# Seek

RESEARCH MAGAZINE FOR KANSAS STATE UNIVERSITY

*FALL • 2019*


## Priorities for preparation

Training the next generation to fight pathogens

## Minding the mind

How scientists study our changing brains

## Automation in the field

Agriculture's modern-day workhorses

## Studying stripes

The zebrafish is more than a 2-inch minnow found in freshwater throughout South Asia and in aquariums worldwide. It's also a model species for studying the human brain.

Thomas Mueller, research assistant professor in the Kansas State University Division of Biology, and his team study neural circuits and behavior in zebrafish. Their work helps scientists better understand how the similar human brain works.

Mueller's research is part of the K-State Cognitive and Neurobiological Approaches to Plasticity Center, or CNAP, which includes an interdisciplinary team focused on neuroscience research and the changing brain. See page 23 to learn more about Mueller's research and CNAP.

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## Features









### Seek more

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CIRCLE OF EXCELLENCE SILVER CASE WINNER AWARDS PROGRAM

***About Seek***

*Seek is Kansas State University's flagship research magazine and invites readers to "See" "K"-State's research, scholarly and creative activities, and discoveries. Seek is produced by the Office of the Vice President for Research and the Division of Communications and Marketing.*

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KANSAS STATE UNIVERSITY

Thank you for taking time to peruse our fall 2019 edition of Seek. We recently closed out our fiscal year 2019, and I'm excited to share that we had another record year of grant proposal submissions, awards and contracts, and total funds awarded to support the research enterprise in the future. As a result, Kansas State University continues to advance its programs and impact. New funding also supports students in their studies through research stipends and our faculty and staff with salary support.

This issue of Seek features a cover story on page 20 about the new multi-institutional, interdisciplinary Cognitive and Neurobiological Approaches to Plasticity Center, or CNAP. The center focuses on brain plasticity, which involves the brain forming memories and learning new information. A $10.6 million Center of Biomedical Research Excellence, or COBRE, grant funds CNAP, and it is only the second COBRE grant that K-State has ever received. The story provides a glimpse at the center and features faculty members and the research they are conducting. Along with fundamental research, the grant also focuses on helping early career faculty and involves collaborators at Wichita State University and the University of Kansas Medical Center.

You may have heard of precision agriculture, another K-State strength, and big data applications to agriculture. This issue includes a story on page 28 that takes a closer look at cutting-edge technology in agriculture and shows how K-State research is developing innovative ways to help producers and their families in our state and around the world.

Building on the themes of agriculture and research that improves Kansas families, we feature a story on page 16 about a five-year, $2.9 million National Science Foundation Research Traineeship Program grant that is helping graduate students strengthen rural communities by addressing water, food and energy challenges in western Kansas. This interdisciplinary project involves engineering, agricultural economics and sociology, among others, and engages the Southwest Research-Extension Center in Garden City.

We have received a number of requests for updates about infectious disease research at the Biosecurity Research Institute, or BRI, at Pat Roberts Hall and how it supports the National Bio and Agro-defense Facility, or NBAF. This issue features a story on page 10 about how BRI faculty and staff are training undergraduate and graduate students while engaging in cutting-edge research that will help keep our food supplies safe and secure and grow the future workforce for biosafety and biosecurity.

This issue highlights how the university engages with Kansas communities by working with K-State Research and Extension. From growing the future workforce to strengthening rural communities, our collaborative research programs reach beyond our campuses. These partnerships enable us to fulfill our land-grant mission to serve students and the people of Kansas, the nation and the world. We invite you to turn the page and learn more.

Peter K. Dorhout, Vice President for Research

*Col. Stephen Shrader, Fort Riley garrison commander, left, and Peter Dorhout, Kansas State University vice president for research, shake hands after the recent signing of a support agreement between the two agencies.*

## Archaeological partners

A partnership between Fort Riley and Kansas State University is paving the way for continued archaeological site surveys on the military installation.

Fort Riley Garrison Commander Col. Stephen Shrader and K-State Vice President for Research Peter Dorhout recently signed the first intergovernmental support agreement between the two agencies. During the five-year agreement, K-State archaeologists will evaluate and analyze Fort Riley property never surveyed before as directed by Fort Riley's cultural resources archeologist.

Site work began in June under the direction of Lauren Ritterbush, professor of sociology, anthropology and social work in the College of Arts and Sciences. Any artifacts the team discovers will help to better understand the past.

"The ancestors of today's Native peoples, who called this region home more than 14,000 years ago, did not recognize land tenure as we do today. Evidence of their past lives as recorded in archaeological sites must be understood on a regional scale undefined by modern political boundaries," Ritterbush said. "This intergovernmental agreement facilitates collaboration between the archaeology faculty and students at K-State and Fort Riley to gain a more complete picture of these peoples before the establishment of Fort Riley, Manhattan and K-State."

## Easing tough conversations in rural communities

Discourse in any town can be difficult at times. Some towns struggle to keep local businesses, while other towns experience demographic shifts in the population. These issues can lead to challenging conversations.

A Kansas State University researcher wants to help and is using historical data to find ways to engage rural Kansas communities in respectful dialogue.

Timothy J. Shaffer, assistant professor of communication studies in the College of Arts and Sciences, is studying how community discussions during the New Deal era were facilitated by Cooperative Extension educators and other community leaders in person and over the radio so that people could better understand the complex challenges they faced. The topics considered during the 1930s and '40s in rural America resonate with today's concerns.

"They discussed things like taxes and soil conservation," Shaffer said. "They talked about imports and exports, which is also a hot topic right now."

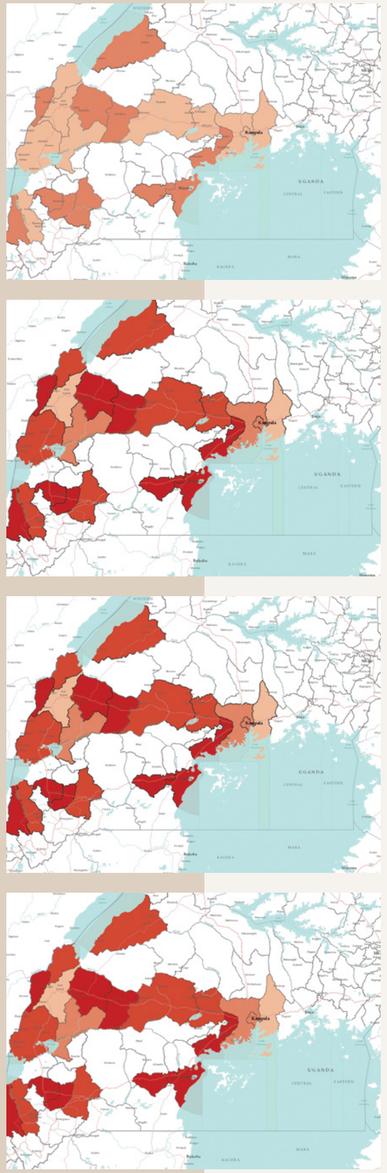
Shaffer's research aims to help organize and convene people for these types of interactions.

He is collaborating with K-State Research and Extension on one possible solution: the master community facilitator program. This program equips volunteers with the skills to lead productive conversations in their communities, which allows change to come from within the specific group.

"People in local communities don't need to only rely on people who are based in Manhattan or larger cities," Shaffer said. "They are empowered to be agents of change within their own communities."

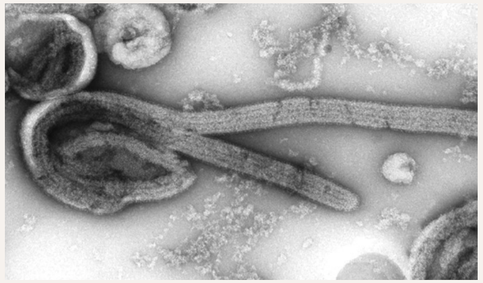






*Caterina Scoglio*

*This electron microscopic image shows the 1976 isolate of Ebola virus. (Photo credit: CDC/Frederick Murphy)*



## New Ebola transmission model predicts recent cases

A new risk assessment model for the transmission of Ebola accurately predicted its spread into the Republic of Uganda, according to the Kansas State University researchers who developed it.

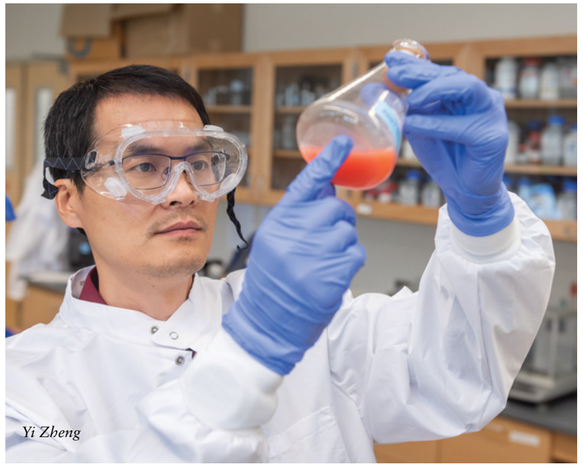
Caterina Scoglio, professor, and Mahbubul Riad, doctoral student, both in the Mike Wiegers Department of Electrical and Computer Engineering in the Carl R. Ice College of Engineering; Musa Sekamatte and Issa Makumbi at the Uganda Ministry of Health; and Felix Ocom with the World Health Organization in Uganda, recently published the paper "Risk assessment of Ebola virus disease spreading in Uganda using a multilayer temporal network" in bioRxiv.

The paper describes a new model to better predict how diseases like Ebola spread. The model combines data of people's constant contacts, such as family members and co-workers, with their temporary contacts, such as people in a market or encountered during travel. According to Scoglio, the model should be used as a risk assessment tool to prepare and distribute resources to mitigate risk, but it also has been accurate thus far regarding the movement of Ebola from the Democratic Republic of Congo into Uganda.

"This is very a new type of model," said Scoglio, also the Paslay professor of electrical and computer engineering. "Since we consider movement data in addition to constant contacts, we saw that not only are the districts directly bordering Congo at risk but that the districts on the path to some important Ugandan destinations also are at risk."

*This series of maps depicts the risk of Ebola spreading as transmission increases within 23 districts in southern Uganda. (Graphic credit: Mahbubul Riad)*

**Risk**
- Not considered
- Low risk
- Moderate risk
- Medium risk
- High risk



*Yi Zheng*

*Ryan Rafferty*

## Two researchers receive prestigious NSF CAREER awards

The National Science Foundation is honoring two Kansas State University researchers with one of the foundation's most prestigious awards for early career faculty members.

Ryan Rafferty, assistant professor of chemistry in the College of Arts and Sciences, and Yi Zheng, assistant professor of grain science and industry in the College of Agriculture, have each received the NSF Faculty Early Career Development Award, or CAREER award.

CAREER awards are five-year grants for early career faculty who have the potential to serve as academic role models in research and education and lead advances in the mission of their departments or organizations.

Rafferty is using the CAREER award to develop both scientific and educational tools to address complex biological barriers, such as separating the brain from the bloodstream of mammals and those of gram-negative bacteria. Future applications of the research include intelligent drug design and antibiotic development.

Zheng's CAREER project focuses on biomanufacturing. He is developing and studying the properties of a novel thermoresponsive polymer material that will facilitate both microalgae cell harvesting and intracellular product recovery, which is a relatively inexpensive and environmentally friendly technology. The material and approach could potentially influence the entire field of biomanufacturing.

*People and their pets may share more than affection. Researchers are comparing health data from both species to find links that could lead to new medical treatments for humans and dogs.*

## Big data collaboration brings big advancements to human, animal health

Researchers at Kansas State University and the University of Missouri-Kansas City are turning big data about human and animal health into a means of saving lives and improving the quality of life for people and their pets.

The collaboration, called 1Data, cleans and standardizes preclinical human and animal health data. Researchers around the world can use the data to rapidly develop and test new therapeutics, drugs and medical technologies for people and companion animals.

With the 1Data platform and its information, researchers can analyze and compare data across animal species or even look at how the genetic information from a specific animal compares to a human. This could help scientists easily identify similarities in diseases that affect people and pets, such as cancers, chronic mitral valve disease and other illnesses.

"With the 1Data platform, researchers have access to a more diverse dataset to aid them in their pursuit of medical advances," said Gerald Wyckoff, director of 1Data and professor of molecular biology and biochemistry at K-State Olathe and the University of Missouri-Kansas City.

Wyckoff leads 1Data with Majid Jaberi-Douraki, associate professor of mathematics with the K-State Institute of Computational Comparative Medicine, and Jim Riviere, professor emeritus with the K-State College of Veterinary Medicine. Multiple graduate students and postdoctoral researchers at both universities are involved.

Data also can be plugged into human and animal computational models, making it possible for researchers to see what drugs are likely to fail during clinical testing and at what phase, thereby saving time and money.

The 1Data team recently signed agreements with the animal health companies Aratana Therapeutics and Elanco Animal Health, which provided historic data from their clinical studies on dogs and cats. Other private companies also are completing data-sharing agreements.

Several projects use the data in various ways.

- One project involves orphan diseases, which are rare diseases that affect fewer than 200,000 people nationwide, according to the U.S. Food and Drug Administration. Researchers are looking at approved therapies for these diseases and testing them against models generated on the 1Data platform.
- A beta version of DrugAssist, a platform for precision and individualized medicine, computes demographic information about patients with either breast cancer or Type 2 diabetes. The platform helps physicians tailor therapeutic drugs for patients. A similar platform for veterinarians is being developed.
- Another project uses health data collected by wearable devices on veterans with PTSD, or post-traumatic stress disorder, and their service animals. The goal is to find how frequently and effectively the service animals are at interventions.

## UN organization brings global livestock conference to K-State

Sometimes the biggest innovations start with simple discussions.

That was a central tenet of the ninth Multi-Stakeholder Partnership Meeting of the Global Agenda for Sustainable Livestock, or GASL, which met in September at Kansas State University.

It was the first time that GASL has met in the U.S. and the first time a university has hosted the conference. There were nearly 300 participants from 22 countries who attended the four-day meeting at K-State.

As part of the United Nations' Food and Agriculture Organization, GASL meets annually to initiate discussions from varied perspectives so that the livestock industry can respond to its biggest challenges. This year's meeting was focused on innovations in the livestock industry and their contributions to sustainability and care for the environment.

The group includes representatives from the livestock industry, agricultural research, global nonprofits and many governments.

Fritz Schneider, GASL chair, credited K-State's global reputation for research, teaching and outreach as a critical component in the choice to bring the meeting to Manhattan. He added that innovation is crucial for a sustainable food system and that a central tenet for GASL is to support and magnify the work of its partners with a multistakeholder approach.

"We advocate for conversation and change," he said.



*Top: A bus tour gives GASL participants the opportunity to tour the Kansas Flint Hills and tallgrass prairie.*

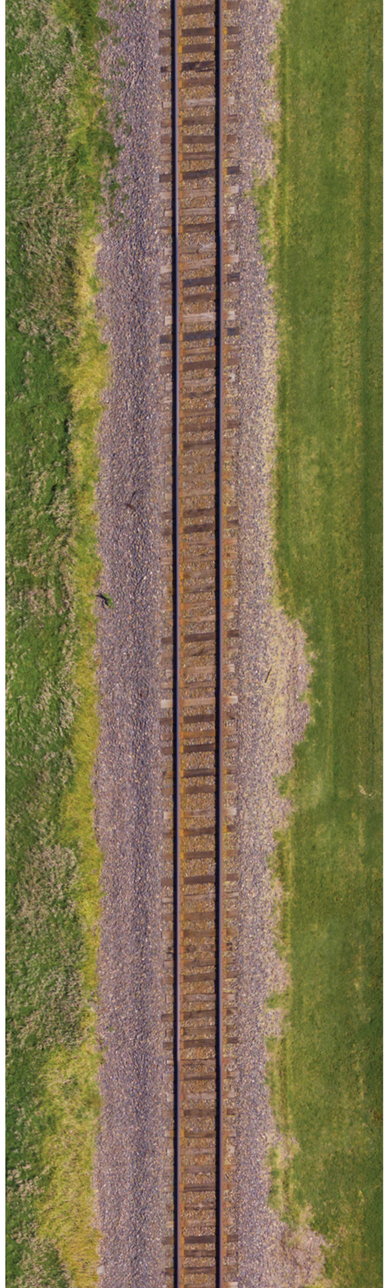
*Middle: Conference participants tour farms and learn about production facilities.*

*Bottom: Fritz Schneider, GASL chair, speaks at the September meeting at K-State.*

**Seek more**

Read more about the Global Agenda for Sustainable Livestock meeting.
*k-state.edu/seek*







## K-State establishes Rural Railroad Safety Center

A more than $2.5 million grant from the U.S. Department of Transportation's Federal Railroad Administration has established the Rural Railroad Safety Center at Kansas State University.

Eric Fitzsimmons, Hale and Mary Siegele professor of civil engineering in the Carl R. Ice College of Engineering, is leading the project. His collaborators are civil engineering faculty members Robert Peterman, professor and Mark H. and Margaret H. Hulings chair; and Christopher Jones and Stacey Kulesza, both associate professors.

"By the end of the three-year grant period, it is our goal to have evolved into a vibrant center for industry-relevant railroad research," Fitzsimmons said. "Additional educational and outreach programs will be in place to train and develop a diverse workforce for the railroad industry and our research outcomes will help ensure the future of the rail industry is as safe and efficient as possible."

Partner institutions include the University of Nebraska, Lincoln; the University of Florida; Pennsylvania State University, Altoona; and California State University, Chico.

## Developing new antibiotics

A Kansas State University biochemist is leading a collaborative project that is exploring new means of treating infections with antibiotics.

*Michal Zolkiewski*

Michal Zolkiewski, professor and head of the biochemistry and molecular biophysics department in the College of Arts and Sciences, has been awarded a nearly $2 million grant from the National Institutes of Health to develop new antibiotics. Zolkiewski will lead a team of investigators that includes University of Kansas researchers.

"Decades of global antibiotic misuse and overuse along with a lack of commercial incentives to develop new drugs have brought us to a point where antimicrobial resistance is a major threat to human health," Zolkiewski said.

According to the Infectious Diseases Society of America, at least 2 million Americans each year develop infections from antibiotic-resistant pathogenic microorganisms and about 25,000 of them result in death.

"The development of novel antimicrobial strategies and the discovery of new antimicrobials are highly relevant to global public health," Zolkiewski said. "We aim to develop a new paradigm of antimicrobial therapy so future generations do not face an existential threat of dying from common infections."

# Priorities for preparation

# Priorities for preparation

## Training the next generation to fight animal, plant pathogens

By Stephanie Jacques

*Daniel Madden, master's student in veterinary biomedical sciences, wears personal protective equipment while he practices working with samples in a biosafety cabinet, an important piece of critical safety equipment.*

Sizzling bacon, smoky pulled pork, mouthwatering barbecue ribs and even the holiday ham could disappear from meals if African swine fever virus ever made its way to the U.S. While the disease does not affect human health, it is nearly 100% fatal to pigs in less than two weeks and could cause billions of dollars in economic damages for U.S. producers. An outbreak would have lasting effects on the pork industry.

"Within 12 years of the virus emerging in the country of Georgia, African swine fever has spread throughout most of Eastern Europe and across the entire continent of Asia into China, Vietnam and Cambodia," said Daniel Madden, who researches the virus as a Kansas State University master's student in veterinary biomedical sciences in the College of Veterinary Medicine. "It is very likely that future outbreaks will occur in areas that have never seen this disease before and we must be prepared."

African swine fever virus and classical swine fever virus, another concerning disease, have not shown up in any U.S. swine populations yet. To keep it that way, Kansas State University is training the next generation of biosecurity and biosafety scientists, like Madden, while also conducting research to combat the most threatening agents to the world's food supply, including swine fever viruses and many other pathogens.

The K-State Biosecurity Research Institute, or BRI, houses several multidisciplinary research programs on pathogens that affect animals, plants and insects as well as food safety and security. The institute has 14 biosafety level-3, or BSL-3, labs; five biosafety level-3 agriculture, or BSL-3Ag, labs; plant pathogen research labs; and food safety processing labs in addition to 10,000 square feet of educational and training space.

"No other facility can do all that we do in one spot when it comes to plants, animals and insect work," said John Henneman, BRI director of biocontainment operations. "We are unique and are working with agents that are not allowed at other nonfederal labs."

In addition to swine fever viruses, the BRI also has research projects that are fighting wheat blast, a fungal disease that threatens wheat harvests; Japanese encephalitis virus, which lives in pigs and is transmitted to humans by mosquitoes; Rift Valley fever virus, a mosquito-borne virus that infects cattle, sheep and goats as well as humans; highly pathogenic avian influenza, which has been detected in more than 50 countries in Africa, Asia, Europe and the Middle East; and foodborne pathogens such as Shiga toxin-producing *E. coli*.

*Above: Any work with pathogens at the Biosecurity Research Institute must be done inside a biosafety cabinet, which has inward airflow and high-efficiency particulate air filtration.*

"We need to understand these diseases, identify what plant and animal strains are resistant, and develop rapid diagnostic tests, vaccines and treatments so if something hits this country, we can identify it and respond before it is widespread," said Julie Johnson, BRI biosafety officer and assistant vice president for research compliance. "If we don't have those things in place, we are vulnerable to exotic diseases. We cannot bury our heads in the sand."

### Next-generation preparation

As a land-grant university, K-State is using the research to train students and improve current practices. In the simulated BSL-3 training lab, which is one of only a few in the nation, students and researchers learn how to properly handle, decontaminate and dispose of high-consequence agents; how to safely enter and exit a containment lab; how to work in a BSL-3Ag lab; and what to do in an emergency while in the lab.

"The BRI is a great facility to help K-State students," Johnson said. "We've had graduate students, undergraduate students and postdoctoral researchers train and gain experience at the BRI. There are very few places they can get this kind of research experience."

According to Johnson, many of the students doing work at the BRI have their eyes on careers at the National Bio and Agro-defense Facility, or NBAF, which is under construction adjacent to the Manhattan campus. It will replace the aging Plum Island Animal Disease Center in New York and be the first biosafety level-4, or BSL-4, facility with the capability to handle livestock as part of its disease preparedness research. The proximity to NBAF and research partnerships will help students make important career connections.

"The training to work in the BRI enabled me to conduct my research on African swine fever virus," Madden said. "Work in a BSL-3 setting requires careful planning and a significant amount of attention to detail. Materials must be handled in very specific ways to maximize safety, and meticulous records and inventories must be maintained for everything I do."

*Above: In the safety of the training lab, Daniel Madden, master's student in veterinary biomedical sciences, goes through each step required to enter a biosafety level-3 lab. He puts on a Tyvek suit, double gloves, lab-dedicated shoes and a powered air purifying respirator.*

## Sustaining hands-on training

In the last 10 years, more than 400 people have been trained at the BRI to work in biocontainment, including more than 25 postdoctoral researchers, more than 80 graduate students and more than 50 undergraduate students. They must complete about 30 hours of training, including online, classroom and hands-on work in the training lab, followed by both written and practical exams. The training lab portion includes emergency response practice and mimics a real working lab.

New researchers learn how to properly dress in personal protective equipment, which includes gloves that are taped to protective sleeves; how to go through interlocking doors; how to use the eyewash station and other emergency equipment; how to work in a biosafety cabinet; and many other steps to maximize safety, said Cheryl Doerr, associate vice president for research compliance.

"Julie Johnson and her team do a fantastic job training people to work in these kinds of labs," Doerr said. "They do all of that in the training lab before they ever enter a containment lab."

K-State leader Nancy Jaax, College of Veterinary Medicine alumna and retired chief of the pathology division at the U.S. Army Medical Research Institute of Infectious Diseases, envisioned the training lab to allow students and researchers to practice processes with mock agents before they enter a lab with real infectious agents.

"The training lab was Nancy Jaax's idea," Johnson said. "Nancy insisted that we needed hands-on training to be effective."

Nancy Jaax became a well-known name in connection with biosecurity and biosafety after the publication of Richard Preston's bestseller, "The Hot Zone." The book tells the true story of Nancy and her husband, Jerry Jaax, who worked to control a strain of Ebola in Reston, Virginia, in 1989. National Geographic also recently released a limited series inspired by the book. The concepts for safe practices that Nancy used when working with BSL-4 agents are similar to practices at the BRI for agents that require BSL-3 or BSL-3Ag safety.

While the BRI includes research of several zoonotic diseases that affect humans, agriculture-related pathogens are of special concern because of their economic impact and potential to affect the food supply.

"At the BRI, we are working on agricultural research," Johnson said. "Many things we study are only dangerous to livestock or crops and not to people, but they are dangerous to people's way of life."

Madden and his adviser, Jürgen Richt, Regents distinguished professor in the College of Veterinary Medicine and director of the Center of Excellence for Emerging and Zoonotic Animal Diseases, or CEEZAD, are collaborating with federal researchers at Plum Island Animal Disease Center and international partners to stop African swine fever virus. They are developing rapid diagnostic tests that could detect DNA, viral antigens or antibodies to the virus so if the disease does show up in the U.S., it can be identified quickly and stopped before it spreads.

"There is no vaccine yet available for African swine fever and outbreaks of the disease result in severe animal and economic losses," Madden said. "Rapid and accurate detection of the virus is critical for controlling epidemics and limiting spread of the disease. Tests that can be performed in the field or at farms would greatly facilitate early response efforts."

## Barrier to human error

Working with economically devastating pathogens requires not only extensive education but the utmost safety and security, which is integrated throughout the BRI. Like an onion, the BRI has layers of security, from the outside gates and the technological firewall to the security codes and 24/7 video monitoring.

"All the training and guidelines that are put in place are because people are human," Henneman said. "The facility itself has layers of safety and the way it is designed offers multiple backups."

Even the air movement in the building has an extensive backup system. Researchers work on samples in a biosafety cabinet, which has negative air pressure so air flows from the outside of the cabinet to the inside. This prevents any particulates in air from getting out of the cabinet, which also has high-efficiency particulate air, or HEPA, filtration. As a backup, the laboratory itself has the same setup with negative air pressure and HEPA filters to clean the air many times in an hour, according to Johnson.

All of these protocols in the BSL-3 and BSL-3Ag labs give students hands-on experience, help them build their resumes and prepare them for careers in fighting diseases and securing the nation's food supply.

"The training I received here has been invaluable to my work," Madden said. "K-State possesses the infrastructure to conduct research on high-consequence and emerging pathogens. The BRI is one of the few facilities capable of handling research on dangerous livestock diseases in a high-containment setting. The breadth and depth of experience I have gained here is simply not available at other universities." *k*

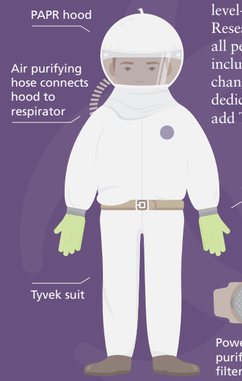
### Seek more

Watch videos of the detailed procedures to enter and exit a biosafety level-3 lab.
*k-state.edu/seek*

## Step-by-step safety and security

As home of the Biosecurity Research Institute, Pat Roberts Hall has layers upon layers of security for safe research of plant, animal and foodborne pathogens.

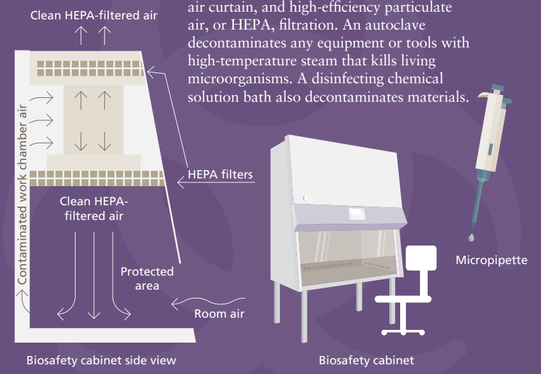
### PROCEDURES




After extensive training, there are numerous steps to enter a biosafety level-3, or BSL-3, lab. Researchers must remove all personal items, including jewelry, and change into containment-dedicated clothing. They add Tyvek suits or disposable gowns; gloves taped at the wrists; powered air purifying respirators, or PAPR, or dust mask-type respirators; lab-dedicated shoes; and a second layer of gloves.

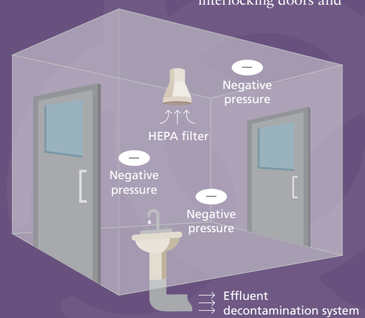
To exit, researchers reverse the entry process while disinfecting or disposing of protective equipment and showering as necessary.

### EQUIPMENT




Inside each lab, researchers handle infectious agents only in biosafety cabinets, which have inward and vertical laminar airflow, like an air curtain, and high-efficiency particulate air, or HEPA, filtration. An autoclave decontaminates any equipment or tools with high-temperature steam that kills living microorganisms. A disinfecting chemical solution bath also decontaminates materials.

### DESIGN

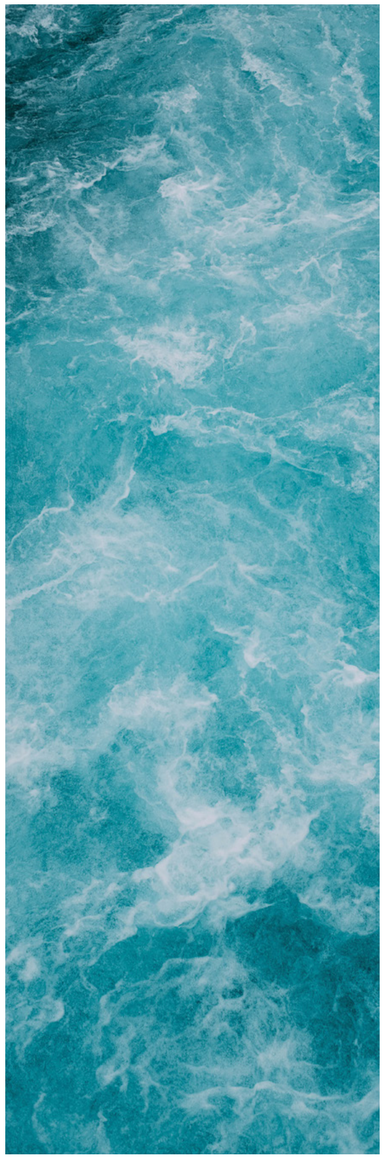



The BSL-3 agriculture research space is designed as a box within a box. Each room is sealed airtight with a set of interlocking doors and negative air pressure. This means the pressure inside the room is lower than outside to keep air flowing in only one direction and to contain any particulates in air. High-efficiency particulate air filters, or HEPA filters, clean the air several times an hour. The filters make the air inside the building cleaner than outside air.

All drains in the research areas lead to the effluent decontamination system tanks, which are similar to oversized pressure cookers, to decontaminate any liquids.

### SECURITY


Pat Roberts Hall is within a perimeter of reinforced fencing and is electronically monitored 24/7 by a robust security system. All building and containment entrances require unique personalized access. Each researcher must be approved by the security and biosafety teams before using any containment lab space. The building's heightened cybersecurity protects electronic data as well.



# Piece by piece, drop by drop

## A range of perspectives helps rural Kansas communities address water shortages

By Mary Lou Peter

Some say great minds think alike, but bringing a diverse group of people together with different backgrounds, educational experiences and interests can result in even better solutions to big problems.

This is the idea behind a new Kansas State University effort that's connecting researchers with a range of expertise to graduate students and communities in western Kansas. Together, they are addressing water shortages that threaten the agricultural economy, the lifeblood of those communities.

The five-year project is made possible by a $2.9 million National Science Foundation Research Traineeship, or NSF NRT, Program grant, which is the first ever awarded in Kansas. As part of the project, researchers in engineering, agricultural economics, sociology and communications are training 50 graduate students who are addressing such challenges as the declining Ogallala Aquifer and the implications for agriculture and affected communities.

Melanie Derby, associate professor in the Alan Levin Department of Mechanical and Nuclear Engineering, leads the project, which is in its first year. Her collaborators come from the Carl R. Ice College of Engineering, the College of Arts and Sciences, the College of Agriculture and K-State Research and Extension.

"Our aim is to create sustainable rural communities in western Kansas and beyond," said Derby, also the Hal and Mary Siegele professor of engineering. "Our research focuses on engineering new technologies, such as water conservation, natural fertilizers with microbes, and reactors that transform animal waste into power. We are using economics and sociology to figure out how to create these technologies in a way that people will use them."

The word interdisciplinary is used a lot in reference to the project: The researchers are creating interdisciplinary graduate classes in which the students conduct interdisciplinary research.

"Interdisciplinary is the idea that mechanical engineers, like me, can learn a lot from other engineers, sociologists and economists," Derby said. "By working together, we can come up with better solutions than on our own."

*Page 18, left: An interdisciplinary team that includes 17 K-State graduate students is involved in the first phase of a National Science Foundation Research Traineeship Program.*

*Page 18, right: K-State graduate students learn about the challenges facing residents in southwest Kansas.*

*Page 19: Dwane Roth, a farmer in southwest Kansas, is working with K-State faculty and graduate students to address water scarcity problems and potential solutions.*

## 'A reason for optimism'

Next summer, the first cohort of 17 graduate students plus Manhattan-based faculty will spend time in southwest Kansas, where they'll get a firsthand view of the water-related challenges that communities face. They will work with Jonathan Aguilar, associate professor of biological and agricultural engineering and K-State Research and Extension specialist who is based at the Southwest Research-Extension Center in Garden City. Aguilar is involved in programs that help farmers with water conservation and efficient use of available water.

As co-principal investigator on the project, Aguilar coordinates the students' data collection activity; arranges interactions with farmers, community leaders and other stakeholders; and plans other activities that provide a closer look at the situation.

"This is particularly important since at least a third of Kansas' agricultural revenue comes from the southwest Kansas area where the Ogallala Aquifer is found," he said.

Matt Sanderson, co-principal investigator and the Randall C. Hill distinguished professor of sociology, anthropology and social work, said his role is to better understand barriers and opportunities for water conservation from a social science perspective.

"Much time and effort has been devoted to solving groundwater depletion in western Kansas and the Ogallala Aquifer more broadly," he said. "The ability to bring together a new generation of top graduate students from across the sciences to work collaboratively and holistically on this problem is a reason for optimism."

The challenge of water conservation in semiarid, groundwater-based communities is systemic, which means that it is difficult to address this challenge by focusing solely on the social, economic or technical aspect alone, Sanderson said. Instead, meaningful change in water use requires a more inclusive perspective that can grasp the social, economic and technical aspects of the problem, all in relation to each other.

"This sort of thinking, called systems thinking, requires moving graduate students outside of their disciplines so they have the time and space to think across disciplinary boundaries and develop new ways of seeing and solving problems," Sanderson said. "These skills are becoming much more important in academia and industry."

## Solutions to declining water

Other co-principal investigators on the project are Prathap Parameswaran, assistant professor of civil engineering, and Stacy Hutchinson, professor of biological and agricultural engineering and associate dean for research and graduate programs.

As part of the effort, Hutchinson, Parameswaran and their graduate students are working at the interface of environmental and water resources engineering.

"As environmental engineers, we work to develop new water treatment technologies that allow us to recover nutrients and clean water from different waste streams. These technologies improve our access to usable water while assisting with food production," Hutchinson said. "As water resource engineers, we look to understand the amount and use potential of different water resources, including natural precipitation, recovered water and groundwater systems."

Hutchinson is working with Emily Nottingham, master's student in biological and agricultural engineering, to study satellite and modeled data to assess soil moisture.

"Surface soils are a large storage reservoir for water," Hutchinson said. "Traditionally, we have studied inputs of water into the soil, such as rainfall and irrigation, and outputs from the soil, such as evapotranspiration and plant water use. Using new data sources, we are tracking the actual amount of water stored in the soil and looking to better understand long-term trends and potential impacts from climate change."

By developing a better understanding of available water storage in the soil profile, the team can help develop plans for managing a declining water source and assisting with climate change mitigation and adaptation, Hutchinson said.

For another engineering perspective, Yufei "Zoe" Ao, doctoral student in civil engineering, recently completed a study on declining groundwater storage in Kansas as part of the High Plains Aquifer, which includes the Ogallala Aquifer, in relation to irrigated cropland. She is starting a new study that uses dynamic network modeling to understand how weather, transportation and crop diseases affect corn, corn products and, ultimately, consumers.

## Supporting vibrant communities

Gaea Hock, associate professor of agricultural education, leads the project's educational programming for graduate students who are pursuing master's or doctoral degrees. As the project moves forward, the doctoral students serve as mentors for the next group of master's students. Those students also are trained to work with agricultural teachers, legislators and the general public to inform them about the research to conserve the Ogallala Aquifer and other water sources.

"We're a land-grant institution and we're here to solve problems in the state," Hock said. "We're doing the research and we have the extension and educational piece. Tax dollars that go toward supporting K-State are going back into supporting Kansans."

Bringing people together from different disciplines is key to addressing issues such as irrigation efficiency, Aguilar said. He noted how engineering can only improve efficiency up to 100%, and most irrigation systems in use are already in the 80% to 98% efficiency range.

"The rest of the gains that a farmer could get would have to come from things like improved genetics, better nutrient and water management, improved agronomic practices, shifting to crops that need less water, managing input costs and better crop marketing," Aguilar said. "An interdisciplinary team is needed to make this possible."

Aguilar isn't alone; other researchers agree in the team approach.

"When we go to solve these problems, hopefully we're not missing solutions because we have a broader view of the situation," Hock said.

"If sustaining vibrant, resilient communities is a key goal for citizens in western Kansas, then they should know the state's land-grant institution is working hard, with the support of the National Science Foundation, to develop new approaches for solving the challenges of water conservation," Sanderson said.

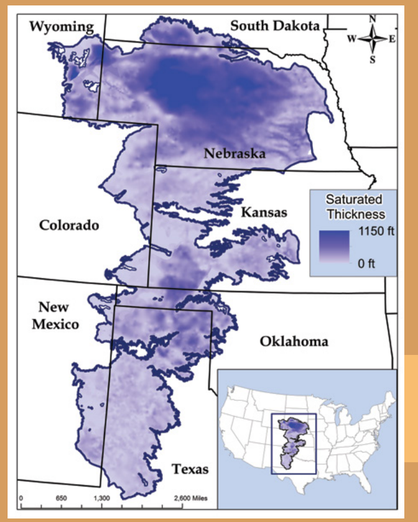
## What students are saying

The National Science Foundation Research Traineeship, or NSF NRT, Program is the first of its kind in Kansas. The project helps train graduate students to find interdisciplinary solutions to problems throughout the state. Read what some of the students involved in the program are saying.

> **"A seminar recently introduced me to interdisciplinary thinking and research. It showed me how bringing people from different backgrounds together can solve difficult problems."**
>
> *— Jordan Morrow, doctoral student in mechanical engineering*

> **"I believe to meet the demands of global needs in this fast-paced world, interdisciplinary research plays a crucial role."**
>
> *— Niloufar Fatthi, doctoral student in chemical engineering*

> **"These experiences will provide me with field knowledge as well as skills necessary to work in an interdisciplinary workplace. Our findings will provide additional information on the feedback loop of water resources and land resources and help rural communities discover better water conservation plans or land policies that are more holistic."**
>
> *— Yufei "Zoe" Ao, doctoral student in civil engineering*



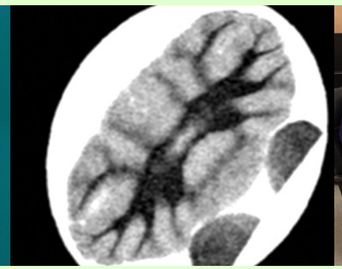

### About the Ogallala Aquifer

The Ogallala Aquifer is a vast underground reservoir that underlies about 112 million acres under parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas and Wyoming. It is part of the High Plains Aquifer, the most abundant source of water in the region, but it is declining faster than it is replenishing.

### Seek more

Read more about the Ogallala Aquifer.
*k-state.edu/seek*

# The changing brain



## Minding the mind

### How scientists study our changing brains

*By Jennifer Tidball*

We can see plasticity in the world around us.

It might look like this: A student studying for a test. An adult adjusting to a hearing aid. A driver trying to remember where the car is parked. A zebrafish memorizing a place with tasty food. A rat learning self-control.

Plasticity is how the brain changes with experience, learning or age. It can be a positive change, such as a child learning the alphabet or an adult choosing a salad instead of cake. But plasticity also can have a negative side, such as a person struggling with alcohol abuse or suffering from a degenerative disease.

"Plasticity can be good and it can be bad, but both are important and that's why we need research on both sides of the coin," said Kimberly Kirkpatrick, Kansas State University distinguished professor of psychological sciences. "It's important to understand why the brain changes because it can help with disease treatment or countermeasures."

Plasticity is the research focus of the Kansas State University Cognitive and Neurobiological Approaches to Plasticity Center, or CNAP.

CNAP is a statewide effort led by K-State to help us understand our changing brains and improve our quality of life. While the center is housed in the K-State psychological sciences department, it involves interdisciplinary researchers from the College of Arts and Sciences, the Carl R. Ice College of Engineering and the College of Veterinary Medicine. CNAP also includes collaborators at the University of Kansas and Wichita State University.

The National Institutes of Health recognizes the importance of neuroscience research and, in 2017, funded CNAP with a prestigious $10.6 million Centers of Biomedical Research Excellence, or COBRE, grant. It is the largest grant in the history of the psychological sciences department and is only the second time the university has received a COBRE grant. Now early in its third year, the center continues to develop and grow.

"What we have been able to do in two years is huge," said Kirkpatrick, CNAP director. "The enrichment to our research community is substantial and our faculty members are able to take their work to the next level."

More than 63 collaborators — including faculty members, scientists, postdoctoral researchers, graduate students and undergraduate students — are involved with CNAP and are conducting cognitive, behavioral and neurobiological research on topics such as self-control, alcohol abuse, aging, hearing, memory loss and learning.

"Our areas of research are diverse, but plasticity is really the glue that fits it all together," Kirkpatrick said. "Everything relates to brain processes, brain health and plasticity in terms of changes that happen in the brain over time or with experiences."

In addition to supporting research, the grant also has funded laboratory upgrades, including a surgery unit, a new histology laboratory and other equipment. The renovations total more than 2,100 square feet in Bluemont Hall and the upgrades have led to new research possibilities.

"These significant improvements in our infrastructure have opened the door to people performing techniques they couldn't do before," Kirkpatrick said. "Facilities matter in neuroscience, and now we can recruit top-of-the-line faculty, graduate students and postdoctoral researchers."

*Kimberly Kirkpatrick is the CNAP director.*

*An adult watches a series of videos as eye tracking technology records what he is watching on the screen.*

## Understanding the brain

For her own research, Kirkpatrick is using the upgraded facilities to study two areas: ways to improve self-control and ways that diet affects the brain and impulsive behavior.

Self-control is associated with many positive behaviors. People with good self-control are less likely to abuse drugs, are less likely to have attention disorders, are more likely to maintain healthy weight and are more likely to have better financial management.

Kirkpatrick is studying behavior in rats and humans to understand how self-control affects the brain. Through time-based interventions, Kirkpatrick's team has found that rats prefer to wait for a larger treat rather than have a smaller treat immediately. Now the team is doing similar behavioral work with humans through computer games, activities and smartphone apps that help people practice self-control.

Through diet-related research, Kirkpatrick has found rats that eat high-fat and high-sugar diets are more likely to engage in impulsive behavior.

"These high-fat or high-sugar diets are causing inflammation in the brain and that's causing damage to cells," Kirkpatrick said. "Even with a return to a healthy diet, some individuals still have nervous system damage that's changing their cognitive behavior long term."

As a result, Kirkpatrick's team is looking at ways to help combat neuroinflammation with omega-3 supplements.

"We are developing interventions that promote decisions that lead to health and prosperity," Kirkpatrick said.

## The aging brain

As we age, we naturally experience cognitive declines. We might forget where we parked our car or what we had for breakfast yesterday. But we also gain more experience and knowledge.

Heather Bailey, assistant professor of psychological sciences, thinks that is important. She is studying how older adults can use their experiences and knowledge to learn new information.

Her project has two groups of people — adults ages 65 to 85 and adults ages 18 to 28 — watch a series of videos that depict everyday activities, such as cooking breakfast, balancing a checkbook or working with technology. Bailey uses eye tracking technology to determine what people pay attention to and uses fMRI, which stands for functional magnetic resonance imaging, to determine what parts of the brain are involved in learning and remembering new information.

"We are finding that when people have relevant knowledge, they are better able to remember the activity in the video," Bailey said. "However, if they don't have any relevant knowledge, then chunking the activity into smaller events can improve their memory."

More than 200 people have participated in this study either on the K-State Manhattan campus or at the Hoglund Brain Imaging Center with the University of Kansas Medical Center.

Bailey is planning further work with people suffering from early onset Alzheimer's disease or other neurodegenerative diseases.

"Our research could help improve older adults' quality of life and help them function independently longer," Bailey said.

But what happens before we age? Can our childhood environments affect our brains as adults?

That's what Mary Cain, professor of psychological sciences, aims to understand. She studies how childhood environments affect alcohol and drug use in adults.

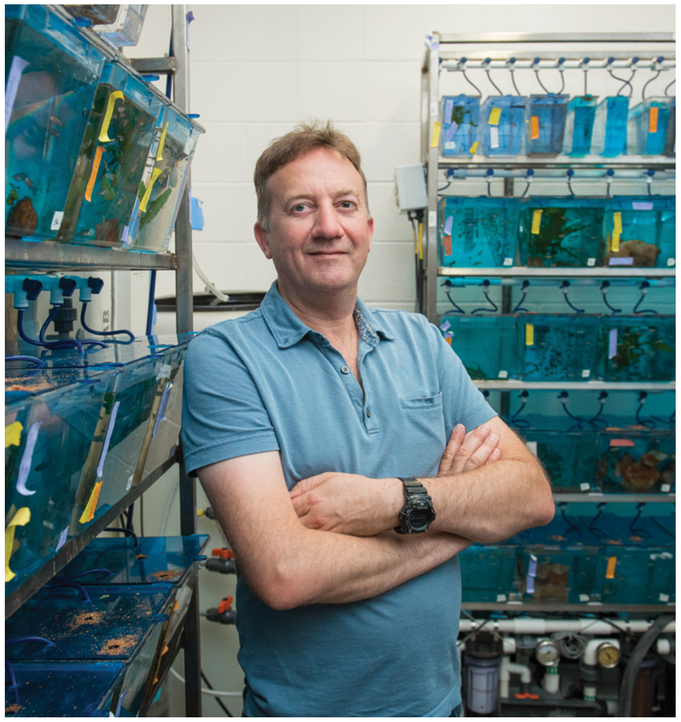
Through her work with rodent models, she has found that rats raised in an enriched environment with toys and social interaction have lower drug and alcohol intake as adults. Cain also has found that rats raised in an enriched environment are very sensitive to the taste of alcohol and sugar water.

"We know that the early rearing environment causes brain changes, but it's really novel that it also may be altering taste," Cain said. "That may have implications for alcohol use in adulthood as well."

By looking at images of the brain, Cain can better understand how the structure of the brain, specifically parts of the nerves themselves, can affect alcohol use in adulthood. Her work also applies to humans.

"Our research shows that any kind of enrichment provided during childhood is protective against drug and alcohol use in adulthood, and that's a result of plasticity changes," Cain said. "Early life enrichment is really important."

*Heather Bailey, assistant professor of psychological sciences, studies how older adults can use their experiences and knowledge to learn new information.*



*Above: Thomas Mueller, research assistant professor of biology, studies the zebrafish, which is an excellent model species for understanding the human brain.*

*Below: This microscopic image shows parts of the zebrafish brain that are activated during different tasks.*

## Comparing the brain

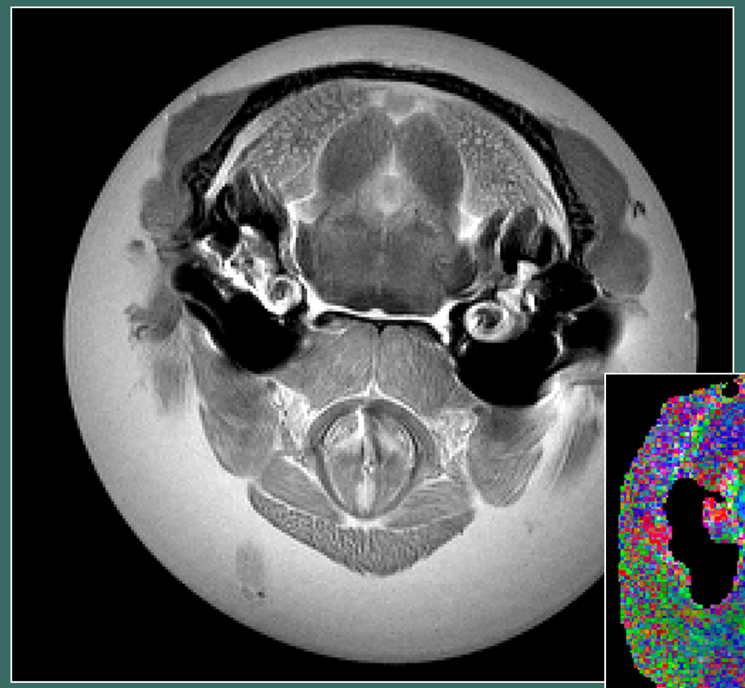
One of the best model species for studying the human brain is a small, 2-inch minnow: the zebrafish. That's because about 75% of human genes also are found in zebrafish and about 84% of human disease genes have a counterpart in zebrafish.

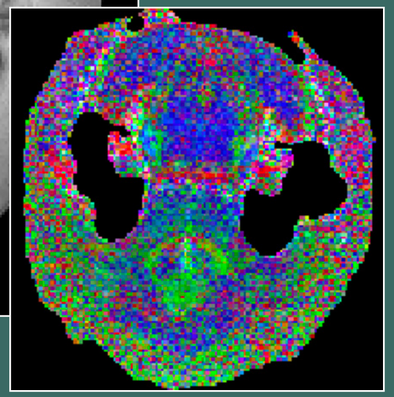
"This shared genetic setup makes zebrafish a fascinating model for studying human affective disorders and the neural basis of affection, emotion and cognition," said Thomas Mueller, research assistant professor in the Division of Biology.

Specifically, Mueller studies the amygdala, which is the part of the human and fish brain that controls emotion and mediates social behavior and associative emotional learning, such as fear learning. Mueller focuses on two neurological disorders that are affected by the amygdala: autism spectrum disorders and post-traumatic stress disorder.

"We like to think that only humans and maybe our pets have emotions," Mueller said. "But my research shows that the neurocircuits and the amygdala of the zebrafish are not only very complex, but also stunningly similar to the mammalian brain, much more similar, in fact, than previously imagined."

Mueller's research group is now using a CNAP pilot grant and part of a $1.3 million Human Frontier Research Foundation grant for an international collaboration to better understand how spatial and associative learning are organized in zebrafish and other fish.





*Left: This anatomical image of a rat brain was created using an image sequencing technique called rapid acquisition with refocusing echoes, or RARE. (Image credit: Tej B. Shrestha and Macy Payne)*

*Below: CNAP researchers use an imaging technique called diffusion tensor imaging, or DTI, to measure signals between neurons. This preliminary DTI image of a rat brain has different colors to show the different directions that fluid flows within the tissue. (Image credit: Tej B. Shrestha and Macy Payne)*

## Imaging the brain

But important functional and anatomical brain research is only as good as the images you can capture.

In fact, CNAP has fostered collaboration in new imaging technologies. As part of the center's mission, Mueller and Cain are working with Stefan Bossmann, university distinguished professor of chemistry. Bossmann's team specializes in state-of-the-art imaging of neurons using a National Science Foundation-funded instrument called an fMRI, which analyzes chemical compounds in the brain.

The partnership also involves Punit Prakash, the Paul L. Spainhour professor in the Mike Wiegers Department of Electrical and Computer Engineering, who is creating better ways to evaluate the images and data.

Bossmann uses a 600-megahertz MRI to capture incredibly detailed images — around 100 micrometers in resolution — of the zebrafish and rodent brains to show what parts of the brain are activated in specific situations. The technique is called diffusion tensor imaging, or DTI, and measures the signaling between neurons. The technique also can benefit people with diseases such as multiple sclerosis because it can determine what neurons are or are not working.

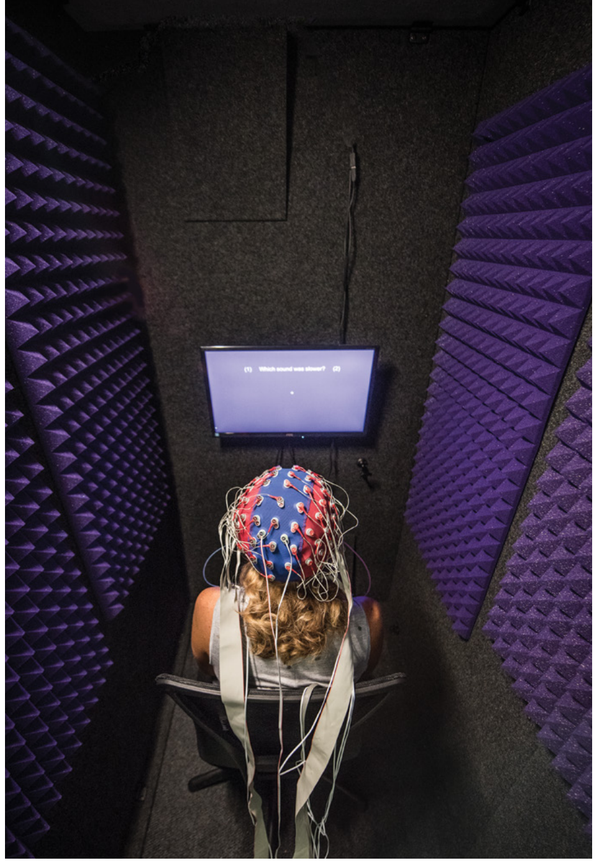
"This kind of functional imaging is very rarely done, and it is not done to the resolution that we have," Bossmann said.

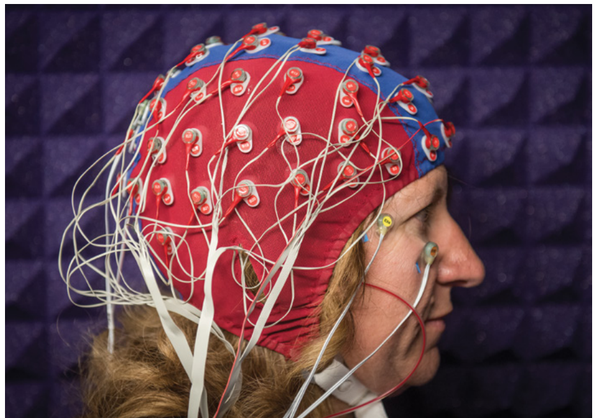
The high-resolution MRI images allow Mueller to create data-rich 3D functional atlases of zebrafish brains. Cain uses the images to study how substances in the brain, specifically myelin, may increase resistance to alcohol abuse.

Bossmann, who also works with the K-State Johnson Cancer Research Center and the Center of Excellence for Pancreatic Cancer Research, uses MRI for tumor research. It was natural for Bossmann to get involved with CNAP, too.

"I am able to collaborate with the team to develop new methodologies and make them available to the community," Bossmann said. "The research can give important insight into therapeutic targets."







*Left: EEG, short for electroencephalography, shows neural activity as it is happening. Participants wear a special cap with noninvasive electrodes that detect electrical activity in the brain.*

*Below: Matthew Wisniewski, assistant professor of psychological sciences, and Alexandria Zakrzewski, research assistant professor of psychological sciences, study how our brains process what we see and what we hear.*

## Training the brain

As our brains process sights and sounds, CNAP scientists use EEG to show neural activity as it is happening. With EEG, short for electroencephalography, participants wear a special cap with noninvasive electrodes that detect electrical activity in the brain.

Matthew Wisniewski, assistant professor of psychological sciences, and Alexandria Zakrzewski, research assistant professor of psychological sciences, are developing new EEG facilities to study how our brains process what we see and what we hear.

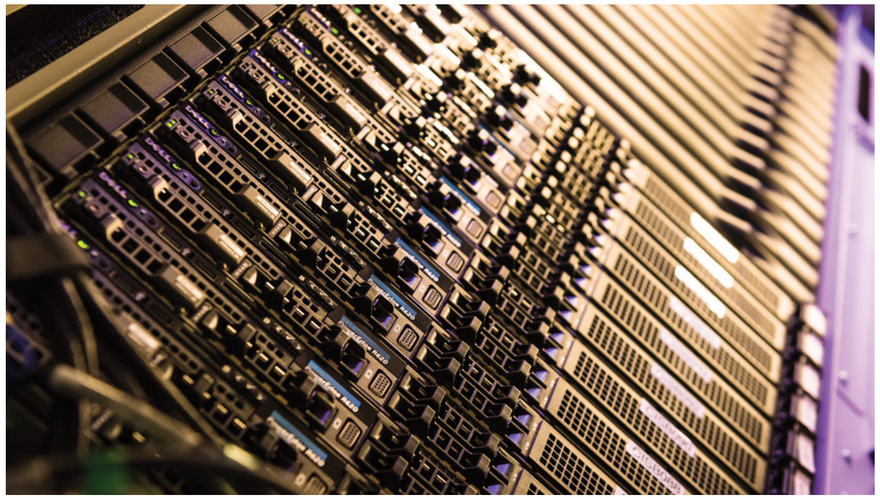
Wisniewski studies auditory learning and his work aims to train people to hear fine details in sound. For his projects, people wear an EEG cap while they are in a sound booth listening to sounds through earphones. The EEG provides a measurement of how the brain reacts to sound before and after training exercises, as well as the extent to which individuals put effort into listening.

"We're measuring their ability to hear details in sound over the course of training," Wisniewski said. "We want to know what types of training are most effective for changing the brain and improving listening performance. These procedures can then be used to train listening skills with hearing aids or cochlear implants."

Zakrzewski's research focuses on metacognition, which is how we think about our own thinking. Her work can help people who are struggling with addiction or who might have poor cognitive ability and not know they are struggling.

"Metacognition is really useful for how we might monitor our judgments and control our behavior," said Zakrzewski, who also leads the EEG facility. "I'm interested in metacognitive accuracy, or how well we know when we're right or wrong."

Zakrzewski has participants make confidence ratings during perceptual or memory tasks and uses EEG imaging techniques to capture metacognition in the brain. She is building training programs to help people improve their metacognitive abilities so they can change or adjust their behaviors.



*Right: Beocat is the high-performance computing cluster at K-State and is the most powerful supercomputer in Kansas.*

*Below: Dan Andresen, professor of computer science, right, and his team are developing new analytic methods for the massive amounts of data and images that CNAP researchers collect.*

## Informing the brain

The research generated from the large amounts of EEG data and high-resolution images of the brain requires a lot of computer power.

Enter Beocat, the high-performance computing cluster at K-State. Beocat is the most powerful supercomputer in Kansas and is 4,000 times more powerful than the average laptop.

"Research is becoming dominated by big data and interdisciplinary teams, and CNAP is a model for this type of interaction," said Dan Andresen, professor of computer science and director of the Institute for Computational Research. "You can have the best ideas and the best researchers, but they aren't going to get their research done unless they have an environment that can handle it."

Beocat's large processing capacity already has made a difference for CNAP research: Data analysis that used to take days can now be done in hours. Researchers can easily crunch numbers and transfer data to collaborators.

K-State computer scientists are developing new analytic methods for the massive amounts of data and images that CNAP researchers collect. Computer science graduate and undergraduate students often partner with the psychological sciences and biology researchers to develop new programs that work quickly and efficiently.

"It is a great experience for these computer science students because they are taken out of their engineering bubble and get interdisciplinary real-world experience," Andresen said. "Science is becoming more digitized and more data dependent. That's where we come in." k

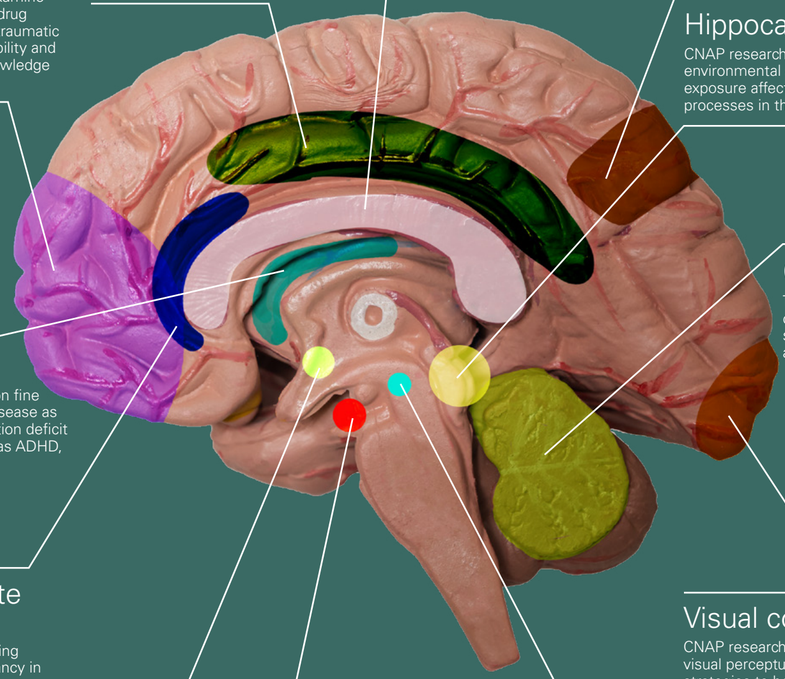
### Seek more

Learn more about CNAP with additional photos and graphics. Listen to a new K-State Global Food Systems podcast, "Something to Chew On," which features an episode on CNAP research.
*k-state.edu/seek*



## The brain

Research at the Kansas State University Cognitive and Neurobiological Approaches to Plasticity Center, or CNAP, addresses many regions of the brain. CNAP involves more than 63 collaborators working on a variety of projects in these brain regions.



### Prefrontal cortex

This key brain region is the focus of multiple CNAP projects that examine memory decline, self-control, drug abuse, decision-making, post-traumatic stress disorder, cognitive flexibility and the role of experience and knowledge in aging.

### Insular cortex

This region is involved in awareness of internal bodily sensations, and a CNAP project focuses on how it relates to regulating eating.

### Corpus callosum

CNAP researchers are examining how environmental enrichment and alcohol exposure affect the communication between brain hemispheres.

### Precuneus

This region is involved in perception and encoding, and a CNAP project evaluates how it contributes to learning in older adults.

### Hippocampus

CNAP researchers are studying how environmental enrichment and alcohol exposure affect learning and memory processes in this region.

### Cerebellum

This region is key for cognitive flexibility in autism spectrum disorders, which is a focus of CNAP research.

### Dorsal striatum

Several CNAP projects focus on fine motor control in Parkinson's disease as well as interval timing in attention deficit hyperactivity disorder, known as ADHD, and diet-induced impulsivity.

### Anterior cingulate cortex

CNAP researchers are examining deficiencies in reward expectancy in post-traumatic stress disorder.

### Visual cortex

CNAP researchers are studying visual perceptual learning to develop strategies to help older adults maintain driving skills.

### Nucleus accumbens

This region is the center of the reward pathway and is important for several CNAP projects that examine reward valuation and self-control.

### Amygdala

CNAP researchers study emotional processing and fear learning, which can be impaired in post-traumatic stress disorder.

### Substantia nigra pars compacta

CNAP researchers are examining how Parkinson's disease affects fine motor control.

# AUTOMATION IN THE FIELD

Robots, drones are becoming agriculture's modern-day workhorses

By Pat Melgares

*Above: A small robotic tractor, measuring about 2 feet tall, enters a row of corn as part of a test on the K-State Agronomy North Farm.*

*Page 31, top left: Dan Flippo, second from left, assistant professor of biological and agricultural engineering, inspects a robotic tractor designed to dig a trench and plant seeds in unison.*

*Page 31, top right: Many of the robotic tractors that K-State researchers are developing were once used as the motor and casing for motorized wheelchairs.*

*Page 31, bottom: K-State is studying tractors that can move through a field and detect diseases and pests on plants. The tractors will be capable of taking infrared images of infected plants, such as this row of corn, and then immediately treating those areas.*

On a patch of land north of the Kansas State University Manhattan campus, Dan Flippo and four of his engineering students test one of their newest creations: a small robotic tractor designed to dig a trench and plant seeds in unison.

The machine, which measures about 2 feet tall and 3 feet wide, crawls slowly across the test site under the group's watchful eyes. The blade intended to cut the trench seems a bit inefficient, and the machine fails to cut the straight path that Flippo had hoped to see.

It turns out to be a great test for the Carl R. Ice College of Engineering students, who will go back to the lab and work out the few hiccups they discovered on this day.

It also offers a glimpse at agriculture of the not-too-distant future, when small machines guided by computer programs may do some of the work and give farmers large volumes of information that they can use to plant, manage and harvest better crops.

"We are not trying to replace or get rid of tractors; we are trying to make more food," said Flippo, assistant professor of biological and agricultural engineering. "By 2050, we are going to have close to 10 billion people, and right now we are not close to meeting the amount of food production that will be needed."

Much of agriculture already is touched by some form of technology, whether it be sensors on tractors that precisely measure planting and fertilizing rates or thermal infrared cameras attached to unmanned aircraft, also known as drones, that fly above farm fields and detect water or insect stress in crops. There are even robotic arms that can milk a cow.

"I think farmers are ready for everything that is easy to adopt and that gives them a reliable and confident source of information," said Ajay Sharda, associate professor of biological and agricultural engineering. "That's their bottom line. They cannot spend hours and hours to set it up or hours to run it."

Therein lies an opportunity for universities like K-State, which in recent years has built considerable momentum toward incorporating technology on America's farms.

## Rovers on the lookout

While companies like John Deere and Case IH are leading the way in developing autonomous, or self-driving, tractors, Flippo says universities play a key part in developing smaller vehicles to aid in farm work.

Flippo's fleet includes several vehicles that spent their first lives as motorized wheelchairs. Flippo and the team of students, which includes undergraduate and graduate students, are using the motors and casing to custom build machines that serve a specific purpose on the farm.

"There are different categories that we are building," Flippo said. "The first is the rover category. This would be like a microwave-size robot. Their purpose is to go out and scout a field, which is important because while humans can scout really well, nobody wants to walk around a field all day."

When entomologists go out to look for pests in a field, they may look at two or three spots and make a judgment about the whole field. Rovers can cover the entire field, perhaps even working through the night, and provide data on pests.

"There are some issues, such as if the rover breaks, you're going to have to go find it in the field," Flippo said, and noted that engineers also need to account for how long a vehicle can hold a charge, how it handles ruts in the field and if it can follow the correct path between rows.

"But these small rovers can go through the field consistently and keep track of the field much better than humans ever could," he said.

Flippo's team is building a second category of ground robots that is slightly bigger than the rovers. They are called ag drones, and Flippo refers to them as "the workhorses." Ag drones can be used to carry chemical tanks to an area of a field or to plant seed in areas, such as sloped hills, where a larger tractor can't go safely.

Larger robots, some the size of lawn mowers and others the size of bed frames, are capable of more conventional farming work, such as pulling disc drills for wheat, scouting fields and planting fields. K-State is not yet working on these types of robots, Flippo said, but he noted that as the robots get bigger, companies and farmers become more concerned about safety.

## Insect detection

Flippo, Sharda and Brian McCornack, professor of entomology in the College of Agriculture, recently received a nearly $883,000 grant from the U.S. Department of Agriculture through its National Robotics Initiative to study the use of robots that detect and defeat insects in crop fields.

The nation's farmers spray nearly $15 billion worth of chemicals annually, yet still lose 37 percent of their crop yields to pest damage, according to the USDA.

The K-State group is working on a rover with a sensor on the front of the vehicle to detect insects, such as aphids, in a sorghum field. The sensor can detect if the concentration of aphids, which measure one-eighth of an inch or less, exceeds a predetermined critical limit.

When the concentration of insects exceeds the critical limit, the robot sends a signal to a sprayer that is mounted to the back of the vehicle. The sprayer takes that cue and knows immediately that it should treat the area.

"We are going to synchronize the system so that based on the moment that the vehicle sees the insects, it will start spraying backward and build a buffer zone around the area," Sharda said. "In other words, it will spray beyond the point where the insect was sensed to establish a full zone of control."

Sharda said spraying from below the crop canopy helps to contain more of the chemical where it's needed and reduce spray drift. Ultimately, that means less chemicals used and less cost to the farmer.

## Eye in the sky

Sharda also is leading a project to use unmanned aircraft, best known as drones, to scout crop fields for water stress. The four-year project is helping farmers schedule irrigation more efficiently because they better understand field areas that are more stressed than others.

The researchers have mounted thermal infrared cameras to the drones, which they fly several hundred feet above the field. The cameras measure canopy temperature throughout the field and send volumes of information to a computer on the ground that formats the data into a model to give the farmer irrigation guidance.

Eventually, Sharda said this system could be combined with information from the ground robots to give farmers an even clearer picture of their crops' water needs.

K-State also is developing drone technology to detect insect pressure in crop fields.

"In regard to unmanned aerial vehicles, I think farmers are getting more confident in terms of what they are seeing," Sharda said. "There is a lot of research being done by universities and lots of companies are spending resources on many acres across the U.S. to make those models more robust. The artificial intelligence capabilities are definitely improving."

## Shrinking workforce

Statistics on farm labor indicate that the industry may need help. A 2013 report by the USDA-funded National Agricultural and Rural Development Policy Center indicates that agriculture is vulnerable to "labor supply shocks, which could increase costs and threaten the ability of some farmers to harvest labor-intensive crops."

The report also noted that 33% of people employed on farms perform an estimated 60% of the work. The reality for U.S. agriculture is that it may be faced with a shrinking workforce, but newer technology can help.

"We are really good at getting seed in the ground fast, but maybe this is the time to rethink it. What does it really take to get those seeds in the ground?" Flippo said. "Just think if we could have a bunch of small robots going out to do that work. They just go out, cover the entire field and get the work done." k

*K-State students work at the Kansas River Valley Experiment Field near Topeka and fly drones nearly 400 feet over corn fields to detect water and insect stress.*

**Seek more**

View videos and photos that show how K-State is developing technology to help farmers.
*k-state.edu/seek*


*The drones being used to detect water and insect stress are packed with sensors, cameras and other modern technology.*

## Measuring smoke

Kansas State University researchers are aiming high — 1,200 feet in the air, to be exact — to understand how smoke affects air quality when landowners conduct prescribed burns on the state's prairie.

A research team is flying unmanned aircraft into the heart of the fire to determine what pollutants are contained in the plume of smoke, which can travel for hundreds of miles.

"The two pollutants of concern are ozone precursors, which chemically react with the moisture and sunlight to form ozone, and PM2.5, which consists of tiny particulates of soot that cross the membrane in the lungs," said Carol Baldwin, a K-State Research and Extension associate in agriculture, natural resources and community vitality.

Baldwin has teamed with the Applied Aviation Research Center at the Kansas State University Polytechnic Campus to fly unmanned aircraft, or drones, through the tips of the smoke plume — 1,200 feet in the air — and measure pollutants.

The researchers use three drones that are armed with a sophisticated set of sensors and hover through the perimeter and middle of the smoke to send information back to computers on the ground. The researchers have conducted the tests during four prescribed burns.

Travis Balthazor, flight operations manager, said the project is especially complicated because the crew has to manage communication for three drones flying simultaneously into a smoke plume, near fire and at high altitudes.

"It's a new way of sampling safely," Baldwin said. "No one has to be that close to the fire. It is collecting relevant data from the plume as it leaves the fire, rather than from a sensor that is 12 feet off the ground on a tower."

The project helps to support the Kansas Flint Hills Smoke Management Plan, which was developed by the Kansas Department of Health and Environment and other stakeholders to minimize the effects of smoke from prescribed burning on large population areas.

*K-State Polytechnic researchers are assisting on a project that uses unmanned aircraft, or drones, to measure pollutants from prescribed fires in Kansas.*

# Connecting night and day

*Engineers help families monitor children's sleep quality*

*By Jennifer Tidball*

A Kansas State University engineering team is developing smart beds to understand a good night's sleep.

The research team from the Carl R. Ice College of Engineering has created a collection of bed sensors and support software to help monitor the health and sleep quality of children with special needs. By comparing nighttime sleep data to daytime behavioral data, these engineers are helping Kansas parents and caregivers develop personalized care for children with special needs.

"We want to help improve the quality of care for these children," said Steve Warren, project leader, professor and Robert and Becca Reichenberger Cornerstone Teaching Scholar in the Mike Wiegers Department of Electrical and Computer Engineering. "Our goal is to use technology to monitor nighttime well-being and understand how a child's sleep quality affects their daytime well-being, including their behavior and ability to learn."

For the project, the K-State team partnered with Heartspring, a Wichita-based nonprofit organization that has a residential and day school program. Heartspring serves students who often have multiple diagnoses, including autism spectrum disorders, cerebral palsy, speech and language impairments, and other developmental disabilities.

"Life-changing innovation is paramount to our mission," said Megan Swett, division director of the Heartspring School. "We appreciate the professionals and scholars at Kansas State University who dedicate their lives to developing technological advancements that will help us advance our mission."

The collaborative efforts between K-State and Heartspring have been supported by two National Science Foundation grants totaling more than $525,000.

The K-State engineers have used the funding to develop working smart beds for several Heartspring group homes. Each smart bed supports film sensors under the mattress and load sensors under the bedposts. The sensors are hidden and nonintrusive, so they do not disrupt a child's sleep. Every night, these sensors gather health and sleep quality data, including heart rate, breathing rate, movement, center of position on the bed, sleep cycles and how often a child gets in and out of bed.

The team also has worked with Heartspring paraeducators to record instances of child behavior during the day, such as aggressive behavior or tantrums.

Once they have gathered the nighttime and daytime data, researchers like Bala Natarajan, the Clair N. Palmer and Sara M. Palmer professor of electrical engineering, work on algorithms to correlate these data sets.

"We can come up with models and predictions based on how well the child has slept and how that is affecting daytime behavior," Natarajan said. "The more awareness we have of the students, the better we can provide them with customized care and education."

Beyond monitoring sleep quality, the smart beds and sensors have the potential to help in other important areas, such as predicting nighttime seizures. The smart beds also may make it easier for caregivers and parents to monitor children's health and safety at night in a way that doesn't require checking on them every 15 minutes or sleeping in the same room.

"Another aspect is that these systems can be installed or even set up in someone's home," said David Thompson, assistant professor of electrical and computer engineering. "We can help parents and families."

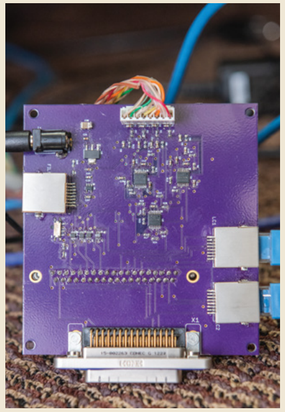
Other researchers on the team include Charles Carlson, teaching assistant professor of electrical and computer engineering, as well as Alaleh Alivar and Ahmad Suliman, both 2019 doctoral graduates in electrical engineering.

"It was an amazing opportunity to work on this project that has so much potential to positively impact the lives of the children at Heartspring," Carlson said.

The research began years ago as senior engineering design projects led by Warren; Punit Prakash, the Paul L. Spainhour professor of electrical engineering; and other university engineering faculty members. Past student projects have developed customized devices and software, such as smartphone tools and apps to help paraeducators, wearable sensors for children's shoes and clothing, and educational games.

*Technology plays an important role in the daily lives of students at Heartspring, a Wichita-based nonprofit organization that has a residential and day school program.*

*Charles Carlson, teaching assistant professor of electrical and computer engineering, sets up sensors under the mattress of the smart bed.*



*The smart bed uses signal conditioning circuits, left, and thin film sensors under the mattress, right*



See Engagement

## Sleeping measurements

Kansas State University researchers have developed a smart bed that uses sensors under the mattress and bed posts to measure signals called ballistocardiograms. A ballistocardiogram represents the body's response to the heart as it beats and moves blood through the body.

Ballistocardiographic waves travel in all directions — through the child, the mattress and the bed — and provide the following data on sleep quality during the night.

**Pulse rate:** Heart rate fluctuates throughout the night and can indicate periods of light and deep sleep.

**Breathing rate:** Breathing rate also changes throughout the night as the body switches between different sleep stages.

**Movement:** People can move as they sleep, and sensors measure a child's center of position on the bed or how much a child gets in and out of bed.

**Sleep cycles:** By looking at changes in pulse rate, breathing rate and movement, the researchers can determine the quality of sleep cycles.

# Fishing for answers

*Why fish and their habitats lure biologist*

*By Beth Bohn*

Keeping fish from being out of water is what drives Keith Gido in his award-winning research to protect native fish species and preserve natural waterways.

The Kansas State University distinguished professor of biology leads the Fish Ecology Lab, where the focus is on the conservation of aquatic systems in the western and central U.S. Gido and his team in the College of Arts and Sciences study fish ecology, invasive species effects and fish assemblage structure.

In this work, Gido has contributed significant findings to his field with more than 120 peer-reviewed publications. His undergraduate and graduate student mentees work for state and federal natural resource agencies, academic institutions and private consulting firms. He has reeled in notable honors, including the 2019 Fisheries Excellence Award from the North Central Division of the American Fisheries Society and the 2015 Donald Tinkle Research Excellence Award from the Southwestern Association of Naturalists. He recently earned the highest faculty ranking of university distinguished professor from K-State for excellence in research and teaching.

Gido said his love of the outdoors, particularly activities associated with water, such as fishing, boating and rafting, drew him to his field.

"A primary motivating factor for my research is to provide science aiding in fish conservation and the preservation of the natural waterways where they live," Gido said.

That motivation is seen in his latest projects. With funding from the National Park Service, Gido and his team are evaluating how large predatory fish that escape from ponds during flooding affect the diversity of native fish species in streams.

"We are monitoring the rate at which the large predators escape from ponds and then testing how they change the behavior of fish using an experimental stream facility," Gido said.

A second study evaluates providing fish passages across barriers such as dams that block their movement. Most of the work is funded through the U.S. Bureau of Reclamation and is taking place on the San Juan River in New Mexico and Utah.

"We implant fish with radio transmitters and move them above the barriers," Gido said. "We can then track their movements and quantify if they move back downstream or stay above the barrier."

A final project is testing how a highly abundant fish and bottom feeder, the gizzard shad, influences sport fish communities and ecosystems of small impoundments in Kansas. The project is being done with the Kansas Department of Wildlife, Parks and Tourism.

With a career devoted to preserving fish species, it's not surprising Gido isn't hooked on just one species.

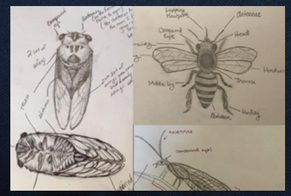
"There are more than 25,000 species of fish on Earth," Gido said. "Rather than have a favorite, I enjoy the diversity of species and amazing adaptations they all have to survive in their environments."

*Keith Gido, university distinguished professor of biology, works at an experimental stream facility on the Konza Prairie Biological Station near Manhattan. The stream facility is being used in a research project by a doctoral student in Gido's Fish Ecology Lab.*









**Seek more**

Check out the Insect Fusion multimedia project.

*Twitter: @InsectFusion*
*YouTube: bit.ly/2mvnsu3*

*k-state.edu/seek*

*The multimedia project Insect Fusion, created by Jeremy Marshall, associate professor of entomology, engages viewers with insects and how they relate to science, art, philosophy and engineering.*

# The being behind the buzz

*Insect Fusion multimedia project engages students in research*

*By Taylor Provine*

If you have never seen a bee do the "waggle dance," Jeremy Marshall can show you.

In fact, he recently performed the dance while wearing a bee costume on the Kansas State University Manhattan campus and students stopped to watch.

The spectacle had a purpose: Marshall, associate professor of entomology in the College of Agriculture, was filming a video and demonstrating how bees communicate the location of the best food source by "dancing" in a figure-eight pattern.

The bee waggle dance video is one of many short, fun videos that are part of Insect Fusion, which is the name of Marshall's YouTube and Twitter pages. The multimedia project shows how insects intersect with disciplines such as science, art, philosophy and engineering, as well as their roles in society and culture.

Through Insect Fusion, Marshall's interest in insects meets his passion for education. Plus, he has some fun along the way.

"I started making these videos to better engage students in the first online class I taught in summer 2018, and that's when the silliness just started emerging," Marshall said. "As I began to see the influence the videos had on my students, I started thinking about how the videos could positively affect teaching, so I began to incorporate them into my other classes to augment the topics the students were learning."

The outcome resulted in higher test scores on video-related questions than in previous years for the same questions, he said.

Because Marshall also is passionate about undergraduate research, he has used the videos to recruit students to the entomology department's undergraduate research program, of which he serves as director.

After observing that many undergraduates were interested in research, he created a new type of program open to all students, regardless of major or academic standing.

During the program, students spend about 10 hours over 10 weeks on a research project in areas of STEM, which stands for science, technology, engineering and math, as well as education, business, art and more. Based on their interests, the students are matched with participating faculty members or industry professionals. The students analyze data, present posters at a research symposium and have their work published in K-State's digital library.

"By the end of the program, the students' confidence levels go up, and they can do an excellent job of explaining their research," Marshall said.

The videos have been very successful in recruiting students to the program, which has involved 124 students in the last three years, Marshall said. As the new faculty director of the Office of Undergraduate Research and Creative Inquiry, Marshall's goal is to grow the program to potentially serve a few thousand students each year.

*Jessica Davis is an award-winning student in the Master of Business Administration program.*

# Mastering her opportunities

*Business student's projects help restaurants, military*

*By Beth Bohn*

It hasn't taken Master of Business Administration student Jessica Davis long to earn accolades for her research, classroom work and teamwork.

Since starting the Kansas State University MBA program in spring 2018, Davis has helped develop a sales forecasting model that a national restaurant chain is using, presented her research at a national conference, and was on a top-placing team at the 2019 Big 12 MBA Case Competition.

Davis came to K-State after earning a bachelor's degree in economics from Fordham University, serving in the U.S. Army as a military intelligence officer and then working in sales.

"I decided to go back to school to get an MBA because I wanted to have a broader knowledge of basic business concepts," Davis said. "I also wanted to learn and develop skills in data analytics and marketing, which are both passions of mine."

She chose K-State's College of Business Administration, she said, because she wanted a program where she could have one-on-one relationships with her classmates and professors.

Those relationships are paying off. In her MBA capstone course this past spring, Davis worked on a team project for client Centralized Supply Chain Services LLC, a company that provides operations management and procurement for national restaurant chains Applebee's and IHOP. The team analyzed Applebee's social media data to create a predictive sales forecasting model to improve company operations planning.

"Our model proved significantly more accurate than Applebee's current forecast model," Davis said. "The company is now using the model to improve its sales forecasts and is integrating it into a dashboard they provide to Applebee's franchises across the country."

Davis and Jaebeom Suh, associate professor of marketing, worked on another project last year to reduce waste in military field rations, or MREs.

"Our goal was to find the most attractive combination of menu components," Davis said. "Soldiers often pick apart the MRE bundles and throw out items they do not like. This wastes food and money, and means soldiers do not always get optimal nutrition."

They surveyed current and former military members to determine their MRE preferences, then used conjoint analysis to determine the most attractive MRE bundle. Davis' paper was selected for presentation at the fall 2018 Society of Marketing Advances conference.

To top off her year, Davis and three other K-State MBA students placed third and won $1,000 at the 2019 Big 12 MBA Case Competition.

Davis is ready for her next opportunity: narrowing down her career interests. She graduates in December and would like a job combining her sales and analytics background. k





# STEM stars

*Three Goldwater scholars pursue research careers*

*By Taylor Provine*

When it comes to producing scholars in undergraduate research, Kansas State University goes for the gold.

The trio of K-State 2019 Barry M. Goldwater scholarship recipients reflects the commitment that the university is making to provide an inclusive environment that welcomes and encourages outstanding diverse students in STEM, which stands for science, technology, engineering and math.

"Preparing these scholars through research involved working on teams," said Peter Dorhout, vice president for research. "Diverse teams will almost always develop the most creative and successful solutions to critical problems that confront them during their research."

The Goldwater scholarship is a prestigious national undergraduate scholarship for students interested in research careers in engineering, mathematics or the natural sciences. Awardees receive up to $7,500 annually for college-related expenses.

Read more about the K-State scholars from the College of Arts and Sciences and the Carl. R. Ice College of Engineering.

*Gabrielle Phillips, Erianna Basgall, Mackenzie Thornton*

**Gabrielle Phillips,** *senior in chemical engineering*

**Research focus:** *Plant genetics and biochemistry*

**Mentor:** *Ruth Welti, university distinguished professor of biology*

Phillips is conducting research at the Kansas Lipidomics Research Center at K-State. She is studying a specific plant gene to understand how it responds to various environmental stresses and what that means for the plant's health and life cycle. The plant gene is similar to a human gene and Phillips said the research could shed light on rare genetic disorders, such as Barth syndrome, and provide better treatment options.

"Winning a Goldwater scholarship is a huge testament to all of the mentorship and support that I have received throughout my research career," Phillips said. "I am honored to be chosen for the award and grateful to all of the people who made it possible."

**Erianna Basgall,** *senior in biochemistry*

**Research focus:** *CRISPR gene editing*

**Mentor:** *Gregory Finnigan, assistant professor of biochemistry and molecular biophysics*

Basgall is using yeast as a model organism to study CRISPR systems and to develop applications for the gene-editing technology. Scientists could potentially use these applications in other fields, such as the medical industry, agriculture and engineering, Basgall said. She has co-authored two peer-reviewed publications about CRISPR.

"It feels really good to have validation that you are doing good research," Basgall said. "It means a lot that the Goldwater Foundation continues to support undergraduate researchers through the scholarship so we can spend more time in the lab."

**Mackenzie Thornton,** *senior in microbiology and pre-medicine*

**Research focus:** *Regulation of translation in cancer cells*

**Mentor:** *Katsura Asano, professor of biology*

Thornton is researching non-AUG translation and how it contributes to cancer progression. AUG is the start codon that allows for the initiation of translation, which is the process of creating protein from mRNA. Many non-AUG start codons can be used at higher frequencies, Thornton said, and the misregulation of these non-AUG start codons can lead to diseases like cancer.

"I am truly humbled to win such a prestigious award," Thornton said. "Fundamental research like this will always be crucial to understanding living systems, and without basic science and understanding mechanisms, we cannot further develop therapeutic targets to combat diseases like cancer or neurodegeneration." k

*Industrial hemp grows at the John C. Pair Horticultural Center near Wichita.*

# industrial hemp

## in-'də-stre-əl 'hemp

*Jason Griffin is the director of the John C. Pair Horticultural Center, which is a K-State Research and Extension research center near Wichita. Griffin explains, in under 100 words, what industrial hemp is and why Kansas State University is studying it.*

Industrial hemp is not marijuana, but it is the legal and nonintoxicating version of cannabis. It can be harvested for its valuable stem fibers that can be used in many products, from clothing to building materials. The seed, or grain, can be pressed for oil or used in numerous culinary endeavors. Some industrial hemp varieties produce elevated concentrations of oils called cannabidiol, or CBD, oil. This oil is extracted and used in various, popular CBD products. We are researching industrial hemp to provide farmers with science-based recommendations for production of this exciting new crop.

**Seek more**

Learn more about industrial hemp.
*k-state.edu/seek*





## Automation of the past

Agriculture is always advancing, from new methods to new machinery. In this 1926 photo from K-State Research and Extension, a horse-driven agricultural seed drill cuts rows and inserts alfalfa seed in the same pass. The seed drill was a development that saved time and reduced seed waste. See page 28 to learn how Kansas State University has continued to improve agricultural practices from workhorses to modern technology, including robots and drones.

*Photo courtesy of the Richard L. D. and Marjorie J. Morse Department of Special Collections.*

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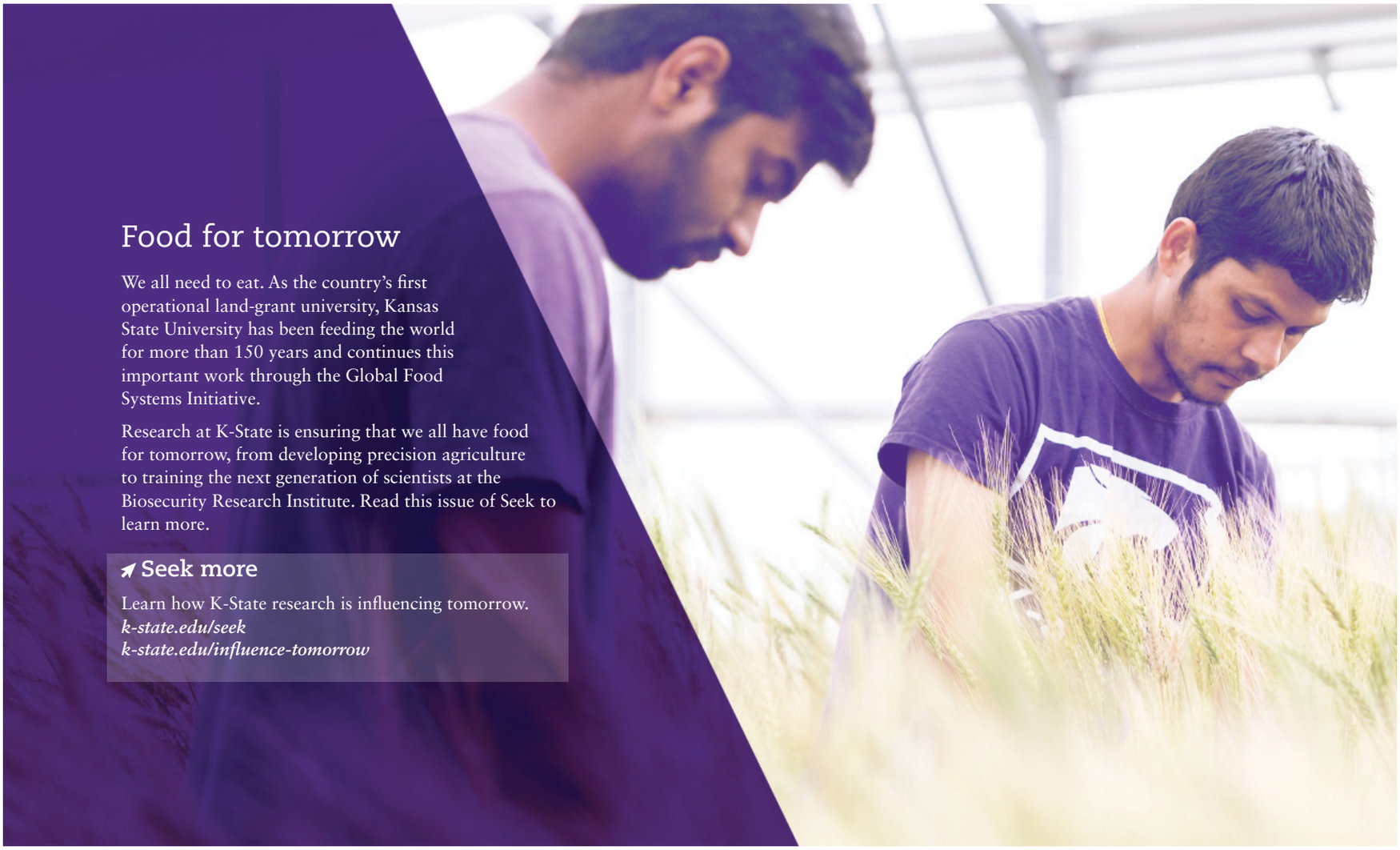

## Food for tomorrow

We all need to eat. As the country's first operational land-grant university, Kansas State University has been feeding the world for more than 150 years and continues this important work through the Global Food Systems Initiative.

Research at K-State is ensuring that we all have food for tomorrow, from developing precision agriculture to training the next generation of scientists at the Biosecurity Research Institute. Read this issue of Seek to learn more.

### Seek more

Learn how K-State research is influencing tomorrow.
***k-state.edu/seek***
***k-state.edu/influence-tomorrow***