Seek

RESEARCH MAGAZINE FOR KANSAS STATE UNIVERSITY

FALL • 2022

FEATURED INSIDE:

From research to reality
A closer look at vaccine development

Bits and bytes boost agriculture
Computer circuitry helps study soils

Pawsitive results
Programs focus on pet nutrition

A model species

Arabidopsis thaliana, commonly called thale cress, is a small weed in the mustard, or cabbage, family. It is a model flowering plant that is often used for genetic studies.

Ruth Welti, university distinguished professor in the Kansas State University Division of Biology, uses these vials of *Arabidopsis thaliana* to extract lipids that her research team measures in the laboratory. Lipids are nonwater-soluble compounds that are found in all living cells. As part of the research process, the scientists put a heated solvent in the vial and add the plants so they can measure the levels of specific lipids in the plants.

The work is done in the Kansas Lipidomics Research Center, which Welti founded and directs. See page 37 to learn more about Welti's lipidomics research.

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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Understanding economic prosperity

Throughout the magazine, look for these icons to learn more about the four areas of K-State's Economic Prosperity Plan and to read more about research in each area.

- Food and agriculture systems innovation
- Digital agriculture and advanced analytics
- Biosecurity and biodefense
- K-State 105

Read more about the Economic Prosperity Plan. *k-state.edu/economic-prosperity*

"I am pleased to share our latest issue of Seek, K-State's award-winning research magazine.

Greetings from Kansas State University. It has been a beautiful fall on our campuses and both students and faculty are excited to be back on campus and in person. K-State's research, discovery, innovation, scholarly and creative work is also back at full volume. Labs, classrooms, studios and field stations are back to full capacity and proposal activity and awards have returned to or exceeded pre-pandemic levels. There is a new energy at K-State with the arrival of our new president, the return to full on-campus operations and several exciting announcements during the past year. These include the Scorpion Biological Services Inc. facility, in addition to several other new corporate partnerships, the continued build-out of the Edge Collaboration District and the launch of K-State's Game-changing Research Initiation Program, or GRIP.

I am pleased to share our latest issue of Seek, K-State's award-winning research magazine, and invite you to learn more about the range of research activity taking place across the university and throughout Kansas. In this issue, we present extended features on our research in soils — across a range of colleges and disciplines — and in vaccine development — largely in our College of Veterinary Medicine, College of Arts and Sciences and Biosecurity Research Institute, or BRI. Research in both of these broad areas aligns directly with the priority areas identified in K-State's Economic Prosperity Plan for Kansas: food and agriculture systems innovation, digital agriculture and advanced analytics, and biosecurity and biodefense.

We also present extended features on global resilience — topics ranging from political resilience to food and energy resilience — as well as pet food and pet nutrition, including work at the Hill's Pet Health and Nutrition Center in our College of Veterinary Medicine and at K-State's renowned grain science and industry program in the College of Agriculture. These topics also connect to our Economic Prosperity Plan, both in the food and agriculture systems innovation and the K-State 105 thrust areas.

Also included are shorter features highlighting several of our researchers themselves, including our most recent early career grant recipients from the National Science Foundation and U.S. Department of Energy, a university distinguished professor, a graduate student and an undergraduate student. It's our talented people who are doing this remarkable work for our state, the nation and the world.

Finally, we include an engagement feature on the work we are starting in partnership with Scorpion following its announcement of plans to construct its new $650 million, 500,000-square-foot biodefense-focused large molecule and biologics biomanufacturing facility in Manhattan.

This is an exciting time at K-State, one of the nation's premier land-grant and public research universities, as we work together to advance and accelerate research, seek to expand our transdisciplinary research portfolio, build new and exciting corporate partnerships and create meaningful connections between research and discovery and the communities we serve and support.

As always — on behalf of the Office of the Vice President for Research, K-State and all the faculty, staff and students driving our research, discovery and innovation — thank you for your interest, your support and your engagement with K-State.

David V. Rosowsky, Ph.D.
Vice President for Research

Notable numbers

K-State research funding on the rise

Total extramural funding and support garnered by Kansas State University now exceeds pre-pandemic funding levels and is on the rise. Fiscal years 2020 and 2021 funding included Higher Education Emergency Relief, or HEER, funding distributed pursuant to the Coronavirus Aid, Relief and Economic Security Act, known as the CARES Act. FY 2018-FY 2020 support totals also included a substantial in-kind investment made by the Schlumberger Corp. to K-State. Excluding the CARES Act support, the FY 2022 total represents a $29.3 million increase in sponsored research support relative to FY 2021 for a net increase of 27% over the past five years and 41% since FY 2016. In 2022, our researchers obtained 1,276 awards — an 8% increase over FY 2021 and a 43% increase over the past five years. The FY 2022 awards totaled $181,647,775, including a 32% increase in federal funding.

Economic development and technology transfer are significant focus areas, as is growth in the number of our strategic partnerships. K-State Innovation Partners, our technology commercialization, economic development and corporate engagement unit facilitated more than $6.4 million in total licensing revenue in FY 2022 and 24 license agreements.

In FY 2022, K-State played a key role in attracting Scorpion Biological Services Inc. to locate its new $650 million commercial-scale facility in Manhattan, Kansas, after the company considered locations in 23 other states. See page 36 to learn more about Scorpion and its partnerships with K-State.

$181.6M in total research awards

1,276 total research awards

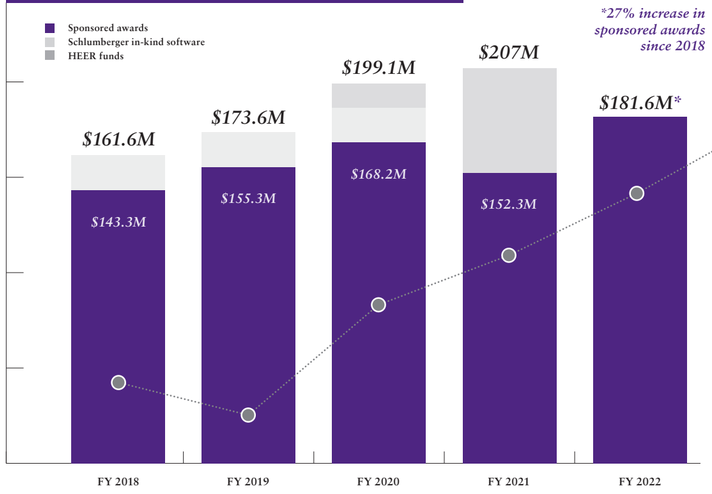
628 researchers funded in FY 2022

$6.4M FY 2022 licensing revenue

24 license agreements

41% net increase in research support since FY 2016

Total award amount by fiscal year



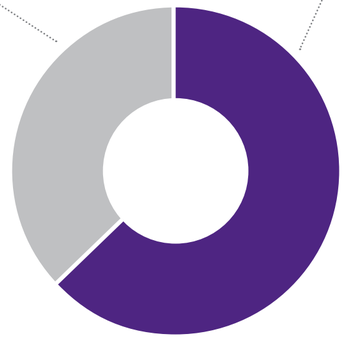
Award count by fiscal year

- FY 2018 ..... *893*
- FY 2019 ..... *877*
- FY 2020 ..... *1,137*
- FY 2021 ..... *1,182*
- FY 2022 ..... *1,276*

Seek more
View the full interactive report online.

Expenditures FY 2021

- **Nonfederal:** *$126M*
- **Federal:** *$78M*



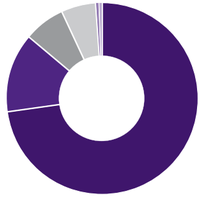
The National Science Foundation conducts the annual Higher Education Research and Development, or HERD, survey, which includes more than 600 higher education institutions. This survey is a primary source of information regarding research expenditures and provides tremendous insight into K-State's research activity and is a key metric for K-State research activity.

Expenditures FY 2018-FY 2021

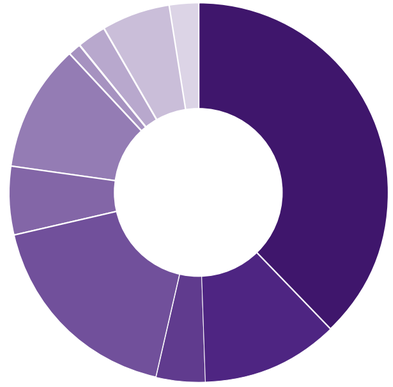
- FY 2018 ..... *$218M*
- FY 2019 ..... *$219M*
- FY 2020 ..... *$214M*
- FY 2021 ..... *$204M*

Award summary by source FY 2022

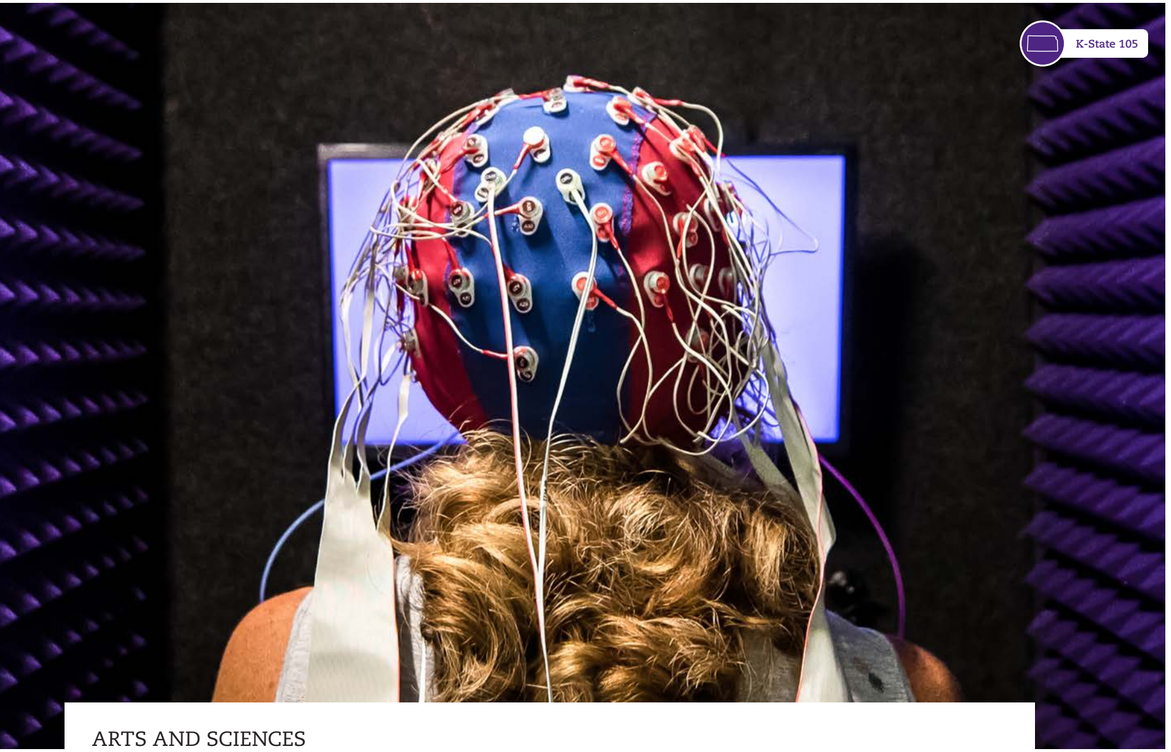
- **Federal:** *$132.2M*
- **State:** *$24.3M*
- **Private (for profit):** *$12.9M*
- **Private (nonprofit):** *$10.3M*
- **Foreign:** *$1.3M*
- **Area/local government:** *$613K*



Award summary by unit FY 2022



- **College of Agriculture** *$68.8M*
- **College of Arts and Sciences** *$21.4M*
- **College of Education** *$7.7M*
- **Carl R. Ice College of Engineering** *$32.1M*
- **College of Health and Human Sciences** *$10.7M*
- **College of Veterinary Medicine** *$19.5M*
- **Cooperative Extension Service** *$2.3M*
- **Office of the Provost** *$4.5M*
- **Office of the Vice President for Research** *$10.6M*
- **Other** *$4.2M*
  - College of Architecture, Planning & Design
  - College of Business Administration
  - Department of Computer Science
  - Division of Communications and Marketing
  - Graduate School
  - K-State Libraries
  - K-State Olathe
  - K-State Salina
  - Office of the President
  - Staley School of Leadership
  - Vice President for Student Life and Dean of Students



ARTS AND SCIENCES

NIH continues supporting neuroscience research center

The Cognitive and Neurobiological Approaches to Plasticity Center, or CNAP, at Kansas State University has received a grant of $11.2 million from the National Institutes of Health.

The phase II grant is part of the Centers of Biomedical Research Excellence, or COBRE, program, and builds on phase I research, which started in July 2017 with the original $10.6 million COBRE grant that established CNAP.

With five years of funding through the phase II grant, CNAP will continue neuroscience-related research on plasticity, which is the way the brain changes over time.

"Receipt of the phase II COBRE award is a fantastic achievement for the CNAP center," said Kimberly Kirkpatrick, university distinguished professor of psychological sciences and CNAP director. "We will be using the funds to continue to support junior faculty development and make significant infrastructure upgrades to core facilities to support cutting-edge neuroscience techniques."

CNAP is a statewide effort led by K-State that also involves the University of Kansas and Wichita State University. At K-State, CNAP involves interdisciplinary researchers from the College of Arts and Sciences, the Carl R. Ice College of Engineering, the College of Health and Human Sciences, and the College of Veterinary Medicine.

ARTS AND SCIENCES

Virtual fencing on the tallgrass prairie

Imagine cattle ranching without traditional fencing and the costly, time-consuming fencing repairs. Two Kansas State University ecologists are working to make that vision a reality while benefiting streams and birds. It's part of a multi-partner research project using virtual electronic cattle fencing in the Flint Hills of Kansas.

Virtal fencing is accomplished through special cattle collars and advanced GPS tracking that can be used to create exclusion areas or to move cattle without the need for physical fence lines.

The Nature Conservancy is partnering with K-State, the National Park Service, Kansas Grazing Lands Coalition and private producers to determine if virtual fencing can help managers improve conservation, business and soil carbon outcomes on working cattle ranches in the U.S. K-State received a $435,000 grant from The Nature Conservancy to study the conservation aspects of the project in Kansas.

This work by K-State is part of a $2 million project at three sites that is also assessing how soil carbon and ranching outcomes may be improved with innovative management options made possible by virtual fencing. Additional project sites are located in Colorado and New Mexico.

The Flint Hills is home to some of the last remaining tallgrass prairie in the U.S. During the five-year study, College of Arts and Sciences researchers Alice Boyle, associate professor of biology, and Walter Dodds, university distinguished professor of biology, are serving as the K-State co-principal investigators. They are studying how grazing practices created by virtual fencing affect vegetation, watersheds and grassland birds on the Tallgrass Prairie National Preserve and the neighboring Mushrush Red Angus ranch near Strong City.

AGRICULTURE

Leading the way in economic impact research

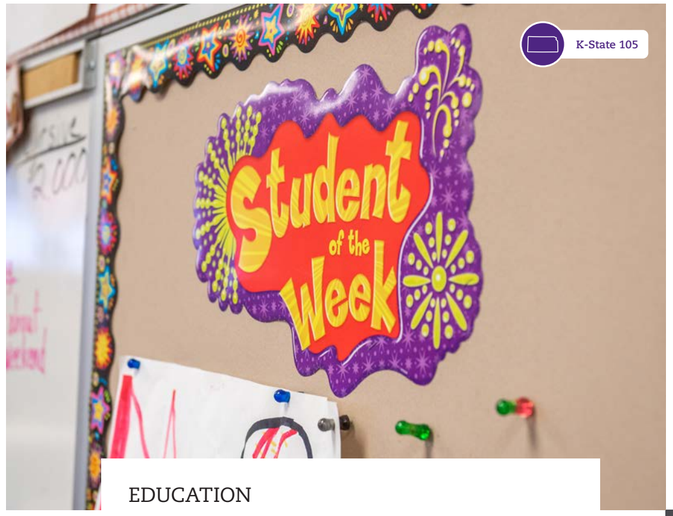
An economic analysis on the impact of international agriculture research and development conducted at U.S. universities over 40 years indicates that every dollar invested provides a return of $8.52 in economic impact.

Timothy Dalton, professor of agricultural economics in the Kansas State University College of Agriculture and director of the Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet, is reporting results from a study of projects completed between 1978 and 2018. The work was funded by the United States Agency for International Development, or USAID, through its Collaborative Research Support Program and Feed the Future Innovation Labs.

The research looked at USAID projects representing an investment of $1.24 billion to support agricultural development and improve food security around the world. Those projects returned $10 billion in economic impact, according to Dalton.

Much of the work is done by agricultural scientists at U.S. land-grant universities.

"These university-funded programs positively impact the most vulnerable populations in low- and middle-income countries," Dalton said. "Those living in poverty on less than $5.50 per day receive 78% of the research benefits, and nearly 30% of those receiving benefits live in extreme poverty on less than a daily net income of $1.90."



EDUCATION

Report details teacher shortages by state

A new report by Kansas State University College of Education researchers shows the scope of the teaching vacancy problem across the country, providing what may be the first data set on teacher shortages by state.

"Is There a National Teacher Shortage? A Systematic Examination of Reports of Teacher Shortages in the United States" was published as a working paper by the Brown University's Annenberg Institute by K-State researchers Tuan Nguyen, assistant professor of curriculum and instruction, and Chanh Bao Lam, data analyst. Paul Bruno, assistant professor at the University of Illinois Urbana-Champaign, is the third author.

Augmenting existing data from federal and state agencies with news reports and publicly available information, the team examined each state's teacher vacancies then grouped them into three categories for comparison. The team's report also includes a look at the number of underqualified individuals serving as teachers to fill vacancies.

According to Nguyen classifying the teacher shortage is difficult because reporting varies from state to state or agency to agency.

"Overall, there are at least 36,500 vacant positions along with 163,000 underqualified individuals filling teaching positions across the United States," Nguyen said. "These vacancies represent 1.67% of teaching positions nationwide, with about 5.16% of positions held by underqualified school district employees."

ENGINEERING

Engineers secure freezing technology patent

Two Kansas State University researchers in the Alan Levin Department of Mechanical and Nuclear Engineering have secured a patent for their work on nanopatterned surfaces and methods for accelerated freezing and liquid recovery.

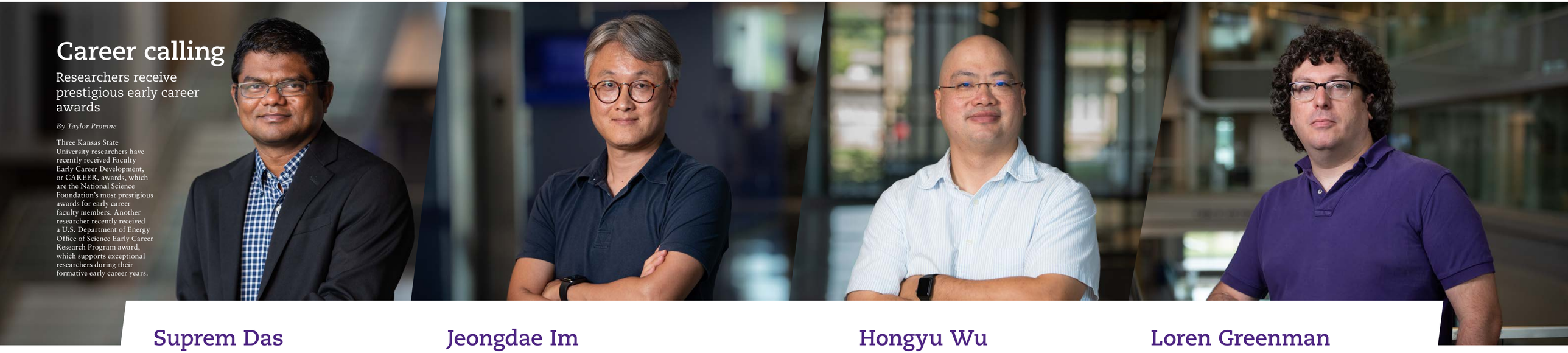
Amy Betz, assistant dean for retention, diversity and inclusion for the Carl R. Ice College of Engineering and associate professor, and Melanie Derby, the Hal and Mary Siegele professor of engineering, teamed up on the project, which was funded by the National Science Foundation. Their goal was to investigate what effect surface structures and coatings have on freezing and frost formation. They wanted to see if a surface that prevents coalescence will accelerate freezing. They discovered that such surfaces did accelerate freezing and did so by orders of magnitude.

K-State Innovation Partners helped the researchers patent their discovery.

"Our research is most applicable to cooling and refrigeration technologies, but it may also be used in water collection, cryogenics and optics," Betz said.

Melanie Derby, left, and Amy Betz study nanopatterned surfaces and methods for accelerated freezing and liquid recovery.

See Faculty Focus



Career calling

Researchers receive prestigious early career awards

By Taylor Provine

Three Kansas State University researchers have recently received Faculty Early Career Development, or CAREER, awards, which are the National Science Foundation's most prestigious awards for early career faculty members. Another researcher recently received a U.S. Department of Energy Office of Science Early Career Research Program award, which supports exceptional researchers during their formative early career years.

Suprem Das

Assistant professor of industrial and manufacturing systems engineering
Carl R. Ice College of Engineering

AREA OF STUDY: Atomically thin nanoscale materials and nanosensors and their advanced manufacturing processes

AWARD: $500,000 NSF CAREER award

PROJECT TITLE: "Rational design of one-dimensional contacts to two-dimensional atomically thin heterostructure for high-performance and low noise field-effect transistors and biosensors"

PROJECT DESCRIPTION: Das and his team are studying how electrons flow and give rise to sensitive signals in atomically thin materials and state-of-the-art devices made of them, such as graphene and encapsulated graphene by hexagonal boron nitride. They are trying to understand how the motion of electrons is affected by impurity atoms that are present in the surrounding — often giving rise to noisy signals. The findings will be used to build ultra-sensitive electronic devices from these atomically thin materials and their nano-engineered structures, Das said.

"This is an integrated research and education project in which students from diverse backgrounds, including women and underrepresented candidates, will be trained on highly interdisciplinary topics such as nanoscale materials, device physics, device engineering and advanced manufacturing," said Das, also a Jeffrey and Joy Lessman — Carl and Mary Ice Keystone research scholar in the college.

Jeongdae Im

Assistant professor of civil engineering
Carl R. Ice College of Engineering

AREA OF STUDY: Environmental microbiology and biotechnology

AWARD: $600,000 NSF CAREER award

PROJECT TITLE: "Mechanisms and control of nitrous oxide emissions from forage conservation"

PROJECT DESCRIPTION: This project focuses on forage conservation process as an unaccounted source of nitrous oxide — the third most important greenhouse gas and the largest remaining threat to the ozone layer. Currently, nitrous oxide emission inventories from agriculture only track emissions from soil management, manure management and field burning of agricultural residues, Im said.

"This project will use a laboratory and field research program to quantify nitrous oxide emissions in forage conservations and investigate the microbial processes that control such emissions," said Im, also a Jeffrey and Joy Lessman Keystone research scholar. "The successful completion of this project will benefit society through the generation of new data and fundamental knowledge to quantify, manage and mitigate the emissions of non-CO2 greenhouse gases from various environmental sources."

Hongyu Wu

Associate professor of electrical and computer engineering
Carl R. Ice College of Engineering

AREA OF STUDY: Smart grid cyber-physical security

AWARD: $500,000 NSF CAREER award

PROJECT TITLE: "Toward attack-resilient cyber-physical smart grids: moving target defense for data integrity attack detection, identification and mitigation"

PROJECT DESCRIPTION: According to Wu, threats of cyberattacks targeting power systems are growing in number and sophistication. His project aims to enhance the resiliency of cyber-physical power grids by providing a theoretical foundation and design-guiding principles that will unlock the full potential of moving target defense approaches.

"The broader impacts of the project include promoting public awareness and understanding of smart grid cybersecurity, contributing to power engineering education, and preparing a diverse learning community, including middle and high school students, with requisite knowledge and skill sets to tackle future power grid security challenges," said Wu, also a Michelle Munson-Serban Simu Keystone research scholar and the Lucas-Rathbone professor in the Mike Wiegers Department of Electrical and Computer Engineering.

Loren Greenman

Associate professor of physics
College of Arts and Sciences

AREA OF STUDY: Ultrafast dynamics in molecules

AWARD: $750,000 DOE Early Career Scientists for Mission-Critical Research grant

PROJECT TITLE: "Theory of the femtosecond and attosecond dynamics of molecules in complex regions of their potential landscapes"

PROJECT DESCRIPTION: Greenman and his team are studying how they can control small molecules at the femtosecond and attosecond time scales, which are one quadrillionth of a second and one quintillionth of a second, respectively. As a theory group, they are using supercomputers to model these processes and develop schemes to control the dynamics at these time scales.

"By understanding the basic science of how these fundamental building blocks of nature interact at these incredibly fast time scales, we expect to learn about their interactions and how energy is transferred in these systems," Greenman said. "Other groups can then build on this knowledge with varying applications, such as better solar photovoltaics or understanding photosynthesis among other biological processes."

BUILDING RESILIENCE

Unraveling global chaos through research

By Michelle Geering

After more than two years of fear and uncertainty during the pandemic, the world still seems tumultuous. Continued supply chain issues, concerns with inflation and a possible recession are a few examples of recent events that cause anxiety.

Additionally, the Russian invasion of Ukraine has intensified international security concerns, sparked record-high gas prices and created new global food supply issues. Global resilience is needed now more than ever — and it starts by understanding the issues.

That's the goal of Kansas State University researchers who are working to provide context and solutions in the areas of politics, oil and food.

Understanding global security

The Russian invasion of Ukraine is an intense focus of K-State scholars in security studies, military history, international relations and similar disciplines.

"This is the biggest single security crisis anywhere in the world in my lifetime," said Andrew Orr, associate professor of history in the College of Arts and Sciences and co-director of the K-State Institute for Military History. "What Russia is doing is a challenge to the basic rules and laws that govern international relations. Treaty law says countries don't conquer other countries and they recognize each other's borders."

> "This is the biggest single security crisis anywhere in the world in my lifetime."
>
> - ANDREW ORR

When Russia began invading Ukraine, an international group of scholars immediately sought K-State's help in forming a Ukraine Working Group. Orr is one of 12 core members of the group, which is aiding Western policymakers on options in supporting Ukraine.

According to Orr, the invasion puts the sovereignty of Ukraine and a dozen other countries into question in addition to emboldening other countries to prey on weak neighbors.

"If Russia overtakes Ukraine, it sets a precedent that one state can take over its neighbor or parts of its neighbor," Orr said. "If that happens, it would require a multigenerational American military presence in Europe to sustain the balance of power."

Below: *Andrew Orr is part of the Ukraine Working Group that is aiding Western policymakers on options for supporting Ukraine.*

Michael Flynn researches public support for or against the U.S. military, people and government.

This threat to the sovereignty of European countries has highlighted the continued need for NATO, which was established in 1949 to ensure the freedoms and security of the 12 North American and European countries through military and political cooperation. The alliance has since expanded to 30 members.

Michael Flynn, associate professor of political science and director of the security studies program, says the U.S. has always played an important leading role in NATO.

"The expansion of NATO could lead to changes in the current U.S. presence within Europe, and possibly expanding that presence within existing host states or into new member states," Flynn said. "However, these decisions are all intimately connected to the domestic political conditions in the member states themselves."

Flynn recently completed collaborative research on military deployments and public support for or dissent against the U.S. military, people and government in host countries. Funded by a U.S. Department of Defense Minerva Research Initiative grant, the study provides lawmakers and military officials with data and tools to make informed decisions about future deployments.

Flynn and his research colleagues recently published a book, "Beyond the Wire: US Military Deployments and Host Country Public Opinion," based on the deployment research. This book outlines the effects that U.S. military presence has on the social fabric of host nations as well as the implications for U.S. foreign policy.

"If people don't perceive a clear external threat, or if the U.S. is perceived to be a less reliable partner, this will likely diminish the United States' influence in the alliances' decisions and actions moving forward," Flynn said. "Russia's actions in Ukraine have likely strengthened the alliance and public support for the United States and its leadership role within member countries."

Understanding the world food crisis

Armed conflicts, climate change, political strife and economic turbulence all contribute to global food insecurity. In May 2022, the United Nations estimated 276 million people were severely food insecure across the globe — a number that has doubled since before the COVID-19 pandemic. K-State researchers have been working for decades to address food shortages.

The war in Ukraine has played a role in the food crisis by causing disruptions to Ukrainian harvesting, planting and exports — all of which have led to food price increases worldwide. Described as the breadbasket of Europe, Ukraine is a top producer and global exporter of sunflower seeds and oil, barley, wheat and corn.

According to Antonina Broyaka, extension associate with the K-State College of Agriculture, grain and legume exports from Ukraine are projected to decrease more than 23%, or more than 12 million metric tons, in the 2022-2023 market year. This is because of logistical disruptions at ports, damaged farming equipment and crops, and active military zones in key agricultural areas of the country.

Broyaka, who is the former dean of the faculty of economics and entrepreneurship at Ukraine's Vinnytsia National Agrarian University, says Ukraine can retain its leadership in the exports of sunflower oil under stable operations of Black Sea ports. If the port operations change, sunflower oil export losses in the current market year could be up to 30%.

Increasing U.S. wheat production is one way to help offset the future effects of the Ukraine war. K-State College of Agriculture and K-State Research and Extension scientists have been diligently working to develop high-yielding wheat varieties tailored to the environmental conditions for eastern, western and central Kansas. These varieties also are grown in areas with similar environmental conditions.

Guorong Zhang, professor of agronomy and wheat breeder with the K-State Agricultural Research Center in Hays, develops hard red and hard white wheat varieties for western Kansas growing conditions. Through multiyear testing at multiple locations, he is able to select the superior wheat lines with high yields, disease resistance and drought tolerance for wheat growers in western Kansas.

"I continue to seek high-yielding varieties to deal with potential food shortages," Zhang said. "We know that even without the Ukraine war the population is increasing. We have to increase wheat yields to meet the food demands of the future. It's a never-ending goal for our breeding work, because the population will continue to rise and weather patterns are changing."

Zhang has developed 10 wheat varieties since beginning work at the Hays research center and was recently part of a K-State research group to receive two patents on new wheat varieties.

Guorong Zhang develops wheat breeds for western Kansas growing conditions.

Antonina Broyaka is closely monitoring how the war is affecting Ukraine's agricultural industry and global food security.

Understanding gas prices

Many factors — demand, available supply and economic conditions — affect the price of oil and gasoline. Additionally, U.S. oil production has not returned to pre-pandemic levels because of labor shortages, supply chain issues, equipment failures, closed or damaged refineries as well as exploration and environmental policy concerns.

Following the Russian invasion of Ukraine, gasoline prices quickly rose and the world saw record-high prices for gasoline during summer 2022. This is a classic example of an energy shock — an increase in the price of energy that is not driven by economic growth or prosperity, researchers said.

Above: *Lance Bachmeier studies how energy shocks affect inflation and the business cycle.*

Lance Bachmeier, professor of economics, said demand for gasoline had been very strong the past few years and prices were not out of line for a strong economy, but the effects on oil prices from the invasion of Ukraine were different.

"With the recent events in Ukraine we saw a big jump in gas prices that cannot be justified by higher oil prices," said Bachmeier, who has spent years studying how gasoline and oil prices affect inflation and the business cycle. "It's an anomaly. Fear is the most likely explanation for the increase in oil and gas prices and we saw the price of gasoline start to decline in July."

> "We have to increase wheat yields to meet the food demands of the future."
>
> - GUORONG ZHANG

Bachmeier, whose work has been published in Energy Economics, the Journal of Commodity Markets and the Routledge Handbook of Energy Economics, said that high gasoline prices do lead to an immediate decline in consumer purchasing.

"When expenditures on gas go up a large amount, we do see a big decrease in certain types of retail sales — especially durable goods such as furniture and cars," Bachmeier said. "Demand for these goods is still high and we will have to continue to watch how these sectors react to the high gas prices."

Seek more

Read how K-State is helping global resilience in other areas, including peace building, sustainability and the power grid.

Pawsitive results

Programs focus on pet nutrition and health

By Beth Bohn

If we are what we eat, the same holds true for our pets, particularly dogs and cats, according to experts and researchers with Kansas State University's pet food program and Hill's Pet Health and Nutrition Center. They say good nutrition is important for healthy pets.

K-State's pet food program, a part of the feed science program in the College of Agriculture's grain science and industry department, is the only program in the U.S. focused on food for dogs and cats. The program offers research expertise and facilities to explore solutions for pet nutritional challenges and pet food processing.

The Hill's Pet Health and Nutrition Center is the primary care service at the Veterinary Health Center, a part of K-State's College of Veterinary Medicine. The center provides annual wellness exams; preventive care such as vaccinations and parasite prevention; acute and chronic illness management; minor surgical procedures; and nutritional assessment.

Feeding the Kansas economy

Pet food is big business. Pet food sales topped $100 billion globally in 2021, with the U.S. share of sales at $42 billion, according to Greg Aldrich, K-State associate professor of grain science and industry and pet food program director.

"K-State created the pet food program as a strategic opportunity for the university to capitalize on the pet food industry in Kansas and Missouri, which are both home to major pet food manufacturing facilities," Aldrich said.

The diverse program utilizes the university's expertise in extrusion, thermal processing, canning, baking, sensory analysis, value-added processes and more. Along with offering a bachelor's degree in feed science management with a pet food emphasis, the program offers master's and doctoral degree options. Members of the pet food industry, including ingredient companies, manufacturers, grain checkoff programs and related entities, are major supporters of the program's research.

"Much of the work we do is evaluating the various ingredients in a pet food application," Aldrich said. "How a pet food is processed can influence its nutritional value and we look at how different processes and food forms might be adapted to provide better food for your dog and cat."

Beyond kibble and canned food

The Food and Drug Administration regulates pet food in the U.S. along with the Association of American Feed Control Officials, a voluntary organization that sets the nutritional guidelines commercial pet foods should meet for animals. Association members are state and federal regulatory officials who oversee ingredient definitions, nutritional standards, label compliance, field operations for inspection staff and program administration.

Commercial pet food options available today are many and range from food made especially for each life stage of a pet to many of the current human diet trends such as whole foods, low fat and high protein.

"In just the last five to 10 years alone, we've gone beyond kibble and canned food," Aldrich said. "Now we're seeing the introduction of refrigerated, fresh, frozen, dehydrated and even home-delivered pet food products."

Each new form of pet food presents processing and nutritional challenges. Research from Aldrich and his team focuses on the effects of ingredients and processing on pet food's nutrition, shelf life and safety.

One current study deals with frozen pet food, which does not go through the thermal processing needed to kill bacteria, including *salmonella*, *E. coli* and *listeria*. These pathogens can sicken pets and the pet owners who handle the food. The Aldrich lab is conducting food micro studies and processing evaluations on GRAS — or generally recognized as safe — food additives that could mitigate pathogenic bacteria in frozen or raw pet food.

Sustainability is a major trend in the pet food industry and an area of emphasis for Aldrich and his graduate students. They are working on several projects using co-products in pet food. Co-products are incidentally produced in the production of another product. Using co-products is a way to utilize all parts of a grain plant or livestock animal, eliminate waste and add value to agricultural commodities.

Aldrich's team is studying if corn-fermented protein from distillers grains, a co-product of the ethanol production process, could be used as an alternative, vegetable-based protein source in pet food. The study includes how the yeast in the fermented protein may enhance palatability and gut health. The team also is looking at ways to concentrate the insoluble fiber of corn — its high-cellulose seed hull — in pet food.

Sorghum, which is high in antioxidant polyphenols, is another grain Aldrich's lab is studying for use in pet food, including the co-product of sorghum-based dried distillers grains. The researchers also are evaluating whole soybeans in extruded pet food to increase protein and fat content.

Above left: *Greg Aldrich researches ways to make dog and cat food more nutritious.*

Above right photos: *Aldrich and several students prepare K-State-made dog treats and other pet food, which use many kinds of ingredients.*

Nutrition and pet health

While the pet food program ensures pet food is safe and nutritious, veterinarians at the Hill's Pet Health and Nutrition Center often treat dogs and cats for problems caused by poor nutrition. The clinic staff includes faculty and veterinary students from the College of Veterinary Medicine.

"We take nutrition and its importance to the health of our patients seriously," said Susan Nelson, veterinarian and professor of clinical sciences. "We perform a nutritional assessment each time we see our patients to determine if adjustments in their diets are needed."

Conducting nutritional assessments is important training for veterinary students, helping them become more confident and competent in the discussions they will have with their future clients about the nutritional health of their pets, Nelson said.

Center staff often recommend adjustments in a pet's diet for weight control. According to the American Animal Hospital Association, more than half of the cats and dogs in the U.S. are overweight or obese. Obesity in dogs and cats can lead to a shortened life span; diminished quality of life; chronic inflammation; skin, orthopedic and metabolic disorders; some cancers; and other life-threatening conditions.

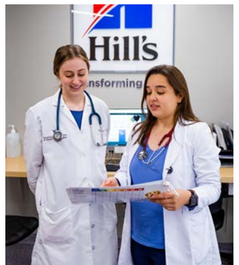
To help dogs and cats that are obese but otherwise healthy, the center offers the Healthy Weight Clinic, a six-month program that provides an individual weight loss diet for each pet client and recommends increased activity.

"Data accumulated by this program shows that animals can lose weight, just like people, if they consume fewer calories and expend more energy," Nelson said.

The center also is involved in clinical studies regarding pet nutrition. A current study is evaluating the palatability of a newly developed dog food to meet the nutritional needs of dogs with cancer.

"This is a pilot study assessing how well dogs eat the food and if it helps them maintain their weight while undergoing various cancer treatments," said Mary Lynn Higginbotham, associate professor of veterinary oncology. "Weight loss is common during cancer treatment, and maintaining weight and meeting nutritional requirements are important for the pet's overall health."

Nelson and colleagues at the center often refer pet clients to clinical trials conducted at the College of Veterinary Medicine. Recent trials have included treatments for osteosarcoma, acute kidney injury and osteoarthritis in dogs, and chronic kidney disease and inflammatory bowel disease in cats.



Below left: *Susan Nelson, clinical professor, left, and Paulina Macias, intern veterinarian, work at the Hill's Pet Health and Nutrition Center.*

Top right: *Fourth-year veterinary student Morgan Hull examines Ryder the dog with Nelson.*

Bottom right: *Hull and Macias work at the Hill's Pet Health and Nutrition Center.*

KIBBLE CON™
AT KANSAS STATE UNIVERSITY

SIDEBAR

A pet project: KibbleCon

One way Kansas State University's pet food program networks with the pet food industry is through an event called KibbleCon.

The conference, coordinated jointly by the university pet food program and K-State Innovation Partners, with sponsorship by various entities from the pet food industry, is an opportunity to showcase the latest pet food research at K-State and hear from national and international experts in the field.

The 2022 KibbleCon focused on the latest research and current industry topics, such as pet food startups and entrepreneurship, marketing, commodity markets and supply chain trends, food safety, packaging and more.

KibbleCon also is an opportunity for K-State students to present their research and network with representatives from the pet food industry. Greg Aldrich, pet food program director, said job placement in the industry is high, with students in the program typically landing jobs three to six months before graduating.

Seek more

Watch a video and learn more about the Hill's Pet Health and Nutrition Center and pet food program.

Bits and bytes boost agriculture

Computer circuitry helps study soils

By Pat Melgares

Can an electronic circuit — not much larger than a postage stamp — help to speed up U.S. farmers' goal to feed a hungry world?

It might, says Raj Khosla, if it's taught to measure soil properties of a farm field so that in a matter of seconds, farmers can adjust water, nitrogen and other inputs to abundantly grow crops.

Think of it as farming in bits and bytes, in real time.

"The United States has constructed an agriculture innovation agenda that in the next 28 crop cycles — which gets us to the year 2050 — we want to grow 40% more food than what is currently grown," said Khosla, a precision agriculture specialist, professor and head of the Kansas State University agronomy department in the College of Agriculture.

"But here is the caveat: We need to achieve this goal by using 50% less water and 50% less nitrogen applied to the crops, which are the two biggest drivers of crop production systems," Khosla added. "This means we have to account for everything that goes into the water and nitrogen budget. We can't leave room for error."

For Khosla, it's exciting work. For the past 10 years, he's been methodically reducing the chance of error in several projects that focus on using sensors to measure soil moisture and nitrogen content.

If successful, farmers would be able to shun more expensive measuring equipment — sometimes a 10-to-12-foot tower in a field with probes snaking into the ground — costing hundreds to thousands of dollars, in favor of dozens to hundreds of biodegradable sensors scattered throughout a field.

Soil sensation

Soil moisture sensors estimate the volume of water in soil based on the principle of electrical resistance, or the soil's ability to transmit electricity. As the water content of the soil increases, the resistance decreases and gives a predictable assessment of water content.

Other sensor-based measurements provide additional data specific to a field, such as the presence of plant-available nutrients to determine how much additional fertilizer should be applied or a crop's reaction to such environmental conditions as temperature and light.

It's research that Khosla has been investigating for a decade and has brought to K-State.

"Ten years ago, I was hypothesizing that someday we would have soil moisture sensors that we could literally throw out in a field, then 'ping' them with a computer to get a measure of that soil's moisture content," Khosla said.

Khosla began conducting field experiments in 2012 in collaboration with private partners that provided sensors mounted on a post and connected to cables that measured soil moisture at five depths. In that setup, Khosla determined that to cover a 22-acre field, a farmer would need about 100 sensor nodes — each at a cost of about $3,000.

"They were expensive," he said. "Even today, they are cost prohibitive for a farmer. Installing those sensors is labor intensive and it's a logistical nightmare to have 12-foot-tall posts sticking out of your 22-acre field at such a high density."

Those early experiments, though, served a purpose: to fuel the research group's motivation to provide a low-cost option that could still gather detailed information of the farmer's entire field.

> "The United States has constructed an agriculture innovation agenda that in the next 28 crop cycles — which gets us to the year 2050 — we want to grow 40% more food than what is currently grown.
>
> - RAJ KHOSLA

Far left: *Raj Khosla and Jeff Siegfried look over data gathered from soil sensors at the K-State North Agronomy Farm.*

Left: *K-State researchers are using prototype soil sensors that are installed between rows of corn.*

> "We can only manage what we can measure. If we can't precisely measure the resources that we're trying to manage, then we won't be able to help farmers.
>
> - RAJ KHOSLA

Above: *Soil sensors collect large volumes of data that are processed by computers using K-State-developed algorithms to translate data.*

Getting rid of guesswork

Now, Khosla is co-leading a collaborative team that is building on those early experiments. In 2018, Khosla and his colleagues at the University of Colorado Boulder and the University of California, Berkeley received a U.S. Department of Energy grant that funds high-risk/high-reward projects through the Advanced Research Project Agency.

The team of researchers includes materials scientists and computer and electrical engineers from the collaborative institutions. Other K-State agronomy researchers involved include Jeff Siegfried and Dipankar Mandal, both postdoctoral research fellows; Wub Yilma, doctoral student; and Ross Unruh, assistant scientist.

Together, the researchers have keyed in on moving agriculture further into the digital age.

The biodegradable sensors that they are working to test, evaluate and assist with design and redevelopment will provide the capability of measuring at high spatial densities. That would allow researchers to estimate soil moisture at every inch of a field and provide huge volumes of data that are crunched by computer algorithms to build an easily readable guide for the farmer.

"There is no spot in the field where there will be guesswork," Khosla said.

Farmers already can apply water, nitrogen and other nutrients in very precise ways, using such current technologies as variable rate irrigation that can be adjusted to provide different rates of water in a field, Khosla said. But knowing the field's needs, foot by foot, is limited to measurements provided by satellite images or unmanned aerial vehicles. Those are good ways to accommodate a field's needs, but still not entirely precise, diagnostic or immediate.

"One idea is that as a pivot is applying water in a field, you can ping sensors that are lined up in the next 20, 50 or even 100 feet of the pivot arm," Khosla said. "That information is sent back to the computer to re-create the real-time soil-moisture data surface that the pivot is encountering while it is applying the water, and the farmer or artificial intelligence-based decision tools can change the rate of application if necessary. I think that's going to be a big deal."

If farmers were to deploy 100 sensors throughout a field, the sensor cost — at 50 cents to $1 each — would be $50 to $100. Setting them up would be as simple as walking the field and tossing and inserting them about. Because they would be biodegradable, they would never have to be collected.

The eco-friendly biodegradable chips, which Khosla thinks will start to deteriorate in about 200 days, are not yet available. Currently, the research team is using larger, more expensive circuits that are not biodegradable to make sure the huge volumes of data they are collecting can be processed by computers using algorithms developed by K-State researchers to translate data that enables farmers to make better decisions.

"We can only manage what we can measure," Khosla said. "If we can't precisely measure the resources that we're trying to manage, then we won't be able to help farmers. I think that's particularly true for these two major inputs in crop production systems — water and nitrogen — that are environmentally so sensitive and important."

But this work is the first step toward an exciting new agricultural era that involves more sensors and data-driven decisions.

"These types of technologies often are for organizations with a very high demand for information technology. They're usually the first ones to get their hands on it," Khosla said. "Well, this time it happens to be agriculture. It's very exciting to be in that environment."

Ryan Hansen is studying the interactions among microbes in a project that could have implications for human health and farm crops.

A lab on a chip

K-State chemical engineer Ryan Hansen also is capitalizing on the power of miniaturized sensors as he and his team build what he terms a "lab on a chip" that studies the interactions among many types of microorganisms.

Among other potential uses, the technology may aid in improving bioinoculants on farm crops, probiotics for human health and antibiotics for medicine.

The technology is called the Microwell Recovery Array, or MRA. The device uses small wells to screen tens of thousands of interactions among microbes in one experiment. In its current form, Hansen said, it is designed to find bacteria that have the strongest interactions with a specific microorganism, which may be a pathogen but could also be beneficial bacteria.

"Microorganisms are social organisms and they interact with each other in symbiotic, competitive or antagonistic ways in their natural ecosystems," said Hansen, associate professor, Steve Hsu Keystone research scholar and Warren and Gisela Kennedy Keystone research scholar in the Carl R. Ice College of Engineering. "It is important to fundamentally understand these interactions to help us predict how diverse collections of microbes function together."

He notes that many ecosystems — such as soil and plant roots — harbor diverse microbial communities.

"Finding interactions that influence the most important microbes can be a very daunting task, especially with the limited experimental techniques available in the standard microbiology laboratory," said Hansen, who is in the Tim Taylor Department of Chemical Engineering.

MRA now makes overcoming the challenge achievable.

> "Developing more reliable biofertilizers is very important for establishing sustainable agricultural practices.
>
> - RYAN HANSEN

"In the case of a probiotic, we want to find symbiotic bacteria that support its function," Hansen said. "In the case of a pathogen, we want to find antagonistic bacteria that can defend against it. With our screening technology, we have shown that we can quickly find both types of interacting cells in just one experiment, equivalent to what would likely take months to do using standard methods."

Hansen said understanding interactions among microbes may also help in developing bio-based fertilizers for farm crops — and decrease the need for chemical fertilizers. Bio-based fertilizers are limited currently because they are often unreliable, he noted.

"Developing more reliable biofertilizers is very important for establishing sustainable agricultural practices," Hansen said.

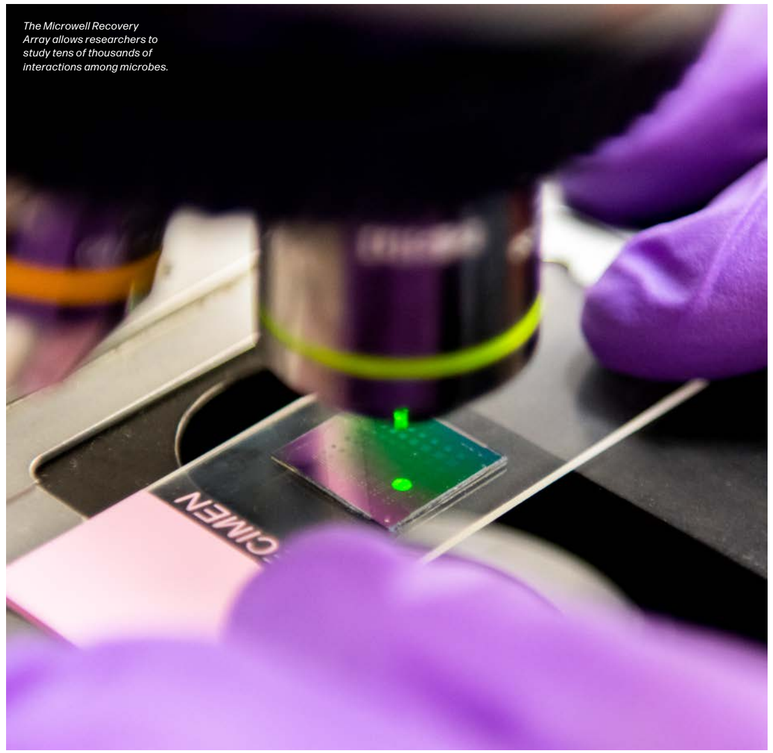
K-State researchers are using MRA technology to screen for symbiotic interactions between a nitrogen-fixing bacterium called *Azospirillum brasilense* and bacteria native to corn root. Hansen said it is likely that symbiotic bacteria can be combined with *A. brasilense* to improve its efficiency and reliability as a biofertilizer.

"In small-scale laboratory studies, we have seen that co-inoculating *A. brasilense* with symbiotic mixtures of bacteria accelerates early stage corn growth compared to inoculating with *A. brasilense* only," Hansen said.

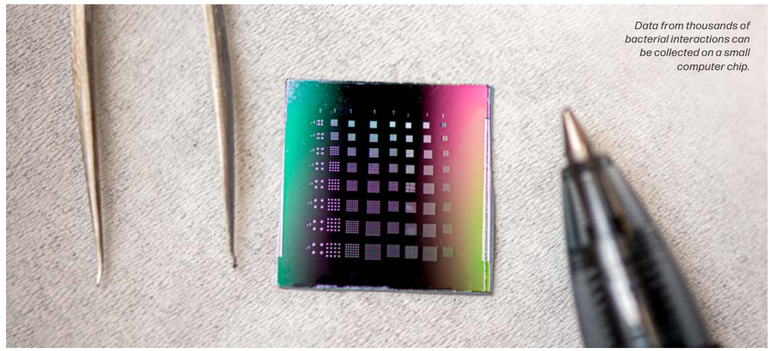
In addition to developing effective bio-fertilizers, Hansen said the ongoing K-State work includes using the MRA to screen soil and plant root samples to discover bacteria that are useful as biocontrol agents, which could reduce the incidence or severity of diseases caused by plant pathogens. The MRA also is helping to discover soil bacteria that can be used to help retain moisture during drought.

Hansen's research has been funded by the National Science Foundation and has been published in journals such as ACS Applied Bio Materials, Biomacromolecules and Frontiers in Microbiology.

Hansen as well as Thomas Platt, assistant professor of biology in the College of Arts and Sciences, and other researchers also were awarded a related patent, "Hydrogel Membrane and Methods for Selective Retrieval of Microbial Targets."



The Microwell Recovery Array allows researchers to study tens of thousands of interactions among microbes.



Data from thousands of bacterial interactions can be collected on a small computer chip.

SIDEBAR

Keeping lead in its place

In a vacant lot east of downtown Kansas City, Missouri, Ganga Hettiarachchi, Kansas State University professor of soil and environmental chemistry, leads her research team in lining out a grid. The researchers hope the work will give them important clues on how to reduce the risk of human exposure to lead.

"We are dividing the sections in this area so we can map the concentration of lead on the entire site," said Ruwandi Kumarasinghe, a member of the team and a research associate in the agronomy department in the College of Agriculture.

The Missouri Department of Health and Senior Services reports that lead-based paint and contaminated dust are the most common sources of exposure in the U.S. Soil often becomes contaminated from natural weathering of exterior-based paint from houses and other structures. Areas around houses built before 1978 — when lead-based paint was banned — are more susceptible to lead contamination.

In early 2022, Hettiarachchi received $700,000 from the U.S. Department of Housing and Urban Development, or HUD, to study the presence of lead in vacant city lots and as many as a dozen brownfield sites, or land previously developed that is no longer in use and has known or suspected contamination.

In 2021, the Centers for Disease Control and Prevention estimated more than 500,000 U.S. children under age 6 have blood lead levels higher than 5 micrograms per deciliter, which at that time was the level at which recommended public health actions be initiated. The reference value is now at 3.5 micrograms per deciliter. Lead exposure can stunt childhood brain development, as well as cause damage to the brain and nervous system in children and adults, among other health risks.

Hettiarachchi said basic soil chemistry could be key to immobilizing or reducing direct exposure to lead and other contaminants in soil. For example, adding phosphorus sources to soil to convert lead into a less soluble form can be combined with common management practices, such as applying mulch or wood bark in home landscapes.

At the test plots in Kansas City, Hettiarachchi and her research team are applying soil amendments to try and find the best ways to decrease the bioavailability of lead to children and adults.

"People think soil chemistry is basic science, and most of the time it is," she said. "But in this case, it is basic science that can be applied to public health."

Amy Roberts, the project manager for the Kansas City, Missouri Health Department's Childhood Lead Poisoning Prevention and Healthy Homes program, notes that Kansas City has some zip codes where the lead poisoning rate is nine times the national average — alarming numbers that she says need to be addressed.

"To our knowledge, there are no studies evaluating the benefits of adding in situ stabilization methods to current state and local lead poisoning mitigation programs," Hettiarachchi said.

The K-State team uses flags to outline a grid for in-field tests of lead levels.

Ganga Hettiarachchi studies lead levels in urban soils.

It's likely that many urban areas across the U.S. have similar risks, and K-State's work is drawing an attentive eye across the country.

"If we are successful in Kansas City, and because the Environmental Protection Agency manages the brownfield program, and HUD is assisting cities and states in addressing lead poisoning issues, the lessons learned can be adopted by any other city around the nation," Hettiarachchi said. "Kansas City could be a model city."

K-State's work is in partnership with the city of Kansas City, Missouri; the EPA; and Children's Mercy Hospital.

> "People think soil chemistry is basic science, and most of the time it is. But in this case, it is basic science that can be applied to public health.
>
> - GANGA HETTIARACHCHI

Seek more

Watch a video about soil research at K-State.

FROM RESEARCH TO REALITY

A closer look at vaccine development

By Jennifer Tidball

The research started a long time ago. Long before you went into your neighborhood pharmacy to get a vaccine — whether an annual flu shot, COVID-19 booster or a shot to protect against another illness or disease. Long before a livestock producer vaccinated an entire herd or flock against an emerging disease. That simple shot for a human or an animal is not so simple. It involved years of research and step-by-step development from an idea to the laboratory to tests and clinical trials before a thorough regulatory approval process that allowed the production and distribution of the vaccine.

> "As we have seen from the COVID-19 pandemic, when available, vaccines can play an important role in protecting people from infections and for controlling the spread of viruses."
>
> - STEPHEN HIGGS

"As we have seen from the COVID-19 pandemic, when available, vaccines can play an important role in protecting people from infections and for controlling the spread of viruses," said Stephen Higgs, director of the Kansas State University Biosecurity Research Institute, or BRI.

Vaccines truly are critical, and K-State is becoming a leader for their development. From the existing biosafety level-3 laboratories at the BRI to the new Biologics Development Module that will expand vaccine research capabilities, the university is enhancing its capacity for this important line of work.

K-State scientists are studying and developing multiple human and animal vaccines and have achieved success with international collaborations, patented intellectual property and partnerships with industry. Their work will expand with nearby partners, too, including the National Bio and Agro-Defense Facility, or NBAF, as well as Scorpion Biological Services Inc. and its planned biodefense-focused biomanufacturing facility in the Manhattan area. See page 36 to read more about the new Scorpion facility.

Here's a closer look at several animal and human vaccine-related success stories that involve K-State research.

Aidan Craig places research sample boxes into a liquid nitrogen tank for long-term storage.

SIDEBAR

A model for vaccine development

Big developments are on the vaccine horizon, thanks to a new pilot research facility that is up and running within the Kansas State University Biosecurity Research Institute, or BRI.

The new Biologics Development Module, or BDM, is a pilot production facility that is primarily designed for vaccines, but could also be used to scale up diagnostics and therapeutics. It uses state-of-the-art equipment that allows scientists and corporate partners to build research from proof of concept to large-scale commercial production.

"Capabilities at the BRI and the researchers who work here enable development, testing and evaluation of current and new vaccines and the technologies to produce them," said Stephen Higgs, BRI director. "Our new BRI-BDM expands these capabilities and the ability to work with industry partners."

The BDM is a biosafety level-2 lab where researchers can safely develop diagnostic, therapeutic and preventative countermeasures for emerging diseases that can affect animal health, human health and the food supply.

"The BDM will be very good for K-State in the sense that our customer base can be animal health companies around the world," said Jishu Shi, professor of vaccine immunology, who provided guidance for the BDM development based on his years of industry experience. "When we work internationally, we not only can help small and large companies, but at the same time, we get to be part of something exciting and develop a new product that will be used in the field to protect animals and humans."

Seek more

Watch a video about the Biologics Development Module.

Above left: Nina Muro, left, and Jishu Shi add reagents to a test plate to determine the efficacy of a vaccine.

Above right photos: Shi's research team has developed a safe and effective protein vaccine to protect swine against classical swine fever.

> "The Biosecurity Research Institute gives us the capability to study this type of virus. This facility is unique and invaluable, and a treasure for the university and for Kansas.
>
> - JISHU SHI

Stopping swine fevers

One of the most devastating diseases for pork producers around the world is classical swine fever.

The pathogen does not affect humans, but it is an incredibly contagious swine disease. While not currently in the U.S., the virus is present in South America and has seen a resurgence in Asia, particularly China and Japan, in recent years.

"If the virus was introduced into the U.S., it would be devastating for the industry," said Jishu Shi, the Dr. Wayne and Hilda Appleton professor of vaccine immunology in the College of Veterinary Medicine.

Shi wants to prevent that from happening by developing better vaccines for swine diseases, particularly classical swine fever and African swine fever.

His team has developed a safe and efficacious protein vaccine to protect swine against classical swine fever. They also developed a novel adjuvant — a vaccine component — that makes the immune response in swine even more effective.

The research was first licensed to an animal health company in 2018 and K-State Innovation Partners coordinated a new licensing agreement last year to use the classical swine fever vaccine platform in combination with other vaccines.

"The Biosecurity Research Institute gives us the capability to study this type of virus," said Shi, also a Vanier and Krause BRI fellow. "This facility is unique and invaluable, and a treasure for the university and for Kansas."

Shi's research has received support from the NBAF Transition Fund, the Department of Homeland Security, the U.S. Department of Agriculture and animal health industry partners. His research team in the anatomy and physiology department includes Rachel Madera, senior research scientist; Lihua Wang, research assistant professor; Yuzhen Li, research associate; Amanda Rezac, research technician; and Aidan Craig, research technician.

Understanding BAPC and CAPC

A K-State-developed nanotechnology is improving vaccine effectiveness through a commercial partnership with Olathe-based Phoreus Biotechnology Inc.

John Tomich, professor of biochemistry and molecular biophysics in the College of Arts and Sciences, led an interdisciplinary research team that created the nanotechnology. They patented and licensed it to Phoreus through K-State Innovation Partners.

The research involves two technology platforms: Branched Amphiphilic Peptide Capsules, or BAPC, and Corralling Amphipathic Peptide Colloids, or CAPC. Both BAPC and CAPC are novel, nanoscale, peptide-based platforms that can increase the efficacy of vaccines and different therapies.

BAPC can be stable for extended periods at room temperature, which makes them a better delivery platform for mRNA and plasmid DNA vaccines. CAPC can deliver small drugs.

"BAPC are easy to prepare, stabilize the nucleic acids and are biodegradable. They can even be prepared dry for long-term storage," Tomich said. "CAPC could revolutionize the small molecule drug industry since many human drugs in the development pipeline fail due to insolubility. The CAPC technology could rescue many of these drug candidates that are currently being abandoned."

Tomich and the Phoreus team continue to collaborate with other universities and industry on using BAPC technology for vaccine development, including work related to an mRNA COVID-19 vaccine and several animal vaccines for swine and poultry.

"There is a push from many directions to build on the success of the existing mRNA COVID vaccines to expand into additional infectious diseases for both human and animal application," said Michael Coe, chief scientific officer at Phoreus. "However, the next generation of mRNA vaccines are self-amplifying mRNA vaccines that mimic modified live virus vaccines, allowing for single-dose administration. Phoreus expects to be a leader in this new development with its BAPC technology."

Improving COVID-19 vaccines

K-State scientists continue work on COVID-19 vaccines through an ongoing research partnership with Tonix Pharmaceuticals. K-State Innovation Partners has coordinated an option-to-license agreement and research collaboration between the two organizations.

The K-State researchers in the College of Veterinary Medicine are working to make mRNA vaccines more stable during transport and storage. This includes mRNA vaccines used against COVID-19.

"Our collaborative team is working to fast-track the stabilized formulation into preclinical models," said Robert DeLong, associate professor at the Nanotechnology Innovation Center of Kansas State.

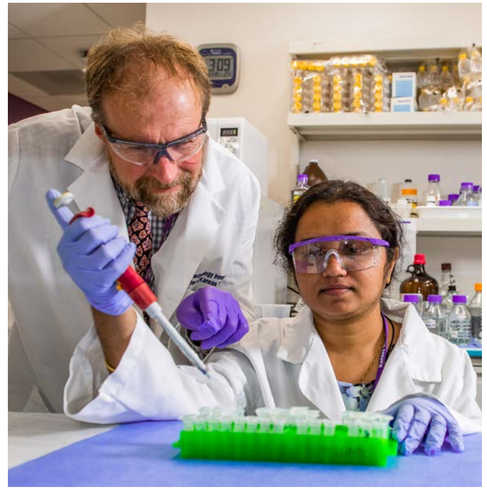
DeLong is leading the vaccine research, along with colleagues Waithaka Mwangi, professor of diagnostic medicine and pathobiology, and Jürgen A. Richt, director of the Center of Excellence for Emerging and Zoonotic Animal Diseases and the Center on Emerging and Zoonotic Infectious Diseases.

The collaborative team is developing a zinc particle, or ZNP, mRNA vaccine that can replace the lipid nanoparticle, or LNP, technology in current COVID-19 vaccines.

"The ZNP technology invented and developed by scientists at K-State has the potential to make mRNA vaccines that are free from LNPs, which could improve the stability of mRNA vaccines at room temperature and facilitate their deployment in places without ultra-cold chain supply systems," said Seth Lederman, chief executive officer of Tonix.

Above left: John Tomich is collaborating with Phoreus Biotechnology Inc. on nanotechnology to improve the efficacy of vaccines.

Below: Robert DeLong, left, and Elza Mathew are working on stabilizing COVID-19 mRNA vaccines in a project funded by Tonix Pharmaceuticals.



Preventing a common cattle disease

Bovine anaplasmosis is a tick-borne disease that affects beef and dairy production in almost all U.S. states.

There is currently no effective vaccine on the market against the disease, but Roman Ganta and researchers in the College of Veterinary Medicine are changing that.

Ganta, university distinguished professor of diagnostic medicine and pathobiology, and his team with the Center of Excellence for Vector-Borne Diseases are developing a vaccine to protect cattle against bovine anaplasmosis. They have worked with K-State Innovation Partners to file a patent for their novel molecular method.

"We started this project because bovine anaplasmosis is an important cattle disease that causes billions of dollars of losses to the cattle industry in the U.S. and many parts of the world," said Ganta, center director.

The disease is transmitted by more than 20 different tick species, which makes it one of the most prevalent tick-transmitted cattle diseases. It can also be transmitted mechanically among cows, but the disease does not affect humans.

The disease is common in nearly all of the U.S. Recent research by Ganta and his collaborators showed that about 50-60% of all beef and dairy cattle from California, Kansas and Missouri tested positive for the disease.

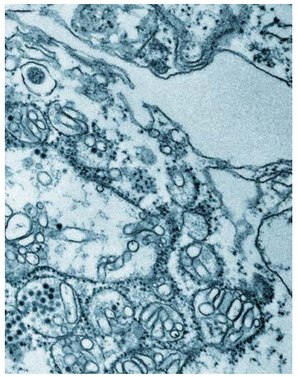
Their vaccine research is also important because many farmers control the disease burden by using antibiotics as a food supplement.

"The antibiotic use can also cause the development of antibiotic-resistant bacteria in addition to the unnecessary use of antibiotics to food animals," Ganta said. "While farm practices may help control the disease, the best option is having a good vaccine."

Ganta and his team continue to extend the vaccine's value for field applications. They have recently published their work in PLOS Pathogens.

Above right: This electron microscopic image shows Zika virus particles. (Photo credit: CDC/Cynthia Goldsmith)

Below: Deborah Jaworski, left, and Roman Ganta examine tick species from the incubator at the Center of Excellence for Vector-Borne Diseases.



Other vaccine success

The vaccine success doesn't stop there. K-State researchers are involved in numerous vaccine development projects through collaborations with other universities, organizations and industry partners.

Zika virus

Scientists with the K-State Biosecurity Research Institute, or BRI, have been involved in a large multi-institutional project to test the very first mRNA vaccine, which was first developed for Zika virus. The mRNA vaccine technology was later used for several COVID-19 vaccines.

The team published a study on the mRNA vaccine in 2017 and in 2022 the 35 co-authors received the international BIAL Award in Biomedicine, which recognizes the most important research reports in the last 20 years in biomedicine.

The College of Veterinary Medicine scientists involved include Stephen Higgs, BRI director; Dana Vanlandingham, professor of arbovirology; and Yan-Jang "Scott" Huang, research assistant professor of arbovirology.

Coronavirus in zoo animals

The K-State Center of Excellence for Emerging and Zoonotic Animal Diseases, or CEEZAD, is helping protect more than 100 mammalian species of animals in zoos around the world against infection with SARS-CoV-2, which is the virus that causes COVID-19.

Zoo animals are receiving an experimental COVID-19 animal vaccine developed by leading animal health company Zoetis. The K-State CEEZAD team, led by Jürgen A. Richt, Regents distinguished professor in the diagnostic medicine and pathobiology department, has been involved in testing the vaccine for safety and efficacy against SARS-CoV-2 infection.

Epizootic hemorrhagic disease

K-State researchers developed a subunit vaccine technology against epizootic hemorrhagic disease. The disease negatively affects the deer and cattle farming industry because it causes high mortality mainly in white-tailed deer and other ruminants, including cattle.

Through K-State Innovation Partners, the patented technology has been licensed to Texas-based BioStone Animal Health LLC.

The work involves multiple K-State CEEZAD researchers, including Richt, CEEZAD director; Igor Morozov, research manager; and Sun Young Sunwoo, postdoctoral fellow. William Wilson, adjunct K-State faculty member and research microbiologist with the U.S. Department of Agriculture Agricultural Research Service, also was involved.

Avian influenza

Richt also has collaborated with researchers at the Icahn School of Medicine at Mount Sinai to develop an avian influenza vaccine that has been licensed to Avimex. The vaccine is being used in Mexico. *k*

STEP BY STEP

Vaccine development — for both human and animal vaccines — involves years of research, laboratory tests, clinical trials and regulatory approval before the vaccine is available for use.

Read more about the steps of vaccine development.

Source: Centers for Disease Control and Prevention

Step 1: Exploratory stage

In this early laboratory stage, scientists perform basic research to understand the pathogen. They determine if it is a bacteria or a virus and if it infects humans or animals. Then the researchers figure out what is the best type of vaccine to develop, such as an mRNA vaccine, subunit vaccine, attenuated live virus vaccine or a vaccine made with an inactivated virus.

Step 2: Preclinical trial stage

Scientists perform rigorous tests in the laboratory to develop a vaccine that is safe and effective at fighting the pathogen. They also determine what vaccine is best for large-scale production and distribution.

Step 3: Clinical development

Both human and animal vaccines undergo clinical trials to determine their safety and effectiveness. Clinical trials are performed in multiple phases where the trial vaccines are given to groups of people or animals. By the end of the clinical trial phases, thousands of people or animals will have received the vaccine.

Step 4: Regulatory review and approval

Federal agencies review the clinical trial data for both human and animal vaccines to make sure they are safe and effective before the vaccines are available for the general public. In the U.S., the Food and Drug Administration, or FDA, regulates and approves vaccines for humans. The U.S. Department of Agriculture Animal and Plant Health Inspection Service, or USDA APHIS, regulates and approves vaccines for animals.

Step 5: Manufacturing

The vaccine is manufactured at FDA-approved or USDA-approved production facilities in large quantities and distributed throughout the country for use.

Step 6: Quality control

After vaccines are on the market, scientists and regulatory agencies continue to monitor the vaccine to make sure it is performing as it should and protecting humans and animals.

Above: This rendering shows the 500,000-square-foot Scorpion Biological Services Inc. commercial-scale facility in Manhattan, Kansas. (Image credit: Scorpion)

New company on the block

Scorpion Biological Services brings research opportunities to state and university community

By Erin Pennington

When Scorpion Biological Services Inc. set out to build a new facility, company leaders considered locations in 23 states. Ultimately, the company chose Manhattan, Kansas, as the location for a new $650 million commercial-scale facility. And Kansas State University was a big reason why.

Scorpion is a biopharmaceutical contract development and manufacturing organization. According to the company, it selected Manhattan because of the area's concentration of biodefense organizations, including the K-State Biosecurity Research Institute and the National Bio and Ago-Defense Facility adjacent to the K-State Manhattan campus. Once fully operational, Scorpion's 500,000-square-foot facility is expected to employ more than 500 people with average salaries of more than $75,000 per year.

K-State Innovation Partners played a key role in attracting Scorpion to the region through a series of presentations and visits. Other important partners included the K-State Office of the Vice President for Research, Manhattan Area Chamber of Commerce, Pottawatomie County Economic Development Corp. and Kansas Department of Commerce.

"Our team immediately saw what an excellent fit Manhattan could be for Scorpion and its goals," said Rebecca Robinson, chief corporate engagement and economic development officer with K-State Innovation Partners. "The opportunities for partnerships between the company and K-State for research, talent development and job opportunities for graduating students are very exciting and will be mutually beneficial."

Scorpion's sister company, Heat Biologics Inc., already has signed a master research agreement with K-State for work that will be done in the Biosecurity Research Institute. The company also has advanced conversations with the university to develop biomanufacturing programs at K-State and Manhattan Area Technical College to help train Scorpion's future workforce.

The master research agreements will lead to scientific collaboration that can help solve biosecurity challenges and develop new technology for economically important animal and zoonotic infectious diseases, K-State leaders said.

"The attraction of Scorpion to Manhattan is one of the early success stories of K-State's Economic Prosperity Plan, which includes a strong focus in biosecurity and biodefense" said David Rosowsky, vice president for research. "This is only the beginning of the growth and opportunities we are cultivating and hoping to create for our faculty, students and community."

> "Our team immediately saw what an excellent fit Manhattan could be for Scorpion and its goals.
>
> - REBECCA ROBINSON

Scorpion is a subsidiary of Nighthawk Biosciences Inc., a clinical-stage biopharmaceutical company that develops novel biodefense assets and therapies to modulate the immune system. Scorpion projects that the Manhattan facility will be complete, fully functional and staffed by April 2027. k

***Above left:** From left, students Cole Hayden, Zolian Zoong Lwe and Amanda Li harvest plant leaves for lipid analysis.*

***Above right:** Ruth Welti examines a plant leaf sample.*

A worldwide lipid leader

Biologist takes center research across the globe

By Malorie Sougéy

For a shining example of success, look no further than Ruth Welti, Kansas State University distinguished professor of biology and founder and director of the Kansas Lipidomics Research Center. With more than 125 publications, 86 undergraduate researchers and $10.9 million in grant funding, it's clear that Welti has significantly influenced her field, colleagues and students.

Welti and her technical team in the College of Arts and Sciences lead the lipidomics center, which uses mass spectrometers to analyze specific types of lipids — compounds present in living organisms that don't dissolve in water. In plants, examples of lipids include seed oils and cell membranes, which provide a site for important processes like photosynthesis.

"My lab analyzes both storage and membrane lipids, which have thousands of different chemical structures," Welti said. "The population of lipid molecules in a particular plant or other organism is also dynamic, changing over the lifetime of an organism and rapidly in response to environmental conditions and other challenges, such as infections. We try to understand what changes occur, identify the proteins that catalyze the alterations and determine the purpose of these alterations in the life of plants."

The Kansas Lipidomics Research Center, which Welti started in 2003 with former K-State biochemist Xuemin Wang, has provided lipid analysis to approximately 700 research groups around the world. Researchers' work in the lab has resulted in at least 315 publications.

"One of our big-picture goals is to understand how plants, and particularly crop plants, can respond when faced with environmental challenges like bad weather — heat or cold, for example — in order to develop strategies for improved crop resilience," Welti said.

The center includes technicians Mary Roth, Pam Tamura and Libin Yao, who analyze samples, operate the mass spectrometers, edit grants and manuscripts, and work with student researchers. Looking to the future, Welti and her team plan to continue to provide detailed information on lipid composition to colleagues doing basic and applied research aimed at crop improvement.

"I'm thankful for the incredibly competent team at the Kansas Lipidomics Research Center and for our ability to provide valuable information to researchers working to unravel the complicated roles of lipid metabolism in plant resilience and production," Welti said. k

Seek more

Learn more about the Kansas Lipidomics Research Center.

Where the grass is greener

Landscape architect uses urban green space to improve mental well-being

By Lindley Lund

A walk in the neighborhood or a visit to a city park may seem like a simple activity. But in March of 2020, these simple actions became much more: coping mechanisms for many people through such an uncertain time.

Research has shown that the COVID-19 pandemic proved the positive influence that being outdoors can have on one's mental health, said Jaeyoung Ha, Kansas State University doctoral student in environmental design and planning in the College of Architecture, Planning & Design. Ha wondered if this same logic could apply to students on college campuses.

"Mental well-being and mental health are very important, especially for college students. The problem is many students do not take it as seriously as physical health," Ha said. "If college students are continuously exposed to urban green spaces, maybe they can naturally and without any effort improve their mental well-being. It could be like a preventative measure."

Ha set out to study the topic further and focused his interdisciplinary research on the psychology, biology and architecture of urban green space to discover what is most beneficial for college students' mental well-being. Using immersive visualization technology, Ha took 360-degree video footage of two urban green spaces with differing biodiversity on the K-State Manhattan campus: a native meadow garden and a large lawn area. He then had 319 university students watch one of the two videos, at random, for six minutes.

"After watching the video clips, regardless of the level of biodiversity, students had lower levels of negative mood states, which means that urban green spaces can be very effective in improving mental well-being," Ha said.

However, it was the native meadow garden that reduced the negative mood state the most among the participating students. This implied that urban green space is beneficial to improve mental well-being, Ha said, but if those restorative effects are to be amplified, more biodiversity should be considered on college campuses to increase the mental well-being of students.

"The association between urban green space and mental health has been consistently studied but many gaps exist," said Hyung Jin Kim, associate professor of landscape architecture and regional & community planning and Ha's faculty mentor. "I believe Jaeyoung's research contributes to the literature on further understanding of how different green spaces affect psychological well-being in different ways."

> "I want to make better urban environments to improve mental well-being in people."
>
> - JAEYOUNG HA

Ha plans to apply this new knowledge to his designing of urban green spaces to not only expose more people to nature but also help them reap the benefits of doing so.

"As a landscape planner and designer, we can change many things," Ha said. "I want to make better urban environments to improve mental well-being in people." *k*

Above: *Jaeyoung Ha uses immersive visualization technology to study how urban green space can improve mental well-being.*

Mind over matter

Student studies how behavior and the brain can increase self-control

By Lindley Lund

Studying psychology was never part of Lexe West's college plan, let alone conducting research. But her plan quickly changed after applying on a whim for an undergraduate research assistant position in a Kansas State University laboratory that would help her find her true passion: the brain.

During her sophomore year, West started her research journey in the Reward, Timing and Decision Laboratory — led by Kimberly Kirkpatrick, university distinguished professor of psychological sciences — and studied how diet affects impulsive choices in rats. She soon discovered her interest was not in the dieting aspect, but instead in the neurobiology behind the decision-making and how it can advance self-control.

"The fact that we could actually change behavior and see changes in the brains is what really interested me," said West, now a junior studying psychological sciences in the College of Arts and Sciences.

Today, West's research focuses on the behavioral techniques for impulsive decision-making and what can increase the rat's self-control. She has received a Barry M. Goldwater Scholarship for her research and has been involved in the McNair Scholars Program at K-State.

"The rats are exposed to time intervals where they have to wait to receive the reward, and over time they become more likely to make a more optimal choice," West said.

In practice, this looks like the rat having two options: a left lever and a right lever. If the rat chooses the right lever, it must wait 15 seconds before receiving one pellet of food. If it chooses the left lever, it must wait 30 seconds before receiving two pellets of food. Over time, as the rat is more frequently exposed to the intervention, it becomes more likely to press the left lever to receive more pellets. The process increases the rat's self-control because it becomes aware of the options and learns the timing.

> "It's amazing. In my lab, I've been able to find a community that I really didn't think I had before.
>
> - LEXE WEST

"Impulsive choice is a trans-disease process that is a risk factor for many diseases and disorders, including substance use disorder, gambling, obesity and attention-deficit/hyperactivity disorder," Kirkpatrick said. "The interventions that we have developed have the potential to reduce risks for disease development as preventative therapies and could also be used in treatment settings."

West plans to continue her research, especially its connections to the neurobiology of Parkinson's disease. But whatever her future may hold, she knows one thing is certain: She would not have made the connections and discoveries she did without taking a chance and joining the laboratory.

"It's amazing," West said. "In my lab, I've been able to find a community that I really didn't think I had before." *k*

Lexe West has found a passion for researching self-control within the brain.

Seek more

Learn more about the Reward, Timing and Decision Laboratory.

K-State researchers developed these vials of a novel adjuvant that can be used in a safe and effective swine fever vaccine.

adjuvant ('a-jə-vənt)

Jishu Shi, the Dr. Wayne and Hilda Appleton professor of vaccine immunology in the College of Veterinary Medicine, explains, in fewer than 100 words, what an adjuvant is and why adjuvants are important for vaccine research and production.

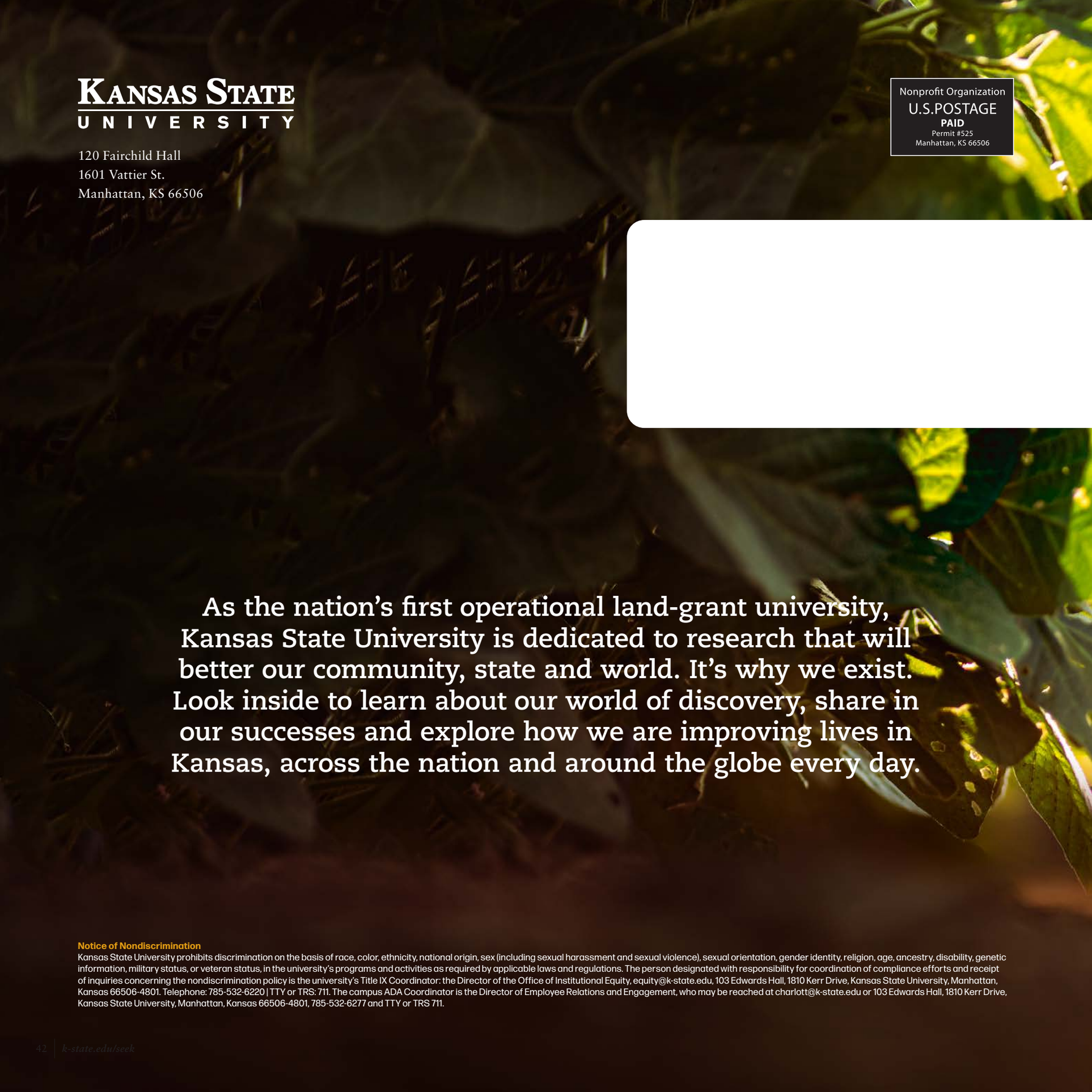
Adjuvants are organic or inorganic materials that are used to stimulate the innate immune system and influence the types and intensity of immune response elicited by an antigen. Adjuvants are essential components of vaccines that consist of antigens that are noninfectious, such as inactivated microbes, microbial proteins, DNA or mRNA. In addition to enhancing vaccine efficacy, adjuvants also help make a vaccine more cost-effective by reducing the amount of antigen required in the formulation. Adjuvants are broadly divided in two different groups: immunostimulants and delivery agents.

See page 28 to read more about Shi's vaccine research.

Meeting the needs of Kansas and the world

For more than 120 years, Kansas State University has been operating the Agricultural Research Center in Hays. The center is a unit of K-State Research and Extension and is known for its leadership and significant contributions in meeting the ever-changing needs of agriculture. This 1920s photo is from a Roundup, which was an on-farm, public educational opportunity at the center. Today, the center's outreach and research continue in weed and soil sciences, beef cattle, entomology, cereal grain breeding and rangeland management. See page 12 to learn how K-State wheat breeders continue to feed a hungry world.

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



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