Seek

RESEARCH MAGAZINE FOR KANSAS STATE UNIVERSITY

SPRING • 2022

Behind the code

Researchers tackle the new world of cybersecurity

Balancing act

Sustaining our future across disciplines

The new normal

Analyzing the ever-changing economy

A wave of natural color

Natural fibers and dyes come together to create the stunning colors of these fabrics, which are made of a linen and rayon blend.

Kansas State University researchers fashioned the vibrant colors of these fabrics using dried cochineal insects, marigold heads, madder plant roots and coreopsis flower heads.

Researchers in the interior design and fashion studies department are making textile production more sustainable by using flowers, plants, nut hulls, sawdust, tree bark, food waste and leaves to naturally dye fibers instead of using synthetic dyes. Typically, natural dyes are used on natural fibers such as wool, silk, soy, cotton, linen and hemp.

See page 20 to learn more about the natural dyes and other sustainable research across a variety of disciplines.

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Seek more

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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

I am both excited and proud to share this latest issue of Seek magazine with you, highlighting just some of the research, scholarly work and creative activity at Kansas State University. K-State is a leading land-grant university, a public research university with rich history of exceptional teaching, research and service to Kansans and to Kansas. It is through our research and discovery that we make our greatest impact. We create new knowledge and new understanding. We change minds and we change the world. We facilitate learning, discovery and engagement through our research. And we help to shape a future that is more secure and more sustainable.

K-State is also an economic engine for Kansas and has been for generations. With the launch of our **Economic Prosperity Plan** for Kansas in December 2021, we boldly and intentionally committed to extending our treasured land-grant mission to explicitly include economic development. Research and economic development go hand in hand. Whether basic — fundamental — research or applied research, lab-based or field-based, physical or computational, incremental or transformational, the value of research lies in its *impact*. Indeed, this is the best destiny of any great research. Impact can take many forms, from extending the state-of-the-art and changing our understanding of the world in which we live, to the creation of new technologies, products and companies. I invite you to learn more about our **Economic Prosperity Plan** and how we are leveraging the research, expertise and facilities at K-State to help create jobs and attract new investments into our state.

As always, we highlight research activity across the entire university in Seek magazine. However, in this issue you will also notice references to the different parts of our **Economic Prosperity Plan**: food and agriculture systems innovation, digital agriculture and advanced analytics, biosecurity and biodefense and K-State 105: Every Town to Gown, which seeks to connect our economic development work to all 105 counties in Kansas.

This issue of Seek includes expansive features on research — being conducted by faculty members and faculty teams that cut across departments and colleges — in sustainability, cybersecurity, digital humanities and our nation's economy. This issue also includes features describing two of our many important research centers, the Chapman Center for Rural Studies and the Johnson Cancer Research Center. And as always, we feature a graduate scholar and undergraduate scholar and their research. Finally, we share a recent example of a technology transfer/economic development success story.

Please enjoy this beautiful new issue of Seek and thank you for your interest, your engagement and your support of research at K-State. We are proud to be Kansas' land-grant university, a great public research university, an engine of discovery and economic development and a point of pride for Kansans.

D. Rosowsky, Vice President for Research

Seek more

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

A plan for economic prosperity in Kansas

You can plan on it: Kansas State University has launched a new strategic initiative to help people and businesses in Kansas.

The university's Economic Prosperity Plan will add thousands of jobs and billions of dollars into the Kansas economy by leveraging K-State's strengths in four key areas: food and agriculture systems innovation; digital agriculture and advanced analytics; biosecurity and biodefense; and extension and outreach.

"Our Economic Prosperity Plan will allow K-State to create 3,000 new jobs and $3 billion in additional investments into the state of Kansas in the next 10 years," said David Rosowsky, vice president for research. "This new initiative will allow K-State to truly demonstrate the value that universities provide to local, state and national economies through job growth and job creation, as well as retaining and attracting talent in the state."

The plan is a response to a request from the Kansas Board of Regents to demonstrate how Kansas institutions of higher education will add to economic prosperity in the state.

Seek more

Read more about the Economic Prosperity Plan.
k-state.edu/seek

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

Researchers are working with producers to transform, sustain and adapt food and agriculture systems worldwide to create jobs in Kansas and bring billions in national and international investment to the state.

Digital agriculture and advanced analytics

K-State is leading the global food system in creating and embracing leading-edge methods that are driven by data, analytics and decision-making in near real time.

Biosecurity and biodefense

University strengths in biosecurity and biodefense are making K-State the foremost U.S. resource for private-public research collaboration on pathogens of global significance.

K-State 105: Every Town to Gown

The university is leveraging its statewide K-State Research and Extension presence to assist businesses and communities in all of the state's 105 counties and to help them access K-State innovation, talent and training through local liaisons and coordinated resources.

A K-State-developed product called CHAMP is used in veterinary classrooms to help students learn how to handle needles and syringes properly.

Researcher develops a model market CHAMP

Veterinary students can now get a leg up on learning clinical skills thanks to a new tool envisioned by Susan Rose, clinical education technician in the Kansas State University College of Veterinary Medicine, and commercialized with help from K-State Innovation Partners.

After recognizing a need for more accurate and robust models for veterinary teaching, one of Rose's latest models has been transformed into a product called CHAMP: Canine Venipuncture & Injection Trainer. This unique canine hind limb model was refined and produced in collaboration with REMEDY Simulation Group, a Pennsylvania-based company specializing in human/anatomical teaching models.

"CHAMP provides an opportunity for many students to learn how to handle needles and syringes properly for the first time," Rose said. "Additionally, it gives them the opportunity to develop muscle memory and hand skills they need to use traditional syringes and needles, butterfly catheters or vacutainers for obtaining blood samples, or how to insert and secure IV catheters."

Rose began creating models for use in K-State veterinary courses years ago. The origins of the CHAMP began in March 2018 with her development of prototype model limbs for practicing venipuncture in junior surgery lab.

REMEDY acquired the exclusive rights to two of Rose's models and the final product was released to the market in October.

See *Shorts*

Wagon ruts are still visible on the Nicodemus wagon trail in Graham County. (Image credit: Nicodemus Historical Society and Museum)

Nicodemus re-enactors gather at the Ellis Depot to portray the arrival of the settlers in 1877. Settlers arrived by train in Ellis, Kansas, and traveled by wagon and on foot to reach Nicodemus. (Image credit: Nicodemus Historical Society and Museum)

Telling the story of Black westward settlement

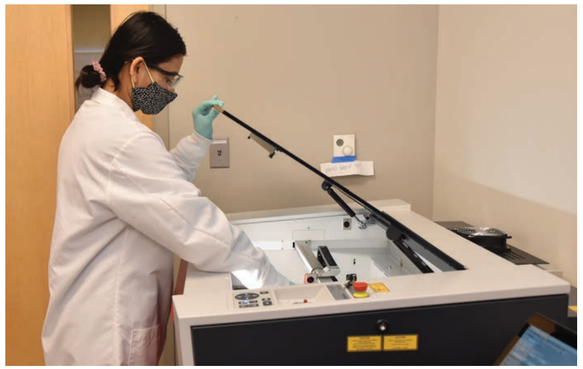
A Kansas State University collaborative project is bringing the history of Nicodemus, Kansas, and the Ellis Trail to life through an interactive website.

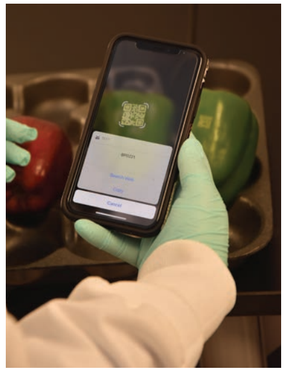
The project, "The Ellis Trail to Nicodemus: Revealing Stories in the Landscape of Black Westward Settlement," is one of 208 humanities projects across the country to recently receive prestigious funding from the National Endowment for the Humanities.

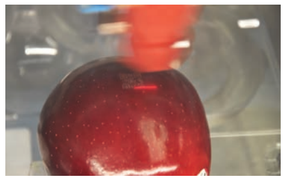
La Barbara James Wigfall, associate professor of landscape architecture and regional & community planning, is leading the project, which also includes researchers from the College of Architecture, Planning & Design and the College of Arts and Sciences. K-State collaborators include Katie Kingery-Page, professor of landscape architecture and associate dean; Kristen Epps, associate professor of history; and Erin Wiersma, associate professor of art. The team will work closely with community partners and project consultants Angela Bates and Robert Alexander, both of the Nicodemus Historical Society.

Nicodemus is the only continuously settled African American town west of the Mississippi River and is a national historic site. The researchers will create an interactive website to describe the Ellis Trail journey that the first Nicodemus settlers took from the train by wagon and on foot to reach the townsite.

Digital agriculture and advanced analytics







Photos above: Durga Khadka, master's student in horticulture and natural resources, uses a laptop to create QR codes that are then etched onto fresh produce with a standing laser. Scanning the QR code with a phone displays information about when the produce was etched. Other photos show the laser-made QR code on cucumbers, red apples and green bell peppers.

From plastic sticker to laser printer

Researchers at the Kansas State University Olathe campus are looking at replacing the plastic sticker on fresh produce with a laser-printed QR code onto the food itself. This would reduce environmental waste and improve food traceability.

Scientists in the Postharvest Physiology and Food Safety labs are testing the quality and safety of using a laser-based engraving technology to "print" on apples, cucumbers and green bell peppers.

In a matter of seconds, the laser engraves a QR code on the surface of the food. Tests are revealing if this exposed surface area affects produce freshness or is more susceptible to microbial contamination.

"The first step was determining whether a laser that's made for metal, plastic and wood engraving could also work on fruit and vegetable surfaces," said Manreet Bhullar, research assistant professor of horticulture and natural resources. "We then need to know whether the QR code stays readable until the end of the product's shelf life and does not increase the chances of microbial contamination on the etched surface. If we can meet those criteria, we can move forward with the technology on commodities that make sense for it."

While grocers use price look-up, or PLU, stickers primarily for inventory purposes, the QR codes also could better track produce throughout the food supply chain. The potential to quickly trace contaminated produce, to reduce foodborne outbreaks, and to lower large-scale disposal of uncontaminated produce during an outbreak mark critical advantages to using QR codes while protecting public health and reducing food loss, researchers said.

Sensory and Consumer Research Center researchers are evaluating the economic feasibility of the technology by looking at consumer acceptability of QR-labeled food.

"We can develop a method that's environmentally sustainable, reduces food loss and addresses the French ban on noncompostable stickers — impacting millions of dollars in U.S. exports," said Eleni Pliakoni, associate professor of urban food production and postharvest handling. "But if consumers don't want to buy food with a printed QR code on it, then it's not viable technology."

The K-State Global Food Systems seed grant program is funding the project.

Seek more

Watch a video of a laser printing the QR code on produce.
k-state.edu/seek

Biosecurity and biodefense

THE FIGHT CONTINUES

Updates on COVID-19 research from K-State

Improving vaccine stability

Researchers at Kansas State University are expanding an industry partnership to increase stability in mRNA vaccines — including those against COVID-19 — during transport and storage.

The agreement, coordinated by K-State Innovation Partners, is an exclusive license and option agreement and research collaboration with Tonix Pharmaceuticals.

Through the partnership, researchers will develop zinc nanoparticle, or ZNP, mRNA vaccines that replace the lipid nanoparticle, or LNP, technology in current COVID-19 vaccines.

"The LNP technology of current mRNA COVID-19 vaccines limits our ability to deploy these vaccines in many parts of the world," said Robert DeLong, associate professor at the Nanotechnology Innovation Center of Kansas State. "The technology we have developed uses zinc to replace LNPs and results in more temperature stable mRNA vaccines."

Developing new treatment options

Progress continues on a potential COVID-19 treatment based on a series of protease inhibitors developed, patented and licensed by Kansas State University.

Kyeong-Ok "KC" Chang and Yunjeong Kim, both virologists in the College of Veterinary Medicine, developed the protease inhibitors, which can help fight against coronaviruses, including SARS-CoV-2, the virus that causes COVID-19. The work is a collaboration with William Groutas at Wichita State University and Stanley Perlman at the University of Iowa.

Cocrystal Pharma Inc., a clinical-stage biotechnology company, is advancing their intranasal lead antiviral candidate, based on technology licensed by K-State Innovation Partners, with plans to begin phase 1 clinical trials in 2022.

ANALYZING THE EVER-CHANGING ECONOMY

By Courtney Roszak-Moore

Resilient. Adaptable. Unpredictable. Economists have used many of these words to describe the state of the economy since the COVID-19 pandemic began more than two years ago. The economy has faced countless hurdles, and no one knows when — or if — it will return to normal.

Kansas State University researchers say the economy's struggle to normalize is a result of a chain reaction that involves the workforce, inflation and supply and demand. It's a volatile cycle that has been felt across the 105 counties of Kansas and throughout the country and world.

The economy is a broad term that is all-encompassing. Broken down, the economy is a result of what every person produces and is driven by two factors: the ability to have a job and how much goods cost. To have a growing economy, society needs a strong and sustainable overall growth rate, but when growth is not sustained, it creates uncertainty.

That uncertainty motivates several K-State researchers across colleges to analyze what is going on with the ever-changing economy and to offer some hope for the future.

What happened?

Flip the calendar back to March 2020. Economic activity went to zero and the country experienced a shutdown. Unemployment rose and people stayed home and didn't go about their normal routine of buying things. To try and rebound the economy, the Federal Reserve issued several rounds of stimulus checks.

"The economic decisions that we saw in March 2020 were driven completely by the fact that we were shut down," said Eric Higgins, research director and the von Waaden Chair of Investment Management in the College of Business Administration. "Once the country opened back up, those issues began to go away and the economy came back."

Fast forward two-plus years. Every day we hear about inflation, unemployment and the volatile market. The economy is experiencing an increased labor shortage because of retirements or decisions not to return to the workforce, Higgins said.

But Higgins wanted to know: Is the economy really bad or are we still experiencing the aftereffects of March 2020?

Higgins and several collaborators tried to find the answers by analyzing and comparing 2020 to the 2008 Great Recession. Their research shows that 2020 was not a repeat recession, but was the result of financial issues and decisions directly correlated to the pandemic. As businesses began to reopen and people left their houses, we began to see increased growth and demand for products.

"If there is a shortage of labor and people want to purchase things, that means the price of labor is going to go up and the price of stuff is going to go up," Higgins said. "The economy isn't bad. I think the economy has rebounded, but it hasn't normalized in terms of what the new normal looks like and that might take a while."

WORDS TO KNOW

Kansas State University researchers define commonly used words associated with the economy.

Economy

What everybody produces. The economy is driven by two forces: the ability to get a job and how much the goods being produced will cost.

The market

Where commodities are purchased or sold, also known as the stock market. The market moves up or down and is influenced by a variety of events and numbers, including inflation.

Inflation

The overall increase in the price level on an annual basis. The Bureau of Labor Statistics collects several different measurements of inflation every month, but the one that's most often cited is the consumer price index.

Great Resignation

An ongoing phenomenon of employees quitting their jobs during the COVID-19 pandemic for a variety of reasons.

Job design

How organizations create a job. It includes aspects such as the supervisor, the co-workers, the assigned tasks, the workspace location and an employee's title.

Supply chain

The relationship between supply and demand. It's the process of how a product goes from an idea to a good that is purchased.

The role of inflation

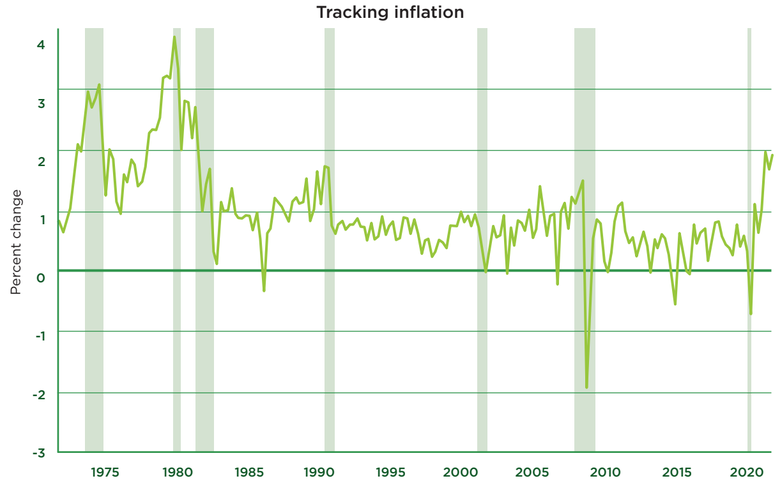
Consumers are feeling part of the new normal when they buy goods at the store and see increased price tags, driven by the highest level of inflation in decades.

Daniel Kuester, director of economic undergraduate studies in the College of Arts and Sciences, has taught courses on the principles of microeconomics and macroeconomics for years.

"Today, people are aware of inflation, and once people become aware of it, and they think about it, they start to forecast it out in their heads and it starts to become self-fulfilling," Kuester said.

Inflation looks at the rate of change in the overall price level on an annual basis. The price of an item can increase or decrease depending on several components, including supply chain factors, the response to a global pandemic and monetary policy, among other factors, Kuester said.

"If you have the same number of goods being produced and you double the money supply and nothing else changes, prices will eventually double," Kuester said.



The consumer price index measures the change in prices for goods and services. This graph shows how the average price of items has changed during the past 50 years for urban consumers in the U.S. By comparing the percent change in goods and services year to year, the Bureau of Labor Statistics is able to determine the inflation rate.

The areas shaded in green indicate periods of recession.

Source: Federal Reserve Economic Data / Federal Reserve Bank of St. Louis

Out of the office

The Great Resignation is an ongoing phenomenon where employees have been leaving their jobs during the pandemic for a variety of reasons. One of those reasons, according to Thomas Kelemen, assistant professor of management in the College of Business Administration, is job design.

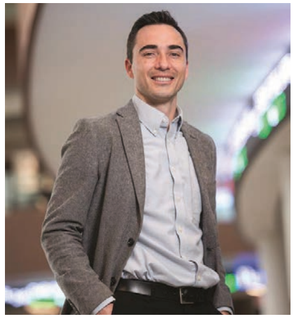
"Job design is how organizations construct an employee's position, which includes their supervisor, co-workers, the tasks they are assigned, dressing policies and the physical space that they're working in," Kelemen said. "It's a pretty broad term and it kind of encompasses all aspects of how the organization creates the job for employees."

The COVID-19 pandemic changed the layout of the job force — it taught employers flexibility and that employees could be productive from home.

Kelemen's own research shows that organizations must look at how to design jobs so that potential employees want to work for them. As organizations start to make changes, it can cause a domino effect in industries.

"I think organizations are going to have to look at lots of different things — how can we attract employees or what is attractive to employees," Kelemen said. "Maybe we had the Great Resignation, so now, what might be coming is the Great Hiring. People are likely going to come back to work. The question is what have organizations learned and are they going to apply that learning to design their jobs to better match what employees want?"

Kelemen recently published in the Harvard Business Review and the Journal of Organizational Behavior for his work on nonstandard business hours.



Thomas Kelemen, assistant professor of management, studies how job design influences an organization's retention rate.

Ashesh Kumar Sinha, assistant professor of industrial and manufacturing systems engineering, researches how labor shortages in transportation affects the supply chain.

Decisions, decisions

The economy, inflation and resignations all connect to supply and demand. The relationship between supply and demand is described with an all-too-familiar term: supply chain.

Ashesh Kumar Sinha, assistant professor of industrial and manufacturing systems engineering in the Carl R. Ice College of Engineering, researches the supply chain in manufacturing and transportation — one of the hardest-hit industries experiencing labor shortages. Sinha has been studying how the job design of a truck driver plays a part in the supply chain.

"If a single driver quits, disruptions occur to the entire network, not just in one area," Sinha said. "Today, drivers are quitting because of the demands of being on the road all the time. To help with this issue, the logistics and planners need to find a way that the drivers won't be away from home as much."

Sinha is partnering with the grain science and industry department in the College of Agriculture on a U.S. Department of Agriculture grant focusing on the supply chain. From 2017-2020 he collaborated with Schneider National, a logistics firm, to research different ways to improve current operations.

Another related, but different, supply chain issue involves the public health sector, which was slammed with an increase in demand for products in March 2020. Jessica Heier Stamm, associate professor of industrial and manufacturing systems engineering, uses mathematical models to represent supply chain systems and improve the decision-making process.

The public health supply chain differs from consumer chains because uncertainty, urgency and decentralization in decision-making increase complexity. Heier Stamm said this provides an opportunity for researchers to account for these factors in their modeling. Insights from the models can help build more robust, resilient systems to ensure communities have enough supply to meet demand.

"It is really looking at what are all of these scenarios and what capabilities do we need to build," said Heier Stamm, a Gisela and Warren Kennedy Cornerstone teaching scholar and a Steve Hsu Keystone research scholar. "In reality, we can talk about preparedness all day, but until we build some of these practices into the everyday operations of our systems they won't stick, which is a big ask."

Heier Stamm is partnering with the Kansas Department of Health and Environment Preparedness Program, which focuses on supply chain integrity. She also is leading a National Science Foundation project on the impact of the public health supply chain coordination structure on the effectiveness of disaster preparedness.

K-State 105

Rural Research & Community Collaboration

Chapman Center for Rural Studies strengthens communities while advancing student learning

By Malorie Sougéy

The Chapman Center for Rural Studies aims to preserve and promote the stories and culture of Kansas with a specific focus on rurality. It is a center of excellence in the Kansas State University College of Arts and Sciences.

Mary Kohn, director of the Chapman Center since August 2020 and associate professor of English, outlines three major responsibilities of the center:

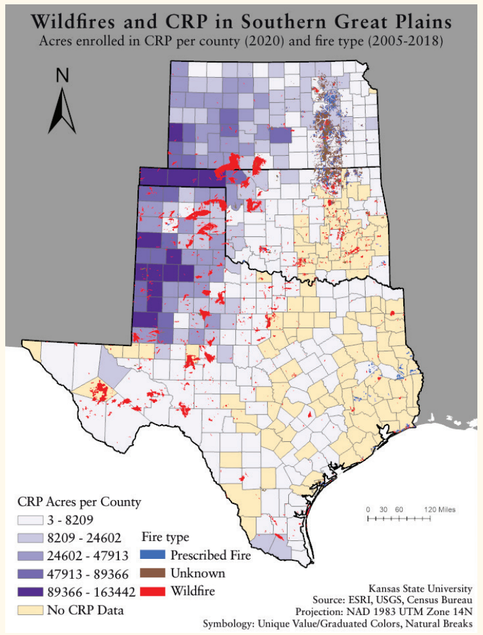
- Give students high-quality, hands-on learning experiences.
- Serve local — especially rural — communities.
- Equip faculty to productively work with students and communities.

"We encourage collaboration between communities, students and faculty to answer the hard questions about what it means to be rural, how we support rural communities and how we preserve their stories," Kohn said.

The future looks bright, too. Recently, the Chapman Center, in partnership with the English department, received a $20,000 Digital Infrastructure Challenge grant from the National Endowment for the Humanities. The grant will allow the center to create a new digital platform, refresh past online exhibits and create platforms for new projects, all to further the center's mission.

"The Chapman Center offers a platform for students, faculty and the community to come together in ways we don't always see in other educational experiences," Kohn said. "The faculty and students witness the real impact of their work and showcase it to a larger audience, and the work gets used by communities in real ways. To me, that's the magic of the Chapman Center."

The following research projects attest to the wide scope and influence the Chapman Center has at the university, in local communities and across the state.



This map shows patterns of wildfire from 2005-2018 and Conservation Reserve Program, or CRP, enrollment per county from 2020. (Map credit: Noel Guzman)

"My collaborators and I hope that increasing knowledge about the dynamics of land management and emergency response in fire-prone landscapes will help rural communities and land managers strengthen their efforts to address wildfire while continuing to support land stewardship activities."

— Audrey Joslin, assistant professor of geography and geospatial sciences

Above right: Audrey Joslin, assistant professor of geography and geospatial sciences, is improving land management in rural communities by increasing awareness of wildfire best practices.

Above left: The Chapman Center team includes, from left, Kinsley Searles, senior in English; Kim Wescott, senior in history; Chester Hubbard, senior in geography and geospatial sciences; Marcellus Caldas, professor of geography and geospatial sciences; Mary Kohn, Chapman Center director; Dustin Vann, Chapman Center office specialist; and Audrey Joslin, assistant professor of geography and geospatial sciences.

Wildfire and landscape conservation

Wildfire events have increased in size and frequency in the southern Great Plains region over the past few decades. Hundreds of square miles of Kansas land burned in 2021 alone.

Audrey Joslin, assistant professor of geography and geospatial sciences, leads the Wildfire and Landscape Conservation project, the Chapman Center's flagship program that recently received a $466,000 National Science Foundation grant.

Joslin works alongside Marcellus Caldas, professor of geography and geospatial sciences, and Jason Bergtold, professor of agricultural economics in the College of Agriculture, to conduct research on regional perceived wildfire risks and land management.

Often the first to respond to wildfires are rural farmers and ranchers, who call upon their informal network of neighbors and friends to help them until firefighters arrive. According to Joslin, these are the same people who make decisions about land management.

"My collaborators and I hope that increasing knowledge about the dynamics of land management and emergency response in fire-prone landscapes will help rural communities and land managers strengthen their efforts to address wildfire while continuing to support land stewardship activities," Joslin said.

The research team is interviewing emergency workers and members of wildfire response networks to gain insight on their experiences and identify patterns of collaboration. They also are collaborating with the Farm Service Agency and the Kansas Forest Service to collect data on land use and wildfire events.

In addition to journal publications, Joslin's team anticipates developing outreach materials to report their findings back to participating communities.

Autographed by Kansas

You might not think there's much you can tell from an autograph, but Kim Westcott knows otherwise. Westcott, senior in history, leads a project where she analyzes, digitizes and preserves Kansas autograph books from the late 19th century.

These books — donated by Rosalea Postma-Carttar — contain handwritten signatures and inscriptions, which include sharing memories, personal and professional encouragement, poetry and more. Such autograph books were kept primarily by women as a way to stay connected to friends and family, and they have been evaluated as a predecessor to modern social media.

Not only do these books reveal snippets of general history, but they also uniquely highlight the moment young women began to enter college for the first time in Kansas.

Westcott is investigating other historians' work on autograph albums, researching the albums' original owners and finding the narratives within the signatures, which often contributes to a narrative about women's progress.

Future plans for this project include the addition of an autograph album archive, which will include a literary review of materials demonstrating the importance of autograph albums and their significance in assessing gender roles in the 19th century.

"My hope for this project is that it will be accessible for people to learn about these amazing everyday women and their impacts on history," Westcott said.

Photos on right: These are some of the Kansas autograph books that Kim Westcott, senior in history, analyzes as part of her Autographed by Kansas project. These autograph books were donated by Rosalea Postma-Carttar and provide a unique look into the historical moment when young women entered college for the first time in Kansas.

The layered history of Kansas land treaties

We all know a spot in Manhattan that we love full well, but do we know the layered histories of the land K-State calls home? Lisa Tatonetti, professor of English, is leading the Kansas Land Treaties project with Mary Kohn, associate professor of English, to shed light on the topic.

Students and faculty are conducting interviews and place-based research for this project, which tells the story of the treaties between the Kanza, or Kaw Nation, and the U.S. government. The project is supported by a Humanities Kansas grant.

As part of the project, the treaties — which provided land for K-State's land grant, among other interests — are being annotated as part of an online exhibit. Tatonetti's team is creating educational materials to promote understanding of these key land cessions, which dispossessed the Kaw people of their traditional homelands.

"This project makes visible the layered and complicated histories of the land we stand on," Tatonetti said. "It's our responsibility as citizens and educators to recognize and share the knowledge of how, after generations of Kaw people had lived, had raised their families and were buried on these lands, they could be forced to relocate their entire nation to present-day Oklahoma. Having educational tools available that blend primary documents with video clips, timelines and maps invites everyday people to acknowledge and share this important history."

Perhaps most importantly, this project has built strong relationships with folks who can share knowledge about both these 19th century treaty encounters and the perspectives of present-day Kaw people.

Supporting bilingualism in rural Kansas

Alisa Garni, associate professor of sociology, and Mary Kohn, associate professor of English, are leading the Prairieview project, which investigates bilingualism in rural Kansas — particularly in one town, given the pseudonym Prairieview to protect residents' privacy.

The researchers are interested in how bilingual teens in rural communities create enclaves to support each other and their families. An important factor in that conversation is immigration.

"Many people consider Prairieview to be a 'new rural immigrant destination,' but it is part of a region with the oldest migratory history in the country," Garni said. "Recent immigration to the town follows an unusual 60-year lull in a history of immigration that is thousands of years old."

Garni and Kohn want to know how recently arrived bilingual youth in Prairieview navigate the ideological monolingualism stemming from this unusual lull, and how multiculturalism and multilingualism might take root in the future.

The team began ethnographic research on Prairieview, including participant observation and in-depth interviews with bilingual youth.

When the COVID-19 pandemic forced the team to remain local, they incorporated new technology to virtually conduct these studies. Undergraduate students on the team were trained to conduct interviews, and they are examining both barriers and support systems that affected rural teens during their online education experience.

Mary Kohn is the director of the Chapman Center for Rural Studies and an associate professor of English. She has led the Chapman Center since August 2020.

Student highlights

The Chapman Center for Rural Studies gives students high-quality, hands-on learning experiences. Learn more about some of the undergraduate researchers working on center projects.

Michaela Forst, senior in agricultural economics and global food systems leadership, works with agricultural data frames on the Wildfire and Landscape Conservation project.

Chester Hubbard, senior in geography and geospatial sciences, interviews scholars and creates maps for the Kansas Land Treaties project.

Kinsley Searles, senior in English, works on the Kansas Land Treaties project and conducts research and oral histories to provide context to the primary texts.

Thai Lopez, senior in English, transcribes and analyzes interviews for the Prairieview project.

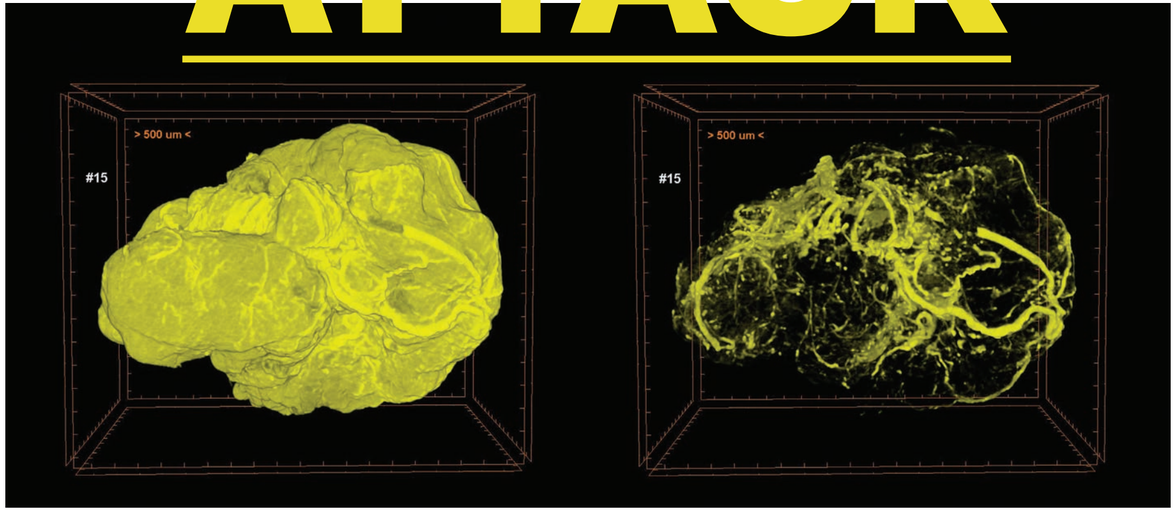
Seek more

Find extra online content about the Chapman Center.

- View the Chapman Center blog, The Rural Telegraph.
- Read the Indigenous Land Acknowledgement from K-State.
- Learn more about Kim Westcott's project with the #autographedbyKansas hashtag on Twitter and Facebook.

k-state.edu/seek

Angles OF ATTACK



This micro-CT image shows a whole breast tumor on the left, and the tumor's microenvironment with diminished blood vessels and chemo- and radiation therapy-resistant regions on the right. *See page 18 to read more about research focused on the tumor microenvironment.* *(Image credit: Brad Behnke)*

Fighting cancer with interdisciplinary science

By Marcia Locke

How do tumors develop despite the body's defenses? Why can the body stop some tumors from forming but not others? What makes cancerous cells live longer than normal cells and wreak havoc on the body? And how can we fight these processes?

Kansas State University researchers are searching for answers to these questions and more through the interdisciplinary Johnson Cancer Research Center in the College of Arts and Sciences.

The center's faculty members span 20 departments in five colleges. They work to better understand cancer and find ways to prevent it, detect it earlier and treat it more successfully, while also training the next generation of scientists.

HELPING THE BODY FIGHT BREAST CANCER

The body's immune system helps fight infections and diseases, including cancers. But cancerous cells can escape or evade the immune attack and develop into tumors. Immunotherapy treatment can boost the immune system so that it can find and attack cancer cells.

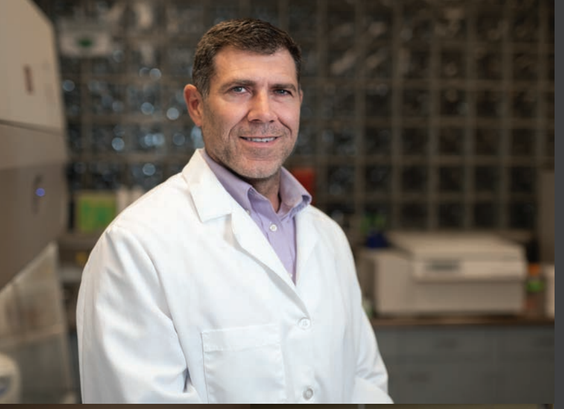
Anna Zolkiewska, professor of biochemistry and molecular biophysics in the College of Arts and Sciences, is developing and improving immunotherapies for breast cancer. She studies immune cells that infiltrate and help destroy breast cancer cells. Her research is supported by more than $1.65 million from the National Cancer Institute and more than $300,000 from the Johnson Cancer Research Center with support from the Flossie E. West Memorial Trust.

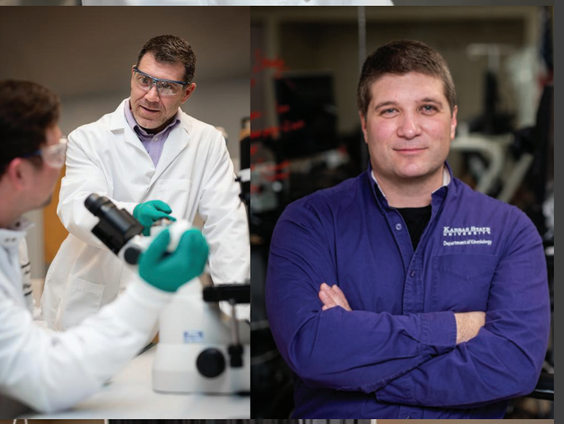
Immunotherapies are very effective against some types of cancer but are less successful against breast tumors. Triple-negative breast cancer, a particularly aggressive form of the disease, is especially hard to treat with any method. A new immunotherapy called immune checkpoint blockade offers hope, but it is effective for only a portion of patients. Zolkiewska is getting closer to finding out why.

She has discovered that a cell-surface protein called ADAM12 is important in triple-negative breast cancers. When she disabled the ADAM12 gene, tumor growth slowed down. Most importantly, tumors lacking ADAM12 contained more cancer-fighting immune cells, especially T cells and B cells.

Zolkiewska also showed that eliminating ADAM12 in breast cancer cells made tumors more responsive to immune checkpoint blockade therapy. This clue could improve immunotherapy efficacy for more patients, but there is evidence that the response may be temporary and followed by acquired resistance. Zolkiewska plans to investigate this effect further. She also is exploring if other proteins from the ADAM family may play a role in recruiting immune cells to breast tumors.

Photos on left: Anna Zolkiewska, professor of biochemistry and molecular biophysics, is developing immunotherapies to treat breast cancer. She has discovered that a protein important to some breast cancers can be disabled to slow tumor growth.





SEEKING ANSWERS IN THE TUMOR'S ENVIRONMENT

Some researchers are seeking clues from the tumor's environment to improve cancer therapies. The Johnson Cancer Research Center has established the Cancer Research Collaboration of Excellence in Tumor Microenvironment Studies.

Brad Behnke, professor of kinesiology and associate dean of research and graduate studies for the College of Health and Human Sciences, is leading the multidisciplinary collaboration. The members' synergistic investigations examine how environmental conditions within tumors affect their development, growth and aggressiveness.

"Many conventional cancer therapies fail due to factors related to the tumor's microenvironment," Behnke said. "We want to identify microenvironment changes that cause cancer growth and therapy resistance, and devise methods to combat them."

Other researchers involved are Amir Bahadori, associate professor in the Alan Levin Department of Mechanical and Nuclear Engineering in the Carl R. Ice College of Engineering; Carl Ade, associate professor of kinesiology in the College of Health and Human Sciences; David Poole, university distinguished professor of kinesiology in the College of Health and Human Sciences and of anatomy and physiology in the College of Veterinary Medicine; Chieko Azuma, clinical associate professor of radiation oncology in the College of Veterinary Medicine; and Wei-Wen Hsu, associate professor of statistics in the College of Arts and Sciences.

These esteemed experts have received individual research support from the National Institutes of Health, NASA, the American Cancer Society, the American Heart Association and additional organizations. Now they are teaming up to discover the changes that occur in the tumor microenvironment when it is exposed to different levels of radiation, oxygen pressures and vitamin D. They seek answers to four main questions.

What DNA mutations occur in response to low-dose radiation?

Low-level radiation exposure can cause DNA mutations that can develop into cancer. Exposure occurs in cancer patients undergoing radiation therapy as well as in radiation workers, astronauts and victims of radioactive material releases. The researchers are examining the biological mechanisms involved in such mutations and trying to develop therapeutics to stop them.

Does exercise increase oxygen in breast tumors and improve the response to radiation therapy?

Tumors contain regions of hypoxic cells, which means they have low oxygen levels or pressures. This makes them resistant to radiation therapy. Aerobic exercise may increase a tumor's blood circulation and oxygen levels and make it more susceptible to radiation therapy. This research will determine if aerobic exercise decreases breast tumor hypoxia and makes radiation therapy more effective.

Does nitrate supplementation increase tumor oxygenation and decrease tumor growth?

Another strategy to reduce tumor hypoxia might be to consume foods or supplements that elevate nitric oxide bioavailability. Beetroot juice is a concentrated source of nitrate and nitrite that is known to increase blood flow to some tissues. The researchers will determine if consuming beetroot juice raises tumor oxygen pressures, which could slow tumor growth and improve radiation therapy.

How do ovarian tumors respond to different levels of vitamin D?

Previous studies have shown that low levels of vitamin D in ovarian cancer patients are associated with larger tumors and lower survival rates. The scientists will determine if circulating vitamin D modifies the tumor microenvironment, and if so, how. The research could help predict ovarian cancer treatment complications, completion and overall survival.

Photos on left: Brad Behnke, professor of kinesiology, top and middle left photos, studies manipulation of tumor oxygenation to improve cancer therapies.

Carl Ade, associate professor of kinesiology, middle right and bottom photos, researches cardiovascular damage caused by cancer treatments.

ATTACKING A KILLER VIRUS

Human papillomavirus, or HPV, causes nearly all cervical cancers — more than half a million worldwide each year. But many people don't know that most humans get HPV at some point in their lives and that it can cause cancers of both men's and women's genitals as well as the throat, skin and other body parts.

Nicholas Wallace, associate professor of biology in the College of Arts and Sciences, wants to reduce the suffering caused by HPV by learning more about its biology. He studies how HPV converts normal cells into factories that make more of the virus and how this leads to the cells' uncontrolled and rapid growth — cancer.

"Typically, HPV infections, and the changes associated with them, are quickly cleared by our immune system," Wallace said. "But if the virus escapes the immune system and the changes become permanent, a tumor will form. By learning how HPV proteins manipulate cells, we can determine which cancers were definitely caused by HPV infection and predict effective treatments."

Recently, Wallace's lab discovered changes in specific genes that cause commonly used chemotherapies to not work in some patients. The researchers are using a nearly $455,000 grant from the National Cancer Institute to test a new drug to treat these chemotherapy-resistant tumors.

Photos above: Nicholas Wallace, associate professor of biology, studies human papillomavirus, or HPV, which is a very common virus that causes nearly all cervical cancers as well as other cancers in men and women.

TRAINING THE NEXT GENERATION

K-State excels at getting students involved in research. A major university goal is to develop highly skilled citizens who can advance the well-being of Kansas, the nation and the world. The Johnson Cancer Research Center helps achieve that goal by investing in student research training.

Through the center's competitive Cancer Research Award program undergraduate students receive faculty-mentored research experiences and monetary awards. Graduate students receive support for their summertime research endeavors.

In 2021, 27 undergraduate students received Cancer Research Awards. Some of their research projects include:

- **Studying lung cancer cell growth.**
- **Developing safer methods to deliver drugs in the body.**
- **Characterizing genetic mutations.**
- **Designing inhibitors to cancer-causing genes.**

The awards support research outside traditional science fields as well. One student is studying the Navajo approach to cancer and another is examining the ethical dimensions of cancer treatment decisions.

The students become integral parts of research teams and some even publish their research. Such experience helps K-State students stand out when applying to graduate and medical schools, which many awardees do successfully.

Seek more

Read more about the Johnson Cancer Research Center.
k-state.edu/seek

BALANCING ACT

Sustaining our future across disciplines

By Michelle Geering

A farmer in western Kansas worries his well will be dry in 30 years. More than 9 million tons of clothing — some items only worn once — go to U.S. landfills each year. Globally, 79% of all consumer plastics end up in landfills or as litter and can take hundreds of years to decompose.

These are a fraction of the sustainability challenges the world faces. If current behaviors and practices are left unchanged, experts say the consequences to our livelihoods and for the environment are bleak.

But all is not lost: A variety of measures and practices can help overcome these challenges. Kansas State University researchers are working across disciplines to engage in sustainability, which meets today's needs without compromising the ability of future generations to do the same. It's a balancing act.

Futuristic farming

Above left: Vaishali Sharda, assistant professor of biological and agricultural engineering, studies how the changing climate affects food systems and water preservation.

Above center and right: Sharda and her co-principal investigator, Ajay Sharda, associate professor of biological and agricultural engineering, are creating an autonomous platform that can precisely apply a spray-on biopolymer ground cover.

For engineer Vaishali Sharda, providing tools and information to make science-based decisions is what drives her work to protect and sustain the food production system.

Much of Sharda's research focuses on the effects the changing climate has on food systems and, most extensively, on preserving water. She uses computer modeling to simulate modified crop management practices and study their impact on crop yields and the sustainability and resilience of water resources. These hydrologic and crop models take into account historic crop yield data, along with crop management practices such as planting dates, soil types and climatic factors, including temperatures, precipitation and wind speed.

"Once your models are robustly calibrated, you can play with these components to study present conditions and the future," said Sharda, assistant professor in the Carl and Melinda Helwig Department of Biological and Agricultural Engineering in the Carl R. Ice College of Engineering. "It gives you a lot of flexibility and a lot of power in your hands to simulate scenarios that would be difficult to create physically."

Sharda and her collaborators are using a $6 million National Science Foundation Established Program to Stimulate Competitive Research, or EPSCoR, RII Track-2 grant to develop a spray-on biopolymer ground cover that acts as a weed barrier and fertilizer source and helps contain soil moisture. The vision is that once created, this biopolymer product would be sustainable and could replace plastics and chemical herbicides while providing natural fertilization through decomposition.

Current management practices cover soils with sheet plastic to prevent weed growth, erosion and moisture loss during the growing season. But using large amounts of plastic creates waste, is not eco-friendly, is costly and is not economically sustainable for field crops.

"New, locally sourced types of bioplastics that fully break down into safe byproducts can be made," Sharda said. "These new materials could provide farmers with a green way to control weeds, fertilize crops, protect soil and water resources, and work with nature to better manage their fields."

Seek more

Watch a video about Vaishali Sharda's research.
k-state.edu/seek

Sustainable beef

Above left: A.J. Tarpoff, associate professor of animal sciences and industry, researches how sun shades can affect animal comfort in weaned calves and reduce animal water needs.

Above right: Dale Blasi, professor of animal sciences and industry, right, uses precision feeding of weaned calves to improve industry sustainability.

The livestock industry is an integral part of global food systems as a source of nutrition, income and biodiversity. Balancing demand and improving production practices are needed to make the industry more sustainable.

Dale Blasi, professor of animal sciences and industry, and A.J. Tarpoff, associate professor of animal sciences and industry, are examining how precision feeding practices and reducing heat stress in post-weaned calves improve a broad range of sustainability factors.

Limit feeding was first introduced 40 years ago and is a practice of feeding calves nutrient-dense, low-roughage feed once a day. For a recent study, the College of Agriculture duo used corn gluten feed made of byproducts from the ethanol and beverage industry. It is a highly digestible, high-energy bran feed that is proving to be more sustainable and healthier for the animals.

Blasi and Tarpoff found that limit feeding reduces manure output by 40-45%, which reduces emissions, fuel usage and labor needed to clean and dispose of the waste.

"The diet they are fed, as opposed to the high-roughage ad lib diet, or grazing diet, is more thoroughly digested and as a consequence, there is less manure output," Blasi said. "The calves produce less because they utilize more of it in their bodies to create a more efficient gain. And it leaves a smaller footprint and lesser headache for the agriculture industry to worry about disposing of that waste."

Additionally, the practice has reduced labor, machinery and fuel needs, which makes it economically sustainable while the calves efficiently gain weight.

"There are no detrimental effects of limit feeding in backgrounder, or weaned calf, phase," Tarpoff said. "We can limit feed them and program their weight gain with a highly digestible feedstuff with no negative attributes at the next level. Ultimately, we're able to grow each pound of beef more effectively."

Blasi and Tarpoff are now looking for ways to reduce heat stress on the animals by adding sun shades on the pens during the summer months to reduce the water needs and improve animal comfort.

"We do not have to reinvent the world to make the beef industry sustainable," Blasi said. "Our job is to account for all the things that we do and make people aware of what is working for us."

In a separate study, Megan Rolf, associate professor of animal sciences and industry, and her colleagues are looking at gases emitted from grazing cattle to genetically evaluate the gas flux rates in cattle.

By measuring oxygen consumed and methane and carbon dioxide produced from grazing beef cows, Rolf and the research team will be able to use these phenotypes, or observed traits, to build prototype genetic evaluation systems.

Rolf said these new prototypes would provide a blueprint for the inclusion of these traits into genetic evaluation systems so that producers might be able to select cattle based on traits such as methane produced or metabolic rate in the future. Over time, this could lead to increased sustainability through long-term genetic increases in production efficiency.

"By approaching sustainability from a genetic standpoint, changes made over time should be fairly permanent and cumulative over the lifetime of those animals," Rolf said.

Changing fashion

Above left: These marigold and coreopsis flowers can create natural dyes with yellow and orange tones. (Photo credit: Kelsie Doty)

Above right: Fashion studies researchers Kelsie Doty, assistant professor, left, and Sherry Haar, professor, create fabric designs using natural dyes.

In the textiles and apparel industry, better sustainability practices are needed, from production to selling to consumer behavior. Researchers in the interior design and fashion studies department in the College of Health and Human Sciences use science, art, education and outreach to create change and awareness.

Kim Hiller, the Barbara Weigand professor in apparel and textiles and fashion studies, is the principal investigator on a project with Melody LeHew, professor of fashion studies. The researchers are using a three-year Sustainable Agriculture Research and Education grant from the U.S. Department of Agriculture to host a hands-on Farm to Fashion camp. The camp is one aspect of their research focused on regenerative and circular fiber, textile and clothing systems.

At the camp, middle and high school youth collaborate with the K-State Sheep and Meat Goat Center and other fashion studies faculty to learn about the fashion supply chain, sustainable fibers and sustainable sheep farming. The goals are to create interest in more sustainable and natural fibers, to change consumer behavior and to spark an interest in the fashion or wool industry in Kansas.

"Our focus in the Farm to Fashion camp is on educating young people to gain an appreciation for where fibers come from and how they are made into textiles and garments," Hiller said. "They already accept the fact that climate change is a concern and that it is necessary to change behaviors. There's been such a drastic shift in the mindset of high school and college students in the last ten years. In a lot of ways, it's easier to change their fashion consumption behaviors if we can help them to understand what the problems are."

LeHew said the camp uses learning activities based on science, technology, engineering and mathematics, or STEM, to introduce sustainable fashion products and processes, which is the basis of a circular economy.

"The current fashion system is linear, based on 'take, make and waste' material use," LeHew said. "Circular economy is built on the premise that manufactured goods must create zero waste during production and the end of the product life cycle. If designed correctly, textile products become technical nutrients put back into the system or they can be composted as a biological nutrient to enrich the soil."

To make textile production more sustainable, Sherry Haar, professor of fashion studies, and Kelsie Doty, assistant professor of fashion studies, research and create designs using natural dyes. They investigate colorfastness, natural color fixatives, alternative dyestuffs from waste, all-natural plant dye transfer, metal amounts in effluent water, care methods for naturally dyed textiles, and corporate and local outreach. In addition, both Haar and Doty use the information they glean from research to create fashion designs for juried competitions, which is an essential component of their scholarly work.

Natural dyeing is a practice and technique that the industry had largely forgotten, except in historical reference, until about 10 years ago when the industry really started looking at sustainable business practices.

"Natural dyes are a way to bring together fashion, agriculture and communities in a way that is sustainable for everyone," said Doty, also the Verna Sullivan-Marler professor in fashion studies.

Sustainability is integrated throughout fashion studies curriculum. For example, in one project students used fabric purchased from and produced by Guatemalan weavers. Students created aprons that were naturally dyed and designed with native flowers and will be auctioned off to sustain the purchase cycle.

Students also learn about sustainable choices in industry and throughout the fashion supply chain.

"We need to educate this generation on how to be better because they are going to be the change-makers to help their companies be sustainable," Haar said. "They're going into companies, and they're asking, 'What are your sustainability policies?' and "What are you doing?'"

Top left: Researchers color wool yarn using natural dye techniques. (Photo credit: Kelsie Doty)

Top right: These fabrics are made of a linen and rayon blend and were colored with natural dyes. See the inside front cover to read more about the natural dyeing techniques.

Bottom: A Farm to Fashion camp participant weaves wool on a tabletop loom. (Photo credit: Kelsie Doty)

Right: Dried leaves can create natural dye imprints and brown, gold and dark purple tones.

Leading the charge

Understanding how nanomaterials can help build better energy supplies is a research focus for Jun Li, professor of chemistry in the College of Arts and Sciences. Li works to develop more efficient fuel cells and increase the energy capacity of lithium batteries, both of which can help reduce the carbon footprint.

Fuel cells convert more energy into electricity with fewer emissions than combustion engines, which makes them a more sustainable option. Li is working to improve the electrocatalysts — the key element to accelerating the electrochemical reactions that convert fuels into electrical energy — in fuel cells. Current technology uses the noble metal platinum as the catalyst, which is costly and unsustainable to produce.

With funding from the U.S. Department of Energy and the National Science Foundation, Li is testing the use of carbon nanomaterials in fuel cell catalysts to reduce the amount of platinum needed and make them more active and stable, leading to more efficient and sustainable energy production.

"We are working to develop new carbon nanomaterials as the supporting material to improve the performance of the catalyst," Li said. "We can help to improve the electrocatalyst, a critical component in the fuel cells so that they will run more efficiently, be more stable and have a longer lifetime."

There is also an unending demand for lighter, longer-running batteries. To build a better battery, Li is researching the use of nanomaterials in emerging lithium-sulfur batteries to improve the capacity and safety.

His work replaces the solid lithium metal electrode with a porous, carbon nanomaterial. Lithium is electroplated into the carbon materials' open space, making it more reversible and safer during the battery charge-discharge process.

"With all the success in powering portable electronics with lithium-ion batteries, there is a strong, never-ending demand for lighter and better operating batteries," Li said. "The future demand for batteries or fuel cells as power sources for larger-scale applications is even bigger — electric cars, electric boats or forklifts in a warehouse. All of these can benefit from better batteries or fuel cells."

Top: Jun Li, professor of chemistry, is improving the efficiency of batteries and fuel cells to make the technology more sustainable.

Bottom left: Tiny coin cell batteries undergo testing.

Bottom right: Researchers are developing more efficient fuel cell and coin cell batteries.

Charles Rice, university distinguished professor of soil microbiology, studies sustainable soil ecosystems.

Sustaining soil

As climate change creates more severe weather episodes — such as floods, drought and high winds — healthy soils are critical for sustainable soil ecosystems.

Charles Rice, university distinguished professor of soil microbiology in the College of Agriculture and a world-renowned researcher in carbon cycling and climate change, is driven to learn how agriculture production systems can be as resilient and efficient as the tallgrass prairie. As part of his work, he was a member of the United Nations Intergovernmental Panel on Climate Change that received the Nobel Peace Prize in 2007.

The three key elements to soil health are carbon, microbial activity and soil structure. Each element relies on the other elements for good soil health, leading to good plant growth, water retention and resiliency during climate change events.

"These elements are intertwined," Rice said. "The carbon is providing food for the microbes. The microbes are cycling the nutrients and making nitrogen and other nutrients available for the plants, which is important for plant productivity. Finally, soil structure provides air and water movement in and out of the soil."

One aspect of his research portfolio is carbon sequestration, or practices that restore carbon in the soil. These practices include no-till farming and agriculture diversification, such as cover crops.

According to Rice, soil tillage releases 30-70% of carbon back into the environment. By keeping the soil intact, limiting water evaporation and allowing the plants to naturally take the carbon dioxide out of the air and put it back into the soil, agriculture has the opportunity to mitigate climate change.

"It is a multiple-win scenario," Rice said. "If we make that soil more resilient and more productive, it is a profitable situation for the farmer. At the same time, if we're more efficient with the nutrients and the crop rotation diversification, we're providing a better habitat to protect the environment."

Sustainable agricultural practices, such as no-till farming and cover crops, can help restore carbon in the soil.

Seek more

Learn more about sustainability research.
k-state.edu/seek

BEHIND THE CODE

RESEARCHERS TACKLE THE NEW WORLD OF CYBERSECURITY

By Jennifer Tidball

Kansas State University cybersecurity researchers want you to know the difference between the stereotype of cybersecurity and the reality of it.

The stereotype: Cyberattacks are committed by hooded hackers cracking code to infiltrate our security systems.

The reality: Cyberattacks certainly can happen that way, but it's much more likely to come in the form of vulnerable and outdated hardware and software, social engineering, phishing scams and ransomware.

That reality can be a pretty scary place. An outdated piece of software can make an autonomous vehicle susceptible to cyberattacks. Clever social engineering can cause an unknowing employee to provide access to sensitive documents. Terrorists can take advantage of weaknesses in our infrastructure, such as power grids and water treatment plants. The things that make our life easier, such as smart doorbells or home security systems, also have the potential to be misused.

As the world becomes more computerized, we also become more vulnerable.

"A great example of the risks we face can be seen in Ukraine where several types of destructive malware aimed at government and financial organizations were deployed in the hours leading up to the invasion," said Scott DeLoach, head of the computer science department in the Carl R. Ice College of Engineering.

That's why K-State researchers are working behind the code to navigate the new world of cybersecurity and to keep our data, our infrastructure and our world safe.

Eugene Vasserman

Arslan Munir

A cybersecurity center of excellence

K-State has long been a research leader in the cybersecurity realm, thanks to the nationally recognized Center for Information and Systems Assurance. Since 2010, the center has held the designation of a National Center of Academic Excellence in Cyber Defense Research from the National Security Agency and Department of Homeland Security.

The center's multipronged mission is to conduct fundamental and applied research in information assurance and computer security; to advance student knowledge; and to engage the professional community.

"Our nation is at risk for cyberattacks," said Eugene Vasserman, center director. "Our critical infrastructure is vulnerable at all scales, from individual water treatment plants to large sections of the power grid."

The looming threat of cyberattacks is what motivates Vasserman and other affiliated researchers to study all areas related to cybersecurity. The center involves more than 16 researchers across multiple disciplines, including computer science; psychological sciences; sociology, anthropology and social work; electrical and computer engineering; physics; and communication studies.

The researchers study important topics such as digital literacy, security and safety online, social media, privacy, machine learning and artificial intelligence.

"We have a very diverse group of members to work with cybersecurity from a holistic perspective," said Vasserman, also an associate professor of computer science and a Michelle Munson-Serban Simu Keystone research scholar. "Cybersecurity is all-encompassing. It's not just technological solutions; it's a sociotechnical field that needs to also consider how groups and individuals interact with technology on a daily basis."

Safety and security

Arslan Munir, associate professor of computer science, takes a novel research approach by involving both safety and security — two key pieces to addressing cybersecurity.

While security involves stopping an intentional adversary, such as a hacker, safety involves addressing something unintentional, such as autonomous vehicle electronics failing.

"My research targets both safety and security because the end effect is similar," said Munir, also a Michelle Munson-Serban Simu Keystone research scholar and director of the Intelligent Systems, Computer Architecture, Analytics and Security Laboratory. "That's why we have to prepare for both."

Munir's team focuses on four areas of cybersecurity research:

- Autonomous vehicles. Munir works to help autonomous vehicles operate safely and securely while adhering to real-time constraints — such as braking at a red light or responding to changing road conditions.
- Hardware-based security for lightweight applications. The team is designing circuits that communicate securely and efficiently with other circuits, which is key for devices — such as smart doorbells, home security cameras or building access control — connected through the Internet of Things.
- Artificial intelligence. Munir is helping make devices that use artificial intelligence — such as autonomous vehicles — more resilient and less susceptible to cyberattacks on the artificial intelligence of the devices.
- Situational awareness. Munir's research has applications for the U.S. military, which uses sensors and devices for situational awareness to understand an environment and take action. For example, if a video camera sensor is providing data on an area, it is important that the sensor provides accurate data and cannot be hacked by an adversarial player.

Munir's work has been supported by organizations such as NASA, the National Science Foundation, the Air Force Office of Scientific Research, the Air Force Research Laboratory and Semiconductor Research Corporation. His hardware security research has generated two patents through K-State Innovation Partners.

The privacy of social networks

How much information we do and don't share online through social media and social networks plays a key role in privacy and cybersecurity.

"How people reason about digital security is very different from how they think about their physical safety and security," Vasserman said. "We have millennia of experience in instinctive, subconscious reasoning about the physical world, but these 'mental shortcuts' can mislead us online. By drawing clear parallels between the physical and the digital, we can encourage people to use existing mental processes to more accurately evaluate digital risk."

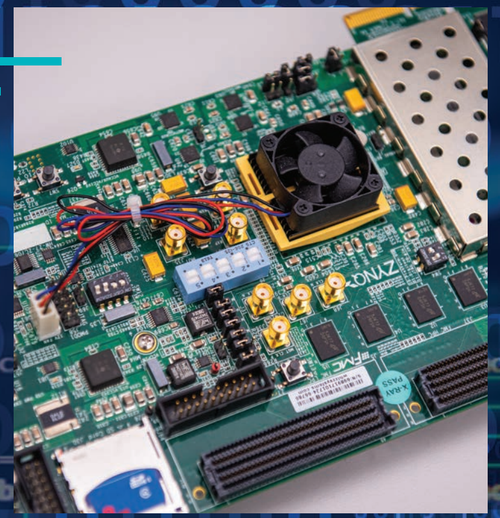
> **"How people reason about digital security is very different from how they think about their physical safety and security."**
>
> *— Eugene Vasserman, associate professor of computer science*

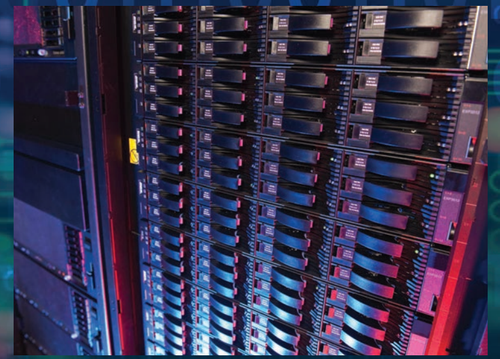
Vasserman is collaborating with George Amariucai, associate professor of computer science, on several projects related to digital literacy. The work involves social media, misinformation and disinformation and the privacy of social networks.

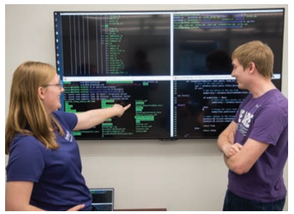
"We are investigating how targeted manipulation efforts can be more successful by collecting information from the targets' social media profiles and behaviors," said Amariucai, also a Michelle Munson-Serban Simu Keystone research scholar. "Privacy mechanisms can then be employed to thwart such attempts, thus lowering users' susceptibility to being manipulated."

Amariucai leads the Probabilistic and Information Theoretic Security, or PITS, Laboratory and is involved in multiple cybersecurity projects that have been supported by the National Science Foundation.

His work focuses on several areas related to privacy: privacy metrics under incomplete statistical information; privacy-utility solutions for dynamic environments with future uncertainty and constraints; privacy-utility strategies in human interactions on social media; and privacy as a defense strategy against stealthy attacks on cyber-physical systems, such as the power grid.







Computer science students collaborate on a project.

Opportunities for students

K-State's work in cybersecurity includes educational and research programs for undergraduate and graduate students. Through university initiatives and nationally funded programs, K-State is helping produce high-quality graduates to meet national, state, local and tribal government demand for skilled cybersecurity personnel.

The K-State Center for Information and Systems Assurance has offered the CyberCorps®: Scholarship for Service program for more than 10 years. The scholarship program, recently funded by a more than $3 million renewal from the National Science Foundation, supports undergraduate and graduate students who are interested in cybersecurity research and practice.

The university also continues restructuring and improving interdisciplinary cybersecurity curriculum.

John Hatcliff

Robby

High-stakes cybersecurity

A high-stakes element of cybersecurity involves military- and defense-related systems. Two K-State researchers are up for the challenge.

John Hatcliff, university distinguished professor of computer science, and Robby, professor of computer science and Don and Linda Glaser — Carl and Mary Ice Keystone research scholar, work to make U.S. military operations more secure. Their research has received funding from the U.S. Army, the U.S. Air Force and the Defense Advanced Research Projects Agency, or DARPA. They also have collaborated with Collins Aerospace.

The technology that Hatcliff and Robby have developed has been successfully used in DARPA demonstrations to provide cyber assurance for the mission control software on CH-47 Chinook helicopters.

Through a partnership with Adventium Labs, they are using an Air Force Phase II Small Business Innovation Research award to make aircraft more secure. They are addressing information security vulnerabilities in complex cyber-physical systems.

Research from Hatcliff and Robby covers other important military-related topics, such as ways to better secure systems on fighter planes or ways to rapidly update the software on a tank with new capabilities without interfering with the vehicle's existing functionality.

But their work has applications beyond the military as well. While their U.S. Department of Defense-funded projects are improving important military technology — such as self-driving cars, tanks and unmanned aerial vehicles — the same computer architecture can apply to biosecurity, precision agriculture and automated farming.

"The same technologies we are working on for military control systems and information systems can be applied to the automation of experiments or agriculture," said Hatcliff, also the Lucas-Rathbone professor in engineering. "There is an opportunity to take a holistic view to automation controls where the platforms and architectures we are working on can be applied broadly to automated agriculture, advanced manufacturing and biosecurity."

Kevin Steinmetz

The social science of cybercrime

Many cybersecurity incidents start with a social engineering element. Think deceptive phishing emails with website links to steal personal information or a cybercriminal using a false identity to trick someone into giving up information.

Criminologist Kevin Steinmetz, professor of sociology, anthropology and social work in the College of Arts and Sciences, is studying how and why social engineering works and how to prevent it. He also is collaborating with law enforcement to better understand cybercrime.

For one project, Steinmetz is using a three-year, $350,000 National Science Foundation grant to study social engineering and online fraud. Through 54 interviews with information technology professionals and social engineers, Steinmetz created tips for developing and implementing policy recommendations to improve cybersecurity at organizations.

"Effective policies are those that are adequately communicated to organizational members," Steinmetz said.

On another three-year, nearly $500,000 NSF grant, Steinmetz is working with law enforcement to help with cybercrime investigations. The project is a collaboration with Indiana University Southeast.

The researchers are interviewing cybercrime law enforcement who investigate internet crimes against children, network intrusions or cyber fraud. While previous research has been more survey-focused, Steinmetz and his collaborators took a different approach and have conducted 47 in-depth interviews with people at six different policing units at the local, state and federal level. They are now finalizing the data for publication.

"We wanted to get more of a boots-on-the-ground perspective of what are the challenges that law enforcement deal with in grappling with cybercrime investigations," Steinmetz said. "We are also interested in how this type of work affects how they view themselves as police, because this is very different work than what we stereotypically associate with law enforcement."

Steinmetz also is working on updates to "Cybercrime and Society," a book he co-authored with Majid Yar. It is one of the leading textbooks on the social science of cybercrime.

Seek more

Read more about cybersecurity research at K-State.
k-state.edu/seek

Tips to prevent social engineering

K-State criminologist Kevin Steinmetz has developed the following tips to help organizations develop policies that help prevent social engineering.

- Educational programs, such as security awareness training, are key to communicating effective policy to organizational members.
- Policies should be effectively written.
- Policies should be tested to measure their effectiveness.
- Technology security measures, such as automated email warnings from outside organizations, should be implemented to support policies.
- Organizations should invest sufficiently in human resources to support policies and good security.
- Leadership matters and organizational administration should champion security.
- Organizations should be structured to support security through a diffusion of responsibility.

A big bang

Graphene and hydrogen research leads to new company HydroGraph

By Jennifer Tidball

It's a research success story that starts with an explosion and continues with the formation of a company based on Kansas State University research.

Or, as physicist Chris Sorensen calls it: serendipity.

"We discovered graphene serendipitously in the lab when we were using controlled explosions to make an aerosol gel," said Sorensen, Cortelyou-Rust university distinguished professor of physics and university distinguished teaching scholar. "I wasn't expecting to make graphene."

But make graphene they did. And that's just the first chapter of the story.

Now, the groundbreaking graphene and related hydrogen research has turned into a successful international company: HydroGraph Clean Power Inc. The company recently went public on the Canadian Securities Exchange and is preparing for decades of growth as an important research and development hub.

HydroGraph and the K-State research involve a simple new way to create graphene: Put acetylene and oxygen in a small chamber and create a controlled detonation that produces large amounts of graphene from a single spark.

Graphene is a single atom-thick, two-dimensional sheet of hexagonally coordinated carbon atoms, which makes it the world's thinnest material and gives it valuable physical and electronic properties. Graphene has numerous applications, such as augmenting high-strength metals, reinforcing concrete, enhancing biomaterials and revolutionizing electronic applications.

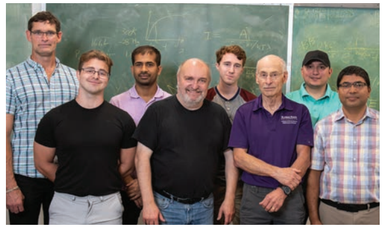
The K-State detonation method of creating graphene checks all the right boxes. The process is safer, cleaner, environmentally friendly, cheaper, consistent and faster than other methods. An added bonus is that it is also scalable and can produce high-quality graphene in mass quantities.

Sorensen's research team had spent several years developing and patenting aerosol gels, but one day found that their explosion synthesis method also could produce nanographene — a dark and incredibly lightweight material. Several years ago, the Kansas State University Research Foundation patented Sorensen's new detonation technique to mass-produce graphene.

Sorensen's work caught the eye of Harold Davidson and Barry Hemsworth, entrepreneurs from Vancouver, British Columbia. Davidson reached out in 2017 to start a collaboration with Sorensen to build up and automate the graphene-making process to an industrial scale. Davidson and Hemsworth created a start-up company called Carbon-2D Graphene Inc. and worked hard to procure venture capital for Carbon-2D to fund Sorensen's research.

The investment paid off. The research not only led to a pilot-scale graphene production device, but another discovery: an environmentally benign, inexpensive method to make hydrogen. This is a significant advancement because hydrogen will be an important energy source in the near future, Sorensen said.

Carbon-2D Graphene Inc. soon became HydroGraph Clean Power Inc. and the collaboration has expanded to involve other K-State researchers and Kjirstin Breure, who became HydroGraph's chief operating officer. The work has resulted in new inventions, intellectual property and endless possibilities.



Top: The K-State team involved in the HydroGraph Clean Power Inc. research collaboration includes, from left, Stephen Corkill, research engineer in physics; Justin Wright, doctoral student in physics; Shusil Sigdel, doctoral student in physics; Stefan Bossmann, university distinguished professor emeritus of chemistry; Luke Kramer, junior in physics and electrical engineering; Chris Sorensen, Cortelyou-Rust university distinguished professor of physics and university distinguished teaching scholar; Jose Covarrubias, recent doctoral graduate in chemistry; and Arjun Nepal, research assistant professor of physics.

Middle: Stephen Corkill, research engineer in physics, prepares a detonation chamber where acetylene and oxygen are added for a controlled detonation that creates large amounts of graphene.

Bottom: This mass quantity of high-quality graphene was created from a single controlled detonation.

"We believe in partnerships and the partnership we have with K-State has been very productive," Davidson said. "The world of nanomaterials is going to open up to us and the process we have. We're using digital methods with our precisely controlled detonation technology, in order to create what we feel are going to be the nanomaterials required for the fourth industrial revolution."

Sorensen soon engaged Stefan Bossmann, university distinguished professor emeritus of chemistry, to assist in the chemical side of the collaboration. Bossmann applied a mild oxidation method to the graphene to make a high-quality graphene oxide, which maintains the integrity of the graphene and creates a new material with numerous possibilities.

"Our process is completely novel and our surface modification methods are ultraprecise," Bossmann said. "We use the explosion graphene and we modify only the outer layer, which means we maintain all other layers and their properties. That's enough to connect this outer layer to virtually any other matrix through well-established organic and inorganic chemistry."

The team of researchers also includes Arjun Nepal, research assistant professor of physics; Stephen Corkill, research engineer in physics; and numerous graduate students and undergraduate students.

Some of the recent patents from the collaborative research team include:

- A method to create hydrogen-rich syngas in a provisional patent titled "Process for synthesis of syngas components."
- A device for upscaling graphene production in a patent application titled "Device and process for mass production of particulate materials."
- A process for developing turbostratic graphene oxide in a patent application titled "Graphene/graphene oxide core/shell particulates and methods."

HydroGraph continues to support the team, and recently established a $1.4 million research partnership for future projects that involve other K-State researchers in the Carl R. Ice College of Engineering and College of Arts and Sciences: Placidus Amama, associate professor in the Tim Taylor Department of Chemical Engineering; Suprem Das, assistant professor of industrial and manufacturing systems engineering; Jun Li, professor of chemistry; and Dong Lin, associate professor of industrial and manufacturing systems engineering.

Other collaborators on the work include the University of Kansas Medical Center and Missouri University of Science and Technology. The funding and research will train nine graduate students.

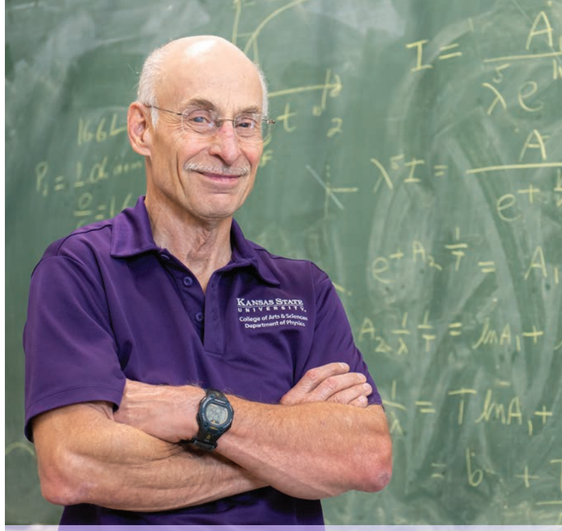
"This research and commercialization partnership with HydroGraph is an excellent example of how K-State is actively working with companies to bring new businesses and jobs into the state of Kansas," said David Rosowsky, K-State vice president for research.

The multi-institutional research team continues to expand on the detonation method to create graphene and hydrogen-rich syngas. They also are developing devices for more efficiently producing the unique graphene and graphene oxide. It's a collaboration with big plans for future growth and development.

"All of this started as curiosity-based research," Sorensen said. "Land-grant universities were founded on the idea that research and creative ideas formulated at the state university would yield useful technologies. That is exactly what happened here. Moreover, this type of intellectual property collaboration could be the future for K-State." *k*

Seek more

Watch a video and see more photos of the graphene and hydrogen research collaboration.
k-state.edu/seek



Chris Sorensen, Cortelyou-Rust university distinguished professor of physics, and his research team have discovered a simple new way to create graphene.

Even large amounts of graphene are very lightweight.

A researcher scoops out large quantities of graphene from a small detonation chamber.

Music and the write stuff

Research strikes chord with jazz professor

By Beth Bohn

Wayne Goins brings music to life, whether playing, composing or writing about it.

"My passion for performing and writing about music is what keeps me moving forward, looking for the next magic moment — both on the stage and on the page," said Goins, university distinguished professor of jazz in the College of Arts and Sciences.

An acclaimed jazz guitarist with 26 albums and numerous original compositions and performances to his credit, Goins also is a prolific writer about all things jazz, soul, blues, pop, funk, reggae, and rhythm and blues.

"My writing is one of the most significant forms of active research that I do — it's a result of having had experience in so many genres of music," Goins said. "I am constantly integrating, processing, revisiting and reformulating all the things that I think I know and then releasing my creative energies out into the world."

Goins is the author of books about music legends — including Jimmy Rogers, Charlie Christian and Pat Metheny — and tips on teaching jazz. He also regularly writes for leading music magazines and journals. Goins currently is writing a 10-piece series on rock music for Power of Music and Audio, or PMA, magazine and pens monthly interviews with some of the greatest jazz guitarists in the country for Jazz Guitar Today magazine. He writes critiques and reviews and analyzes blues albums for Living Blues magazine and also writes music reviews for Kansas City Jazz Ambassadors. He even has written liner notes for some highly acclaimed albums.

"The writing process feeds my incessant need to constantly deliver something that was only an idea until it came into fruition," he said. "It is my way of giving birth — and it keeps my mind sharp, too."

Goins particularly enjoys digging into biographical and historical material about music for his writing.

"I love exhaustive research," he said. "The process of leaving no stone unturned when it comes to the comprehensive study of any given artist and their entire musical output really energizes me. I'm what I call a completist — I like having entire collections of things."

When it comes to inspiration for his music and writing, Goins looks to music legends and well-known authors: Guitarists George Benson and Pat Metheny, pianist Bill Evans and music giants Prince, Miles Davis and Jimi Hendrix are among his favorites. As a writer, he enjoys Eric Nisenson, Joan Didion, Peter Guralnick, Joyce Maynard, Susanna Kaysen, Nora Ephron, Anthony Bourdain and Christopher Hitchens, to name a few.

"A constantly curious, creative and craving mind is what keeps me inspired," Goins said.

Seek more

Listen to several recordings featuring Wayne Goins.
k-state.edu/seek

Wayne Goins, university distinguished professor of jazz, is a prolific writer, composer and musician.

Members of the Gordon Parks project team stand at the "Gordon Parks: Homeward to the Prairie I Come," exhibition at the Beach Museum of Art. The team includes, from left, Sarah Price, collections manager; Katherine Karlin and Cameron Leader-Picone, both associate professors of English; Aileen June Wang, curator; and Mark Crosby, associate professor of English.

A passion for Parks

Team digitizes Gordon Parks' work

By Taylor Provine

The iconic Gordon Parks was more than a prominent photographer: He was also a writer, filmmaker and musician. Several Kansas State University researchers are highlighting some of his multimedia material in a digital archive.

Katherine Karlin and Cameron Leader-Picone, both associate professors of English, and Aileen June Wang, curator at the Marianna Kistler Beach Museum of Art, are leading the Gordon Parks project. Their team includes other College of Arts and Sciences faculty in the A.Q. Miller School of Journalism and Mass Communications and English department as well as staff at the Beach Museum of Art.

In 1969, Parks was the first African American to direct a Hollywood feature film based on his semiautobiographical novel, "The Learning Tree." The K-State project examines the movie — filmed in his hometown of Fort Scott, Kansas — and several of its related documents that are housed in the K-State Richard L. D. and Marjorie J. Morse Department of Special Collections.

"It's interesting in many ways," Karlin said. "It's a rare example of a movie that a director adapted from a novel that he wrote himself, it was made in Kansas, and it chronicles Black life in Kansas in the 1920s, which has not been chronicled much on film or in literature."

The researchers received a National Endowment for the Humanities grant to support the planning of the project and are working with the Gordon Parks Foundation to publish the content, which includes photographs of the movie shoot, memorabilia and interviews, on a website.

"This is a way to highlight his writing in connection with his photography and to look at the ways in which his work existed across mediums and across forms," Leader-Picone said. "But more than that, I think there's a broader significance to thinking about Parks, not just as singular figure, but as a representative of a tradition of creative work coming out of the Black Midwest, particularly in areas in which we tend not to think about the Black experience."

In 1973, Parks donated 128 of his photographs to the university. The K-State project also includes in-person and virtual exhibitions of the photographs, titled "Gordon Parks: Homeward to the Prairie I Come," at the Beach Museum of Art. The exhibition co-curators include Wang and Sarah Price, collections manager.

Wang is editing an exhibition catalog that includes research and essays about Parks by all project team members. It will be published by K-State's New Prairie Press as an open-access e-book.

"In the catalog, I argue that Parks saw his gift to K-State as an opportunity to create a self-portrait of sorts and think about what he wanted to say to his fellow Kansans," Wang said.

The exhibition will be on display through May 28, 2022.

Seek more

View the project's team members, see the virtual exhibition and learn more about its related events and programming.
k-state.edu/seek

Digital agriculture and advanced analytics

Ivan Grijalva looks over plants in his lab for evidence of the sugarcane aphid. Grijalva, doctoral student in entomology, is among a group of researchers using artificial intelligence to simplify identification of the leaf-sucking insects.

A pesky pest

Entomologist uses AI to spot tiny insect

By Pat Melgares

Ivan Grijalva considers the sugarcane aphid a big headache.

Strange, perhaps, since it would take about 16 of the pear-shaped, soft-bodied, leaf-sucking insects — lined up end to end — to measure 1 inch. In a farm field, aphids are rarely visible at first glance, even though hundreds or thousands may be present.

Trivial? Not to Grijalva, Kansas State University doctoral student in entomology, who is using machine learning to detect and classify sugarcane aphid populations on sorghum leaves without the use of manual labor.

"Using digital cameras, we collect images of the aphid on leaves while scouting farm fields, then we create computer algorithms that are able to detect and classify different densities of the sugarcane aphid on leaves," Grijalva said.

Technology is key to bringing all the pieces together.

"Nobody likes to count aphids," said Brian McCornack, entomology department head in the College of Agriculture and Grijalva's advisor. "It's tedious, and we need ways to standardize yet simplify the process. We can provide growers with all the information needed to manage a field, but we need to make decision tools accessible. A lot of the time, it comes down to a number: How many bugs are in my field, and what do I do about it?"

The more images researchers take of infested leaves, the more reliable the algorithm. The artificial intelligence gained ultimately allows machines to recognize infestations and eliminates the need to count aphids manually.

"Automated detection with images makes it entirely possible to confirm the presence of an insect pest and potentially target insecticide applications for precise control with the aid of robotics," Grijalva said.

That is in line with what is known as Integrated Pest Management, or IPM, which is an environmentally sensitive approach to pest management that relies on a combination of cost-effective control tactics.

"Pest identification and monitoring, use of economic threshold levels and applying insecticides only when justified are current practices in IPM that we need to use to make a giant leap toward securing food production for a growing world population," Grijalva said. "Our project will enable scientists to provide management recommendations to growers to maximize the efficiency of insecticides while minimizing the negative impacts on the environment."

Grijalva also is involved in a project with Ajay Sharda and Dan Flippo — both associate professors in the Carl and Melinda Helwig Department of Biological and Agricultural Engineering in the Carl R. Ice College of Engineering. Sharda is a Patrick Wilburn — Carl and Mary Ice Keystone research scholar and Flippo is a Patrick Wilburn Keystone research scholar. The researchers are using machine learning to recognize aphids under sorghum canopies, which then triggers a ground robot to spray it.

"The impact of digital agriculture on today's farms is tremendous," Grijalva said. "With the ability of information and tools provided by digital agriculture, farmers can be more efficient in food production. We can save time and production costs, while guaranteeing the safety of our food supply. We need to continue research in this area to increase our ability to transform our current management practices into the new, digital area of agriculture."

See page 20 to read about other K-State research related to sustainability.

Food and agriculture systems innovation

Jill Broxterman, senior in food science and industry, is seeking ways to add more protein to dairy-based products without changing how they look, taste and feel.

Making good foods better

Food science student has appetite for research

By Beth Bohn

Jill Broxterman is hungry to take on the challenge of feeding a growing world, whether by ensuring food products are safe to consume or by making foods more nutritious.

Originally an engineering major when she entered Kansas State University in fall 2019, Broxterman soon switched to food science and industry, offered through the College of Agriculture. The college is home to the Food Science Institute, which facilitates the university's food science programs and provides research and technical assistance to the food industries.

"I was drawn to the real-world applications of food science and I love the chemistry and biology behind it," said Broxterman, now a senior. "I also was very interested in the research and development opportunities that this degree has to offer, so my advisor recommended that I do undergraduate research to gain experience and enhance my lab skills."

Broxterman currently is working with milk proteins — casein and whey — and microparticulation — a way to control particle size — in the lab of Jayendra Amamcharla, professor of animal sciences and industry, who has a research emphasis on dairy foods.

"Greek yogurt, for example, has the high protein content that consumers want, but that means it also has an increased thickness or viscosity," Broxterman said. "Consumers want the higher protein content but still expect the same mouthfeel and consistency of regular yogurt. This poses a challenge for the dairy industry: increasing protein content while attempting to maintain the viscosity."

Altering the casein and whey protein interactions through microparticulation is one of the ways to control the viscosity.

"Whey proteins can be microparticulated, which limits the casein-whey protein interactions, and then used as an ingredient in acid gel-type products, including some dairy foods like yogurt," Broxterman said. "Microparticulation may be a potential solution for the dairy industry to give consumers dairy products with high protein content and with the desirable mouthfeel, texture or viscosity."

Broxterman presented on her milk protein research at the K-State fall 2021 Animal Sciences and Industry Undergraduate Research Symposium.

With the world's population expected to exceed 9 billion people by 2050, it is projected that farmers will need to produce 70% to 100% more food. This challenge is why Broxterman chose to pair her food science major with K-State's secondary degree in global food systems leadership.

An honors list student, Broxterman plans on completing her bachelor's degree in spring 2023. She wants to get her master's degree but may consider working in the food industry first as a quality assurance or research and development specialist.

Seek more

Learn more about the Food Science Institute.
k-state.edu/seek

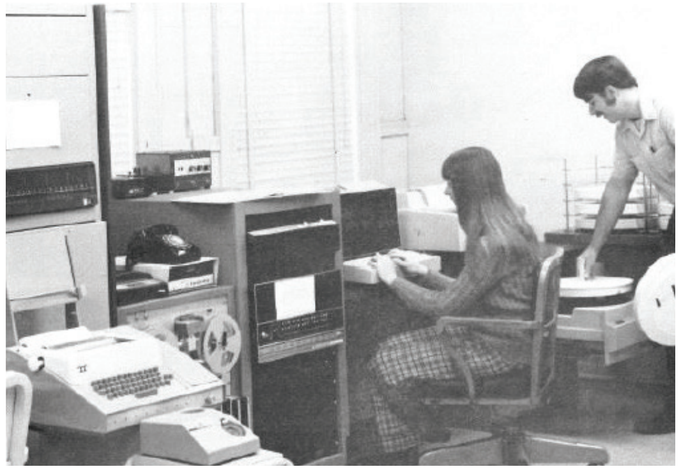
triple bottom line

'tri-pəl 'bä-təm 'lɪn

Hansin Bilgili, assistant professor of management in the Kansas State University College of Business Administration, explains, in fewer than 100 words, what triple bottom line is and why it is important for sustainability.

Triple bottom line, or TBL, is an expansion of the traditional understanding of measurement of firm performance, which focuses on financial performance or profit. The TBL approach demands managers pay equal attention to additional performance metrics: environmental and social performance. Under a TBL approach, managers not only need to pursue profitability, but also vigorously consider the cumulative impact of their strategies on people — employees and communities — and the planet or natural environment. When adopted, the TBL approach not only holds managers responsible to a broader group of stakeholders, but also provides a foundation for sustainable organization management.

See page 20 to read more about sustainability research and see page 8 to learn how researchers are analyzing the ever-changing economy.



The science of computing

The computers of today are vastly different from the first-generation computers that filled a room. Kansas State University's first computer, built by engineering professors W.R. Ford and J.E. Wolfe from 1954-1956, helped researchers solve complex calculations in minutes instead of months. In the top photo from 1975, Linda Shapiro, assistant professor of computer science, and Earl Harris, hardware analyst, work on computers in the department's hardware room. The bottom photo from the 1980s shows the Nichols Hall computer machine room, which held large computers that connected to terminals in a nearby computer lab. See page 28 to learn how K-State computer scientists continue to improve cybersecurity and keep our data safe.

Photos courtesy of the K-State computer science department.

KANSAS STATE UNIVERSITY

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Innovating our state

K-State Innovation Partners is the Kansas State University unit that connects the university with industry and communities. Read more about K-State success in corporate engagement, technology commercialization and economic development.

$3.7 million

K-State licensing revenue in fiscal year 2021

24

companies

Number of companies K-State Innovation Partners has assisted in establishing or expanding their presence in Kansas since 2009

$55.4 million

Total annual payroll of the jobs that have been generated by K-State Innovation Partners' clients

Nearly $6.2 million

Value of K-State technology commercialization in fiscal year 2021

Seek more

Learn how K-State is building economic prosperity in Kansas.
k-state.edu/seek

201

companies

Number of companies advanced through K-State Innovation Partners since 2009

1,299 jobs

Total number of jobs created by K-State Innovation Partners' clients since 2009

$7 million

Value of the total equity held by K-State Innovation Partners

Source: K-State Innovation Partners