a set of standard operating procedures to help protect customers, employees, and the general public.

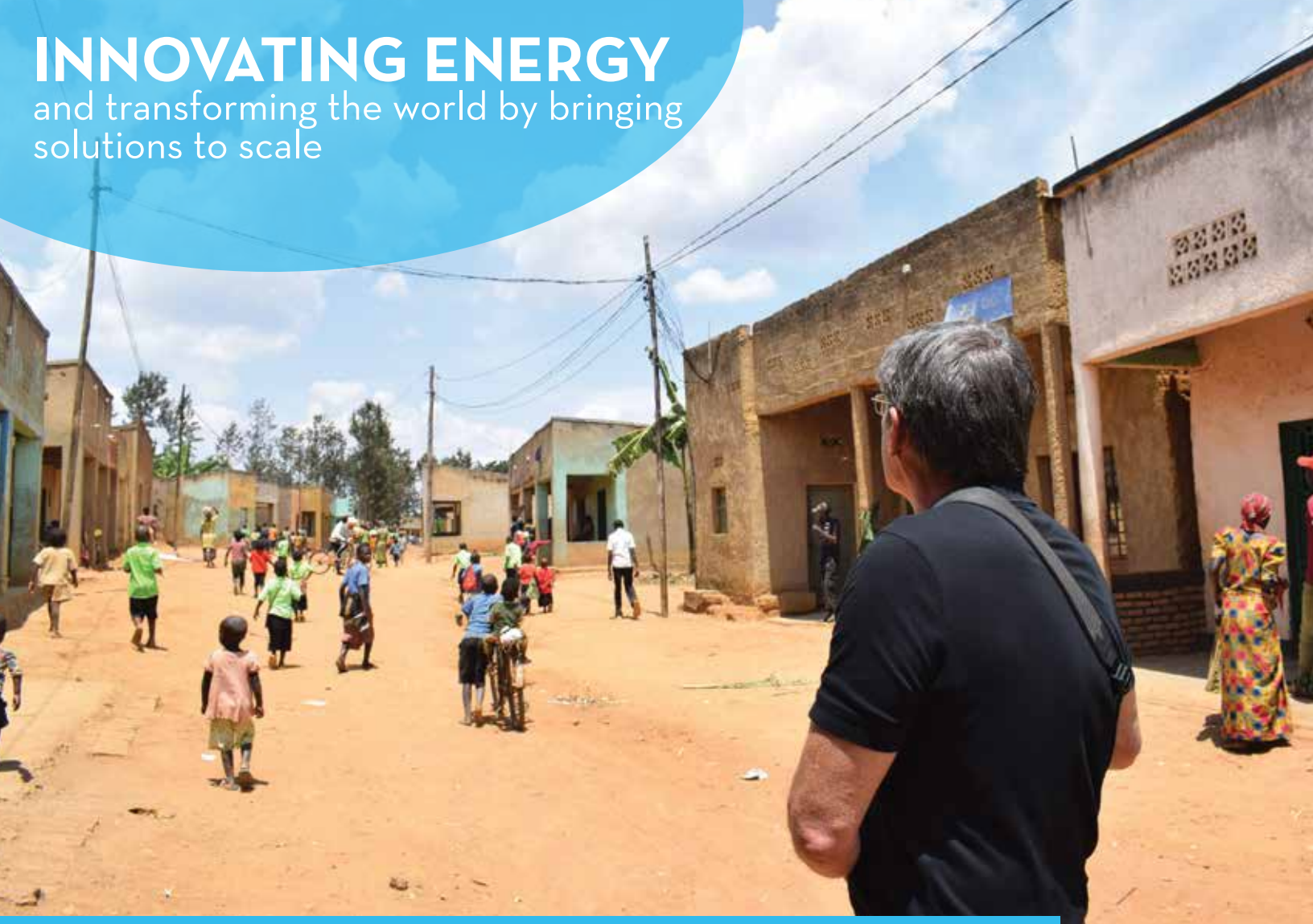
Once fieldwork is complete, the team will analyze the data to understand the extent of the migration and what factors impact it the most. “What we’re really doing here is injecting some additional knowledge into a prioritization process. Where do you go first? How urgently do you act on a particular size and type of leak?” Bell said.

Finally, they’ll use a combination of modeling and simulation to see if they can replicate those behaviors to thoroughly understand what is happening. Part of the issue currently is that gas can migrate long distances before it becomes apparent at the surface near the leak, making them difficult to locate. This part of the gas migration – when the gas sits a few centimeters above the ground before being carried away by the wind – is the least understood. That’s what UT Arlington is focusing on. “Results from this project will help us understand how far gas may migrate in different soil conditions to improve leak response protocols, and will inform how detection techniques may be improved,” said Bell.

Smits expects to get better predictions around what causes gas migration to occur, which will allow for better, more efficient responses to leaks. Ultimately, the substantial data collected on gas migration for a range of atmospheric, surface, and subsurface conditions will provide organizations like PHMSA with information that will enable them to create guidelines for prioritizing leaks, based on location and environmental factors. ■

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Scott Kelly, astronaut and subject of the NASA Twins Study, shares his experiences during his yearlong orbit around Earth. Researchers from 12 universities, including CSU, compared his health changes to that of his twin brother on Earth. *Photo: NASA*

Insight on how a human's body responds to spaceflight with **NASA TWINS STUDY**

by Mary Guiden

When NASA decided to study identical twin astronauts – one remaining on Earth while the other orbited high above for nearly one year, starting in March 2015 – scientists were not sure what they would find.

Would Scott Kelly undergo a Benjamin Button or *Interstellar*-like effect, and return to Earth younger than his brother Mark?

Based on preliminary results released in January 2017, Colorado State University Professor Susan Bailey, who studies telomeres, or the protective “caps” on the ends of chromosomes, found that Scott’s telomeres in his white blood cells got longer while in space. Changes in telomere length could

(continued on next page)



Professor Susan Bailey studies telomeres, or the protective caps on the end of chromosomes. Telomeres typically shorten as a person ages. *Photo: John Eisele/ CSU Photography*

BREAKING NEW GROUND FOR GLOBAL IMPACT

mean a person is at risk for accelerated aging or the diseases that come along with getting older. Telomeres typically shorten as a person ages.

These findings ran counter to what Bailey thought might occur and are confirmed in “The NASA Twins Study: A multidimensional analysis of a yearlong human spaceflight,” published in *Science* on April 12.

To study the twins’ telomeres, Bailey and her team received vials of their blood over 25 months, spanning time points before, during, and after spaceflight. Her team processed and analyzed the precious samples, delivered fresh from the space station by Soyuz rocket and overnight couriers.

“We were surprised; that was the first reaction,” said Bailey, when asked how it felt to see the initial findings. “But that’s what science is all about, right?”

Results from the study have implications for astronauts and people who want to explore space in the years to come through private ventures as humankind ventures longer and deeper in space.

NASA has announced plans for a mission to Mars and to a cis-Lunar station (between the Earth and the Moon), which will provide new opportunities for studying what happens to the human body during extended spaceflight.

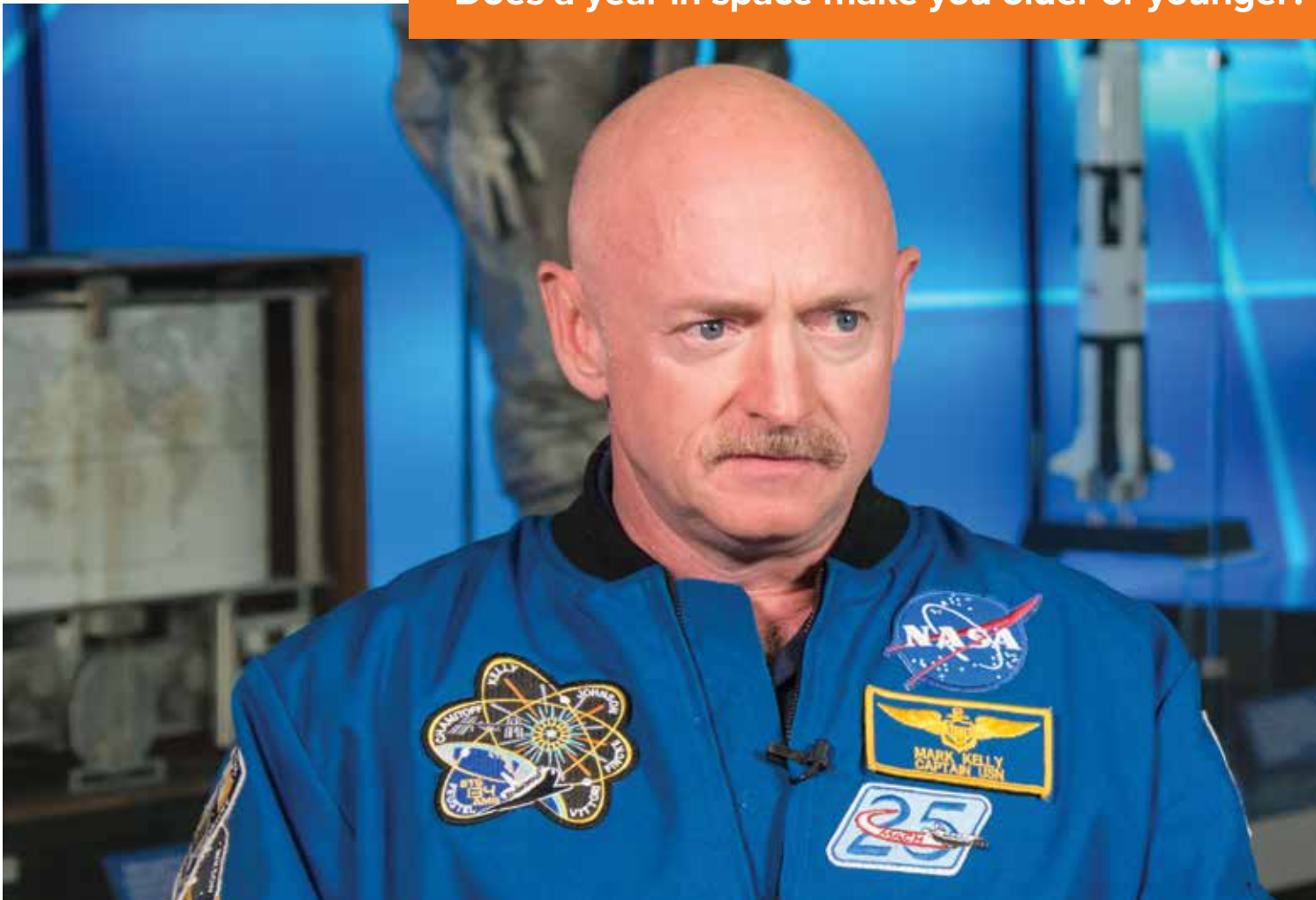
12 universities, more than 80 researchers

Bailey’s project was one of 10 investigations supported by 84 researchers across 12 universities, all coordinated by NASA’s Human Research Program.

Among the conclusions, the research teams found:

- Scott experienced dramatic shifts in telomere length dynamics, a biomarker that can help evaluate health and potential long-term risks of spaceflight.

Does a year in space make you older or younger?



- 91.3 percent of Scott’s gene expression levels returned to normal or baseline levels within six months of landing back on Earth. (Note: This does not mean that the rest of his DNA was mutated, as reported in some stories published last year.)
- The flu vaccine administered in space worked exactly the same as on Earth.
- Changes in Scott’s diversity of gut flora in space were no greater than stress-related changes scientists observe on Earth.
- Proper nutrition and exercise while in space resulted in decreased body mass and increased folic acid, which is vital for making red blood cells, for Scott.

Shorter telomeres mean a higher risk for some age-related health conditions

Bailey said that from her perspective, “the most striking finding” is the elongation of Scott’s telomeres in space. While most of his telomeres returned to near preflight averages, he now has more short telomeres than he did prior to the 340-day mission.

Having shorter telomeres puts a person at higher risk for accelerated aging, said Bailey. This also increases the risk for diseases that come along with aging, including cardiovascular disease and some cancers.

“For us Earthlings, it’s pretty similar,” Bailey explained. “We all worry about getting older, and everyone wants to avoid cardiovascular disease and cancer. If we can figure out what’s going on, what’s causing these changes in telomere length, perhaps we could slow it down. That’s something that would be of benefit to everybody.”

Launching a new research mission

Bailey will continue her telomere research with NASA through a new project designed to answer questions about astronaut health and performance on long missions as they journey to the Moon and Mars.

(continued on next page)



Identical twin astronauts, Scott and Mark Kelly, are subjects of NASA’s Twins Study. Scott (right) spent a year in space while Mark (left) stayed on Earth as a control subject. Researchers looked at the effects of space travel on the human body.
Photo: NASA



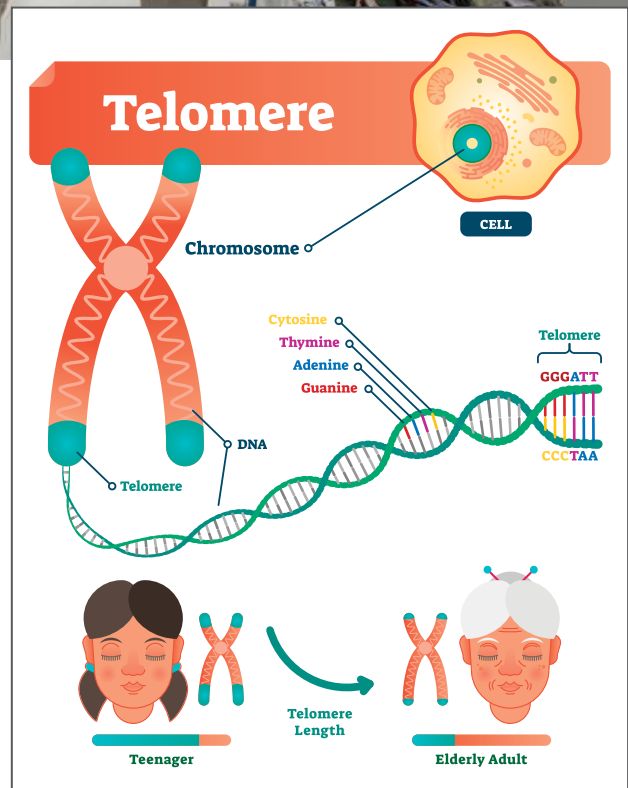
Scott Kelly and Russian cosmonaut Mikhail Korniyenko collaborating aboard the space shuttle during Scott's yearlong orbit around Earth. Photo: NASA

In this integrated One-Year Mission Project, she'll study 10 astronauts on one-year missions, 10 on six-month missions, and 10 on trips from two to three months at a time. Health data will be compared with people on the ground who are in isolation for those same periods of time.

"We're trying to determine if it is indeed something specific about space flight that is causing the changes we've seen," she explained.

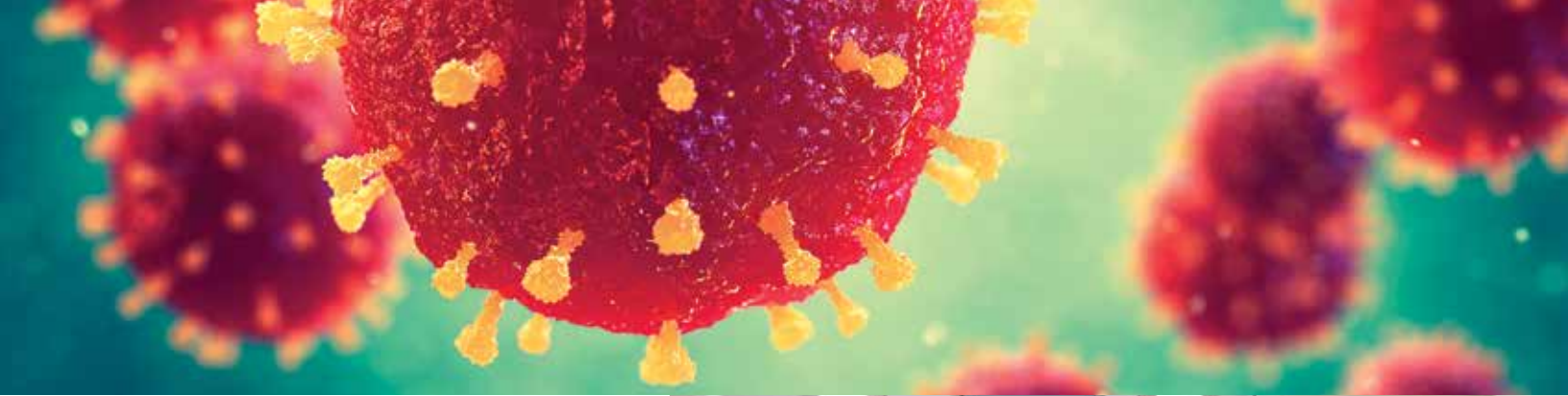
NASA's Human Research Program and Space Biology Program funded 25 proposals, all of which will contribute to the space agency's long-term plans, which include human missions to the Moon and Mars.

Through these studies, NASA aims to address five hazards of human space travel: space radiation, isolation and confinement, distance from Earth, gravity fields (or lack thereof), and hostile or closed environments that pose great risks to the human mind and body in space. ■



Telomeres are protective caps at the ends of our chromosomes that have been found to shorten as we age and are one possible way to compare aging between individuals.

Read our story outlining the preliminary findings: <https://col.st/o05jT>



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BioMARC is a nonprofit biologics Contract Development and Manufacturing Organization owned and operated by Colorado State University serving biopharmaceutical companies and government agencies. We specialize in high containment: Biosafety Level 2 (BSL-2) and Biosafety Level 3 (BSL-3), CDC Tier 1 select agents, and spore-forming microorganisms. BioMARC manufactures vaccines, bio-therapeutics, and diagnostic reagents in our FDA- and CDC-inspected state-of-the-art facility.

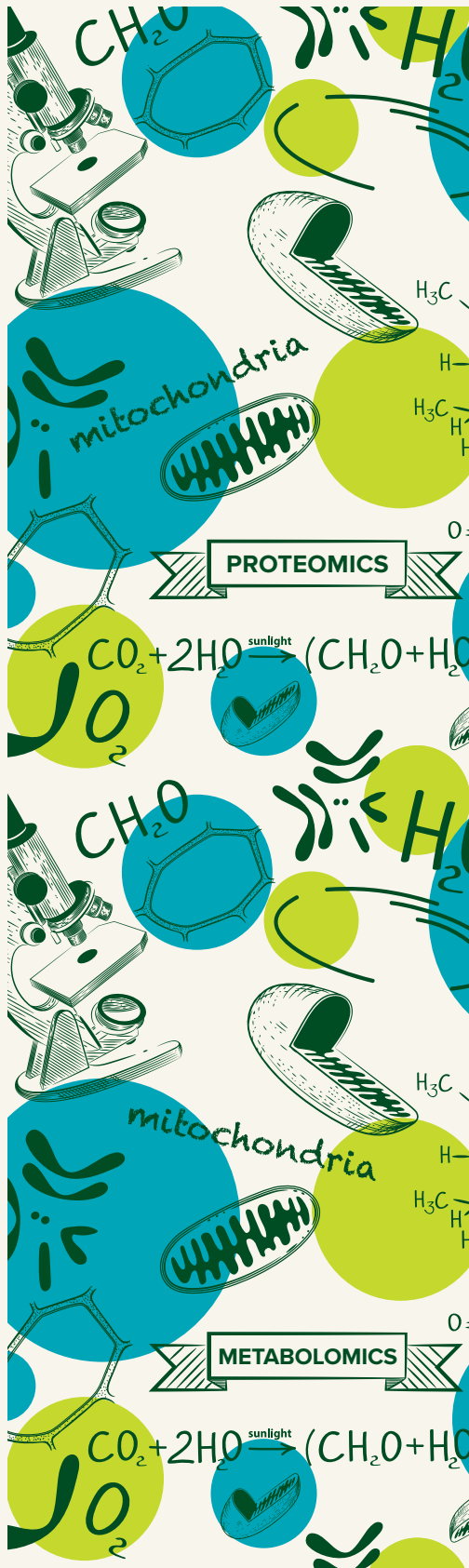


BioMARC

Biopharmaceutical Manufacturing
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VICE PRESIDENT
FOR RESEARCH
COLORADO STATE UNIVERSITY



Biomarkers of disease: mining the “omics” orchestra of life

by Anne Manning

Barth Syndrome is a genetic disease that causes an enlarged, weakened heart. The condition is linked to changes in mitochondria – the cellular organelles responsible for metabolizing fuels and providing energy to the cell.

Colorado State University’s Adam Chicco, a professor of biomedical sciences who studies mitochondria, set out to discover exactly what’s different in the mitochondria of Barth patients.

It was a tall order; after all, mitochondria are complex, bilayer structures with millions of proteins and molecules. Where to begin?

Chicco went to CSU’s Proteomics and Metabolomics Facility, whose experts supplied him with a broad characterization of the proteins and metabolites found in the mitochondria of human and mouse hearts with Barth Syndrome. The sweeping overview allowed him to look for patterns present in both species that could lead to clues about the disease.

The data revealed a clue worth exploring – a specific defect in fat metabolism leading to deficiency in a critical coenzyme called CoA, which was associated with low levels of a B vitamin. Based on that observation, Chicco designed a series of experiments to specifically study the effects of CoA deficiency on cardiac mitochondria in mice. The goal was to better understand its role in the development of Barth Syndrome, which could lead to new therapies to delay or reverse its progression.

THE AGE OF -OMICS

Going, or gone, are the days when life scientists chased hunches. We live in an age of “-omics,” in which researchers can attack complex problems armed with comprehensive sets of data on genes, proteins, and other molecules of interest.

The suffix “-omics” might best be associated with the Human Genome Project, completed in 2002, in which an international team of scientists cataloged every gene in the human body – the cast of characters in the play of life.



Colorado State University Microbiology, Immunology, and Pathology Assistant Professor Brendan Podell, Health and Exercise Science Associate Professor Adam Chicco, and Microbiology, Immunology, and Pathology Professor Randall Basaraba collaborate. Photo: Bill Cotton/CSU Photography

For Chicco and his heart mitochondria, it was a combination of both analyses that allowed him to focus in on CoA, which provided new insights into an old problem.

“The development of chronic disease is a complex process – involving both beneficial and pathogenic changes that can be difficult to sort out without having the full picture,” Chicco said. “Just because you see one

Of course, just knowing the cast of characters doesn’t tell you what’s going to happen in the play, or which lines the actors (genes) will recite. But knowing the cast list is a game changer. It’s a powerful starting point for new science.

The analogy translates to other “-omics” as well. For example, proteomics is the characterization of every protein in a cell, and metabolomics refers to the small molecules, or metabolites, involved in all aspects of cellular metabolism. Together, the full characterization of these biological molecules gives scientists new avenues for meaningful, directed inquiry.

protein or metabolite change here or there, it doesn’t mean that it is part of the problem. Defining the landscape of all changes associated with a particular phenotype can provide a context for better understanding where individual changes fit in the overall process.”

In some ways, that’s the challenge of proteomics and metabolomics – you can see everything. Like a *Where’s Waldo?* illustration, it can be daunting to look for cohesive patterns in an endless sea of information. This is where bioinformatics professionals are extremely helpful: to analyze “-omic” data.

THE POWER OF MASS SPEC

The key technology at the PMF is mass spectrometry, which has been called the most important breakthrough in biochemical and biomolecular research in 100 years.

In mass spectrometry, molecules are fed into a machine, heated up, ionized, and separated by mass and charge. During the ionization process, the molecules are blasted into little pieces, and the way they break apart provides feedback on their structure. The technology is keyed on the ability to backtrack and deduce all the structures in the sample, based on their “mass spec” patterns. It is by far the best way to determine the molecular makeup of any biological sample.

The samples that come through the PMF at CSU are too numerous to count: blood, tissue, urine, stools, beer, soil, volatile compounds, meat, water, and biofuels, to name a few.

Identifying proteins and small molecules is fundamental to just about every organic scientific study imaginable, so naturally researchers from all over campus (as well as outside companies and organizations) use the facility.

EQUIPMENT AND EXPERTISE

CSU’s PMF has 10 mass spectrometers with varying specialized capabilities, says Director Corey Broeckling.

The facility performs profiling, both targeted – honing in on one or more particular compounds – and nontargeted – creating a complete picture of everything in the sample, which is what Chicco wanted. Analytes measured include not only metabolites and proteins, but polymers, environmental compounds, metals, and more.

The PMF has several Ph.D.-level staff members, including Broeckling, in addition to experienced mass spectrometry, biology, and chemistry experts who provide critical insight and expertise for researchers. PMF staff work with researchers to design experiments and to get the most out of the data they uncover. Researchers pay user fees typical of cost-recovery operations for PMF services.

“I don’t know that there is a proteomics or metabolomics dataset out there that’s ever been fully mined for data,” Broeckling said. “There’s just so much in them. The question is, what can we pull out of them that’s going to contribute to biological meaning? The more we can move that forward, the more we can provide for everyone.” ■

LEARN MORE ABOUT THE PROTEOMICS AND METABOLOMICS FACILITY: WWW.RESEARCH.COLOSTATE.EDU/PMF



RESEARCH ADMINISTRATION: It's complicated

With Colorado State University's research expenditures reaching a record of nearly \$400 million for Fiscal Year 2019 – one-third of the institution's overall annual billion-dollar budget – the University is poised to continue its high-level research mission.

by Kate Jeracki

While grants from both public and private sources allow faculty and researchers to explore important scientific questions and make cutting-edge discoveries, each one comes with its own set of specific reporting rules and regulations.

"As our reputation grows, so does our research funding, and with the privilege of that funding comes rules we have to follow in new ways," explained Rick Miranda, provost and executive vice president for CSU. "It is our goal to have a research program that is the envy of other R1 institutions and become a university that others look to when they need a model of the right way to do things."

This is where the small platoon of CSU's research administrators comes in, to make sure we do research right. More than 160 dedicated professionals are deployed in colleges, units, departments, and labs across campus and in remote locations, all with the mission of helping investigators secure external funding, then ensuring compliance with the terms and conditions of the funding contracts once the research begins.

It can be as complicated as it sounds.

Research administrators play a critical role in the success of our research enterprise," said Vice President for Research Alan Rudolph. "They make our research possible in significant ways."

A SENSE OF HUMOR

The research administrator's job starts in the pre-award phase with assisting faculty in the development of the administrative sections of a grant proposal, completing required government and agency forms, drafting budget justifications, interpreting guidelines, coordinating documents, and helping to meet deadlines. It continues through ensuring the request is submitted correctly, and, once the grant is awarded, really ramps up with negotiating the award requirements, setting up accounts and cost accounting so researchers can spend the funds properly, and keeping on top of all the reports required throughout the life of the grant.

It can be as complicated as it sounds, especially when you add in compliance with shifting policies at the University, state, and federal levels and all the different rules and regulations of all the different funding partners – one project can have multiple funding sources and potential subcontractors at other institutions, and each researcher can have multiple sponsored projects underway at once.

That's why the top characteristic that Diane Barrett, director of the Office of Sponsored Programs, looks for when hiring a new research administrator is a sense of humor.



“No one goes into this profession on purpose,” explained Barrett, who has been in research administration for more than three decades but whose education was in the performing arts. In fact, there is no undergraduate program in research administration anywhere. “But once you start working in it, you get hooked. It’s intellectually rewarding, constantly changing, and you get to work with a great, collaborative group of people. It keeps you on your toes.”

Indeed, a 2016 survey of the members of the Society of Research Administrators International found that administrators themselves ranked knowledge of rules and regulations and customer service and collegiality the most important qualities for success in the field. No one considered math and budgeting proficiency the qualities of most importance.

Christa Johnson, associate vice president for research, sees the role of the Office of Sponsored Programs as not only supporting the University’s overall research enterprise, but also providing research administrators the resources they need to support individual faculty in their research.

“Our efforts aren’t top-down; we give people a chance to interact, meet in person, learn new things, and share what they know,” said Johnson, who started her career teaching the humanities. “They share knowledge and best practices – everything. We learn so much in the process.”

A NETWORK OF KNOWLEDGE

When Johnson came to CSU from Washington University in 2015, one of her first initiatives was to bring the far-flung research administrators closer together, so they can share what they

have learned through dealing with various funding agencies. The result was RAM (Research Administrators and Managers) Around, which meets monthly in the Morgan Library Event Hall to provide a forum for knowledge exchange as well as professional development.

“The research administrators at CSU are naturally a very collaborative group, and Christa and Diane have helped make us more so,” said Margi Cech, financial and research manager for the College

of Natural Sciences, who was always fascinated by research but was never involved in it as an undergrad. “Their efforts, such as RAMAround, have really elevated an awareness of the importance

of research administration on campus. We have established a tremendous network of colleagues we can call on when we have questions about a certain funding agency or a new requirement.”

Ron Splitterger, director of research services, who started at CSU as a volunteer in the 1960s while he was a student at Fort Collins High School, has seen several important changes over the years: grant systems moving from paper to online, for example, as well as the professionalization of the research administrator role and the growing appreciation of their importance to the success of the University’s research enterprise.

“Research has always been part of CSU’s land-grant mission,” he said. “Our vision for a healthy institution depends on a unified approach to the research mission. The VP for research understands that we wouldn’t be successful without it, and through things like RAMAround, I feel the administration really appreciates the research administrators and is listening to their concerns.” ■

“No one goes into this profession on purpose, but once you start working in it, you get hooked.”



Members of RAMAround meet monthly in Morgan Library to share experiences and best practices in negotiating the research grant funding process. *Photos by John Eisele/CSU Photography*

Research enterprise hits record \$398.5 million

by Anne Manning

Colorado State University's spending on research activities hit a record \$398.5 million for Fiscal Year 2019, a 6.3 percent increase over the previous year.

Spending on research, which has grown by nearly \$100 million in the last decade, signals a bright future for the University's research environment. In the fiscal year that ended June 30, CSU posted increases in all areas of sponsored project awards, including federal and industry funding.

"With our total expenditures closing in on \$400 million this year, it's clear that our research enterprise has never been stronger," said Vice President for Research Alan Rudolph. "In an era of shrinking federal funding and increased competition for that funding, the fact that our federal expenditures have continued to increase speaks to the quality, breadth, and depth of our faculty."

Federal awards

About 70 percent of CSU's research dollars comes in the form of grants awarded by federal funding agencies. The remainder originates from other sources, including state and local governments, private foundations, nonprofits, and industry partners.

Federal expenditures totaled \$284.3 million in Fiscal Year 2019, compared with \$268.7 million in the previous year. Nonfederal sources totaled \$56.6 million this year, compared with \$53 million in 2018.

As in previous years, the largest share of expenditures from federal sources came from the Department of Defense, for a



Brian Foy, professor in the Department of Microbiology, Immunology, and Pathology, in the lab with former student Jasmine Donkoh. *Photo: John Eisele/CSU Photography*

total of \$92.3 million, or 23 percent of CSU's total federal funding. Other federal sources include the U.S. Department of Health and Human Services, U.S. Department of Agriculture, the National Science Foundation, and the U.S. Department of Commerce.

Breadth of awards

CSU's steadily growing research enterprise is fueled by faculty who compete for and are awarded grants and contracts. One such notable award

earlier this year came to the Cooperative Institute for Research in the Atmosphere, which secured a \$128 million funding renewal from the National Oceanic and Atmospheric Administration. CIRA, operating at CSU since 1980, is one of 16 such cooperative institutes at U.S. research universities. CIRA supports a broad spectrum of NOAA research, including forecast model improvements, hurricane track and intensity forecasting, real-time satellite tools for the National Weather Service, and forecaster training on use of satellite observations.

Of note this year was the signing of an agreement with Zoetis, a premier animal health company, to establish a research lab at CSU for exploring livestock immune systems.

“Our impressive growth in industry sponsorship and collaboration is sure to accelerate further as a result of this landmark agreement with Zoetis,” Rudolph said. “This historic R&D incubator lab will pave the way for new alternatives to antibiotics in food-producing animals and innovations to improve animal health.”

The University also recently announced a partnership with the Coalition for

Epidemic Preparedness Innovations for developing a vaccine candidate against Rift Valley fever. The coalition will provide up to \$9.5 million for manufacturing and preclinical studies, in collaboration with CSU faculty. This will be the first time CSU researchers are involved in both the production of a vaccine and the sponsorship of its use in humans.

In Fiscal Year 2019, CSU researchers requested a total of \$1.3 billion in funding from various sources, representing a 27.7 percent increase over the previous year. Proposal submissions are one of many metrics University officials use to gauge the health of the research climate.

Commercialization records

This research climate is also closely tied to the work of CSU Ventures, the University’s technology and intellectual property licensing office. CSU Ventures brings technologies and ideas, the majority of which originate in CSU research laboratories, to industry and the marketplace.

“Our impressive growth in industry sponsorship and collaboration is sure to accelerate further as a result of this landmark agreement with Zoetis.”

*– Alan Rudolph,
vice president for research*

In Fiscal Year 2019, CSU Ventures supported a record 261 inventors, who disclosed a record 127 new inventions. Licenses to CSU intellectual property also reached an all-time high, with 52 licenses signed in 2019. Licensing income for the University totaled \$3.8 million, including the sale of the Rapid InterLibrary Loan service to ExLibris. The RapidILL service was developed by CSU Libraries staff and provides efficient peer-to-peer sharing and document delivery for libraries worldwide.

The University also saw the establishment of six startup companies and the issuance of 47 patents.

The six new startup companies and their faculty leads, are:

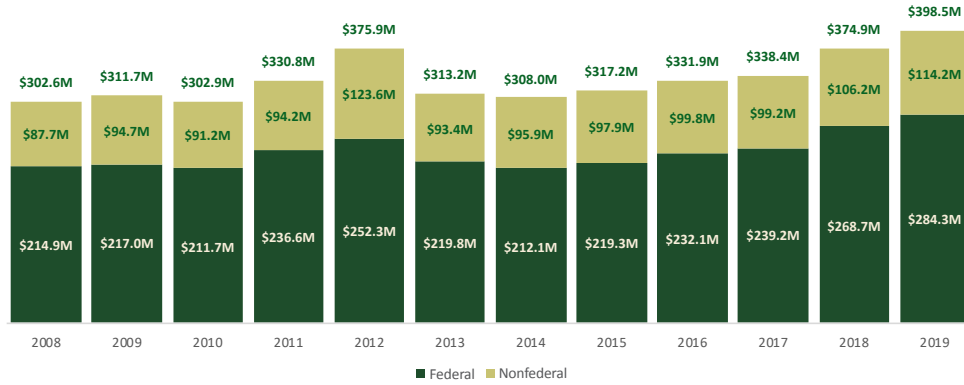
- AST UPAS, John Volckens
- AST On-Target, Chuck Henry
- Cypris, Garret Miyake
- New Iridium, Garret Miyake
- S3NSE Technologies, Tom Sale
- YoungHeart, Sue James

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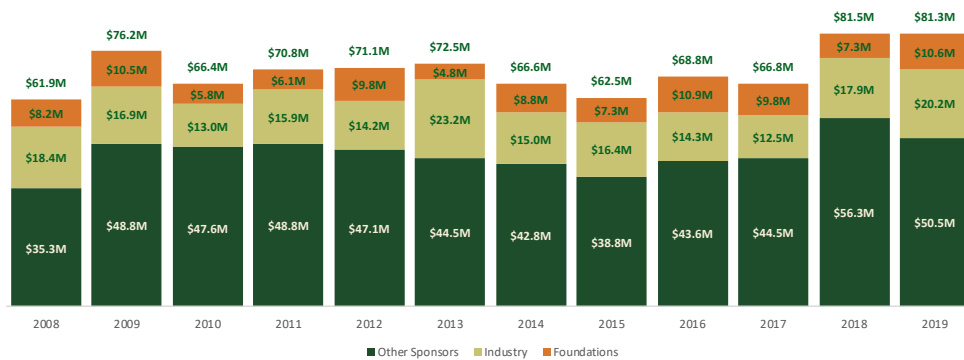


Dr. Katherine “Kat” Boehle demonstrates test strips that can confirm the authenticity of antibiotics in Chuck Henry’s lab. *Photo: John Eisele/CSU Photography*

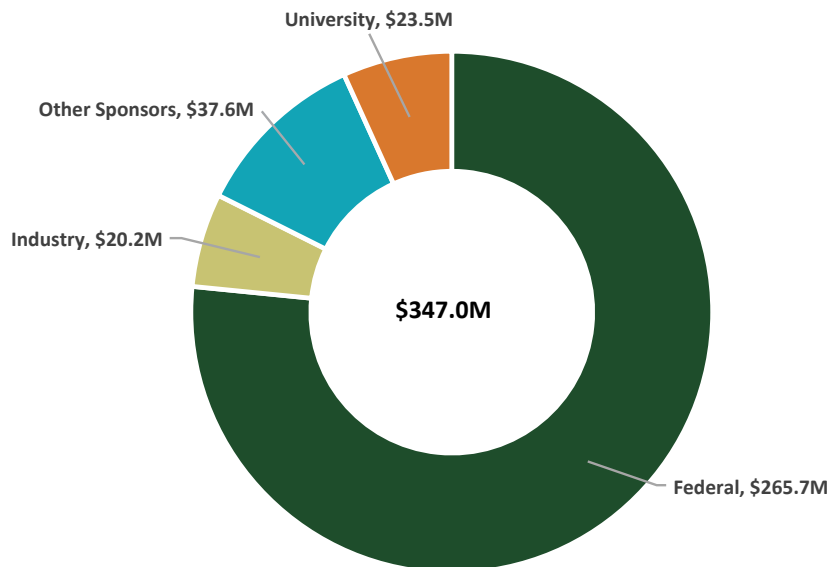
Research Expenditures by Fiscal Year



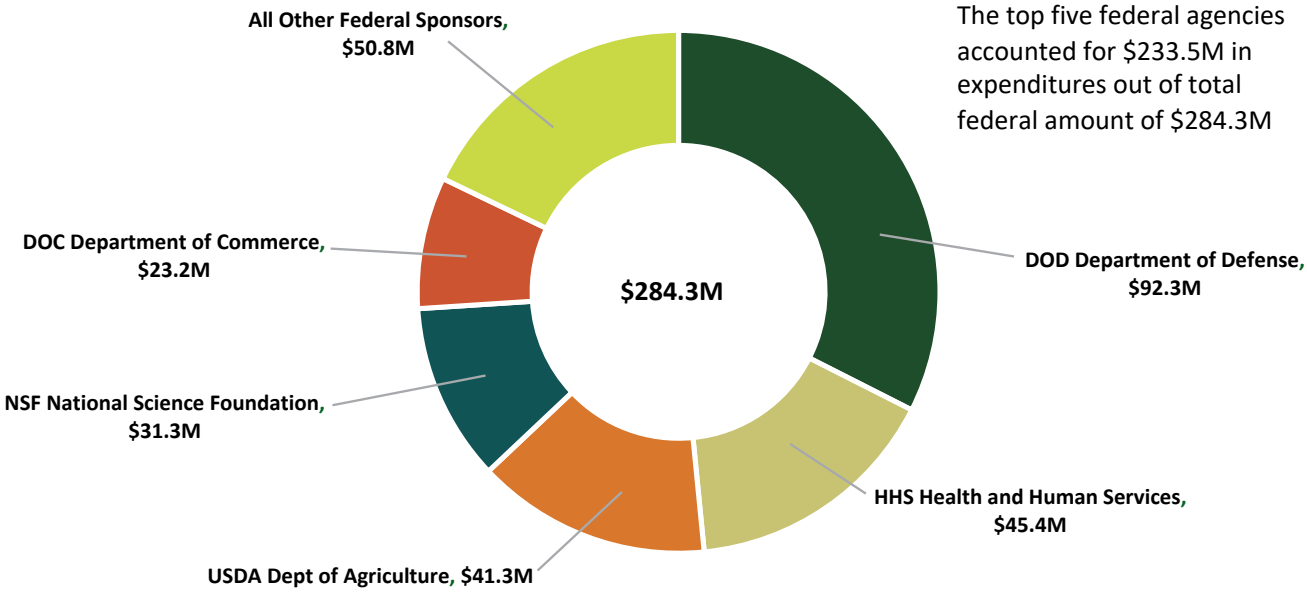
Research Sponsored by Industry, Foundations, and Other Sponsors



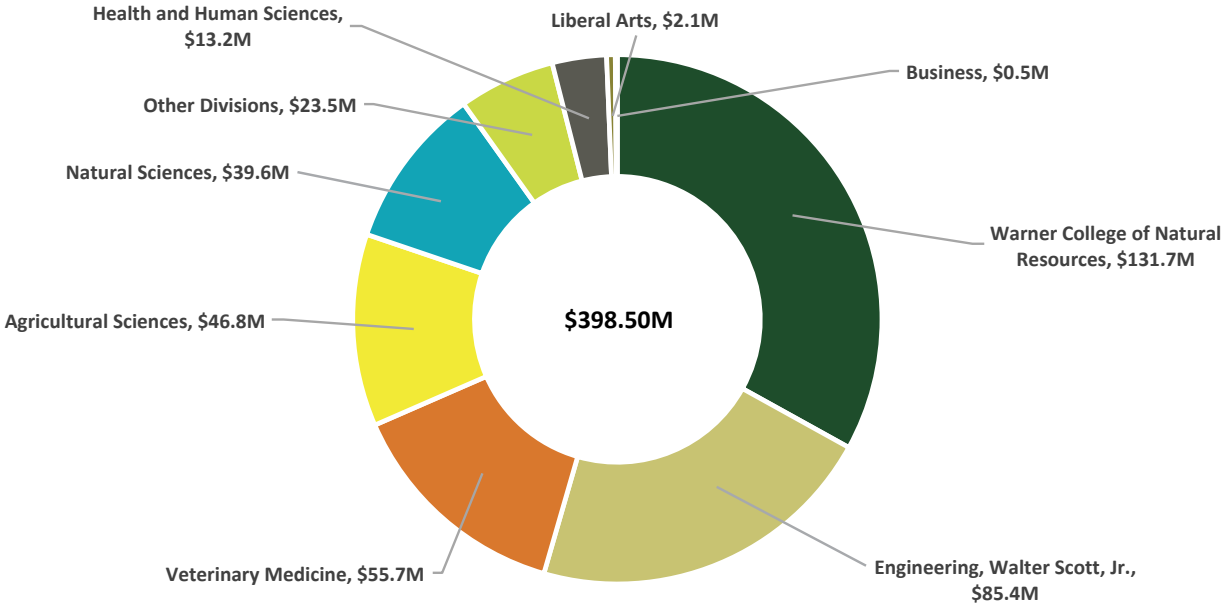
FY 2019 Funding by Sponsor Type



FY 2019 Top 5 Federal Agency Sponsors by Expenditures



FY 2019 Expenditures by College





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