Fall 2023

re:search

An inside look at innovation and discovery at Missouri University of Science and Technology

DIAGNOSTIC BREATHING

SOLVING FOR HEALTH

MISSOURI S&T

Researchers in Missouri S&T's Electromagnetic Compatibility Laboratory work in specialized chambers that block outside interference to help partner businesses like Apple, Google, Intel and LG find better ways to tackle problems with unintended electromagnetic emissions, or noise, and signal integrity.

Their work on a federal level focuses on the susceptibility of electronics to electromagnetic energy. "For national defense purposes, it can be useful to know how to disrupt adversaries' electronics, while also understanding how they could potentially interfere with ours," says **Daryl Beetner**, EMC lab director and professor of electrical and computer engineering.

*Missouri S&T computer engineering senior **Andrew Lazarski** works in the S&T Electromagnetic Compatibility Lab's anechoic chamber. The room is used to measure radiated emissions and susceptibility in a noise-free environment.*

DEAR FRIENDS OF MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY,

What do worms, spinach, artificial intelligence and deep breaths have in common? Although seemingly unrelated, they all figure into Missouri S&T's efforts to address and improve the delivery of health care.

Researchers in disciplines across our campus collaborate on projects as diverse as studying how music might improve memory in elderly people, creating new ways to deliver medication to treat dementia, using artificial intelligence to modernize the kidney transplant process, and using new nanomaterials to 3D-print cells for tissue engineering.

This collaboration among disciplines is a perfect example of bioconvergence — the bringing together of the physical sciences, engineering, biology, technology and medicine — and Missouri S&T is leading the way in this emerging field.

But biotech research is nothing new at S&T. It goes further back than the 1980s, when an S&T ceramic engineer developed and patented microscopic glass beads that, once irradiated, can be injected into the blood supply to treat liver cancer. In fact, it goes all the way back to the early days of our university.

In the 1920s, the first woman scientist hired by the forerunner to the National Institutes of Health came to Rolla to lead research on the blindness-causing eye disease trachoma. Dr. Ida Bengtson also taught bacteriology courses and conducted research at our university, and her work led to the creation of Rolla's Trachoma Hospital, one of only four such facilities in the country. The hospital closed in the late 1950s after a cure for trachoma was found, but the building still stands and today houses the Missouri S&T Rock Mechanics and Explosives Research Center.

I am honored to share the creative work Missouri S&T researchers are doing to solve important challenges in the bioconvergence domain. But bio-related research is only a small part of the innovation and discovery happening at Missouri S&T.

On the following pages, we present a few examples of that amazing work. We trust that you will find these projects as inspiring as I do.

Best Regards,

Kamal Khayat

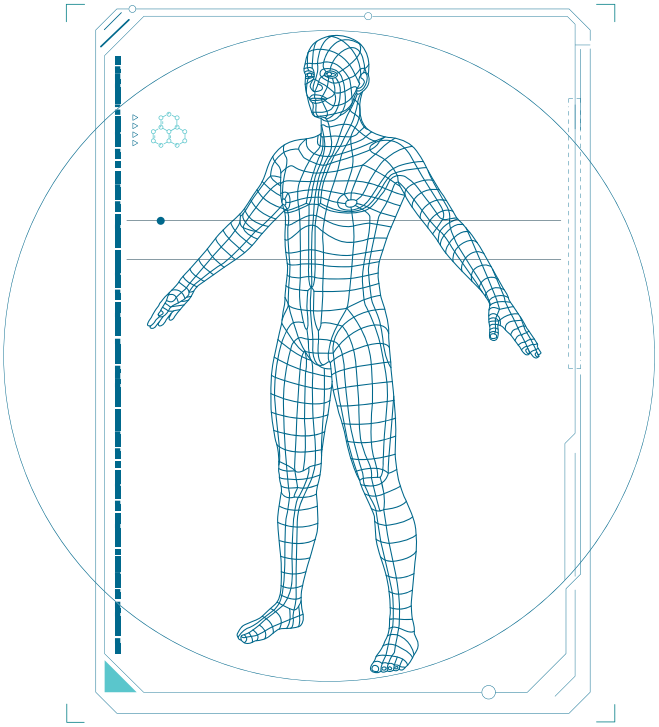
Vice Chancellor of Research

*On the cover: S&T researcher **Jie Huang** captures a human breath to study the volatile organic compounds it contains.*

INSIDE THIS ISSUE

How S&T researchers are

SOLVING FOR HEALTH



Bioconvergence — the juncture of the physical sciences, engineering, biological sciences, technology and medicine — is poised to become one of the greatest areas of academic and scientific research ever imagined, and Missouri S&T is well-positioned to become a leader in this emerging field.

S&T is creating new academic programs to further research in a range of bio-related fields, which will lead to advances in a broad array of medical specialties.

Since the 1980s, when a ceramic engineering professor at S&T developed microscopic glass beads that can be irradiated and injected into the blood supply to treat liver cancer from the inside out, research at Missouri S&T has supported biology, medicine and public health, among other related fields.

Today, bio-related research at S&T includes studies on how music could improve memory in older adults, creating drug-delivery systems to treat Alzheimer's disease and other forms of dementia, developing nanomaterials to 3D-print tissues capable of growth that could one day be used in the human body, and using artificial intelligence to modernize and optimize the kidney transplant process. In these areas and more, Missouri S&T researchers are drawing expertise from many disciplines to address important biotech challenges in creative, innovative ways.

Read on to learn more about how Missouri S&T is solving for health.

Long known as a STEM-focused university, Missouri S&T has had biological sciences in our DNA for nearly 100 years. Dr. Ida Bengtson, one of the leading U.S. Public Health Service scientists of the 1920s, came to Rolla to lead trachoma research. She taught bacteriology and conducted research in the basement of a landmark campus building and went on to develop a test that is still used to diagnose Rocky Mountain spotted fever.

One step closer to 3D-printing human organs

It may be decades before human organs can successfully be 3D-printed and transplanted, but Missouri S&T researcher **Anthony Convertine**, the Roberta and G. Robert Couch Assistant Professor of Materials Science and Engineering, has created a new type of nanomaterial for use in 3D-printing that takes us one step closer.

The material, which is synthesized directly in water without the need for toxic organic solvents, will make 3D-printing of cells faster, easier and more accurate.

"These new materials rapidly solidify when exposed to light, making them ideal for 3D-printing cells containing bioinks," he says. "This process is much faster and simpler than existing bioink formulations and more environmentally friendly as well."

Although printing 3D scaffolds for tissue engineering is his goal, Convertine says the creation of this method is an important step toward eventually printing large tissue specimens that could be used for multiple purposes. "These are complex tissues that will be able to grow thanks to our better, more accurate process for doing this work," he says.

With Convertine's process, the tissues will be printed into separate planes with capillaries included. Then, the tissues developed, called tissue pixels, can be assembled into larger and larger samples.

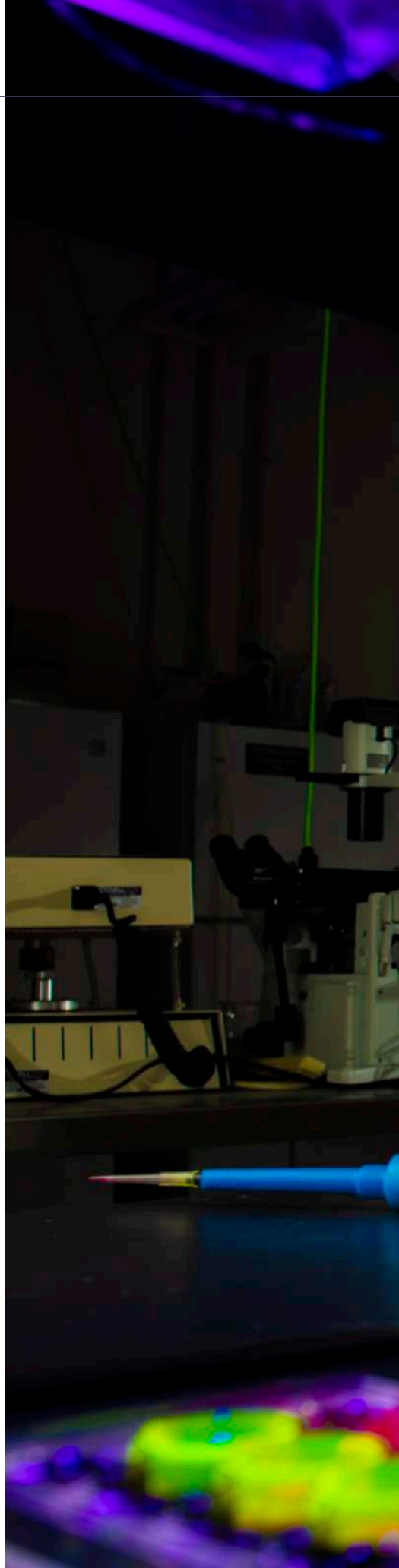
This process could be used to help heal wounds and create new vascularized tissues for patients with potentially life-threatening injuries.

Other possibilities include using the printed nanoparticles to administer more targeted chemotherapy to cancer patients or contain brain cell damage to its initial area in patients with traumatic brain injuries, Convertine says.

He says his work stands out because the nanoparticles are created in water, require no other solvents and create no other byproducts. Plus, the research team found that using thiol as a reagent keeps oxygen from slowing down the process, allowing the printed materials to harden much faster.

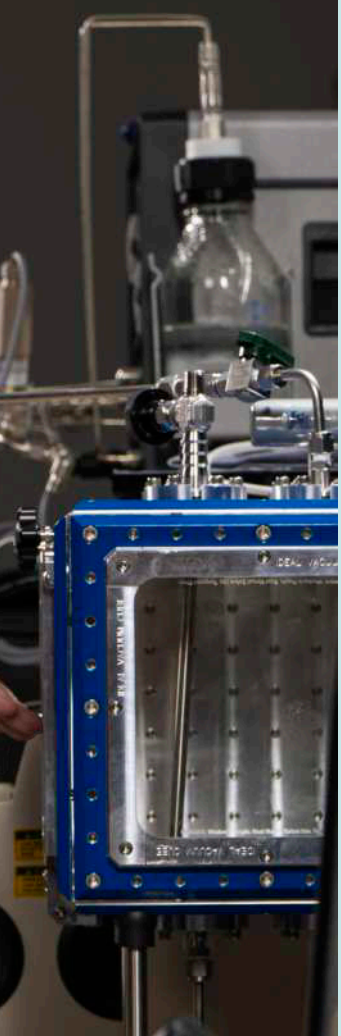
The nanoparticles Convertine has created are also unique because they have characteristics of both glass and polymer materials.

"I have conducted research over the years related to both glass and polymers, and I saw the potential for some crossover," he says. "We were able to bridge these two complex types of materials together in a simple but impactful way. The core of the material is similar to glass, while the corona of the particles is made from polymers."



Biomedical engineer Anthony Convertine, the Roberta and G. Robert Crouch Assistant Professor of Materials Science and Engineering at Missouri S&T, studies polymer science with a goal of finding the next step in drug-delivery systems. He is a member of the National Academy of Inventors.

DIAGNOSTIC BREATHING



When an ill person schedules a doctor visit, bloodwork or other diagnostic testing is often needed before a physician can diagnose the problem. But **Jie Huang**, the Roy E. Wilkens Endowed Associate Professor of Electrical Engineering at Missouri S&T, is developing a way to get the same results from a breath of air.

Huang is leading a team of researchers to develop a cost-effective diagnostic tool that uses microwave sensors in a coaxial cable to measure the volatile organic compounds (VOCs) in a person's breath. The team is ready to use the technology in large-scale clinical trials.

Huang says the system could eventually be used to detect kidney disease, cancer, diabetes or lung conditions. It could also be used in airports or other large crowds to detect contagious particles in a person's breath profile.

"With how ultra-sensitive the measurements will be, people will be able to quickly have an indication of what type of disease or illness they may have," Huang says. "Take diabetes, for example. We can measure the amount of acetone in a person's breath, and this can indicate the possibility of them having this disease."

"Several hundred volatile organic compounds can be measured, so we can develop a panel with this information and potentially correlate the results to certain diseases," Huang says.

The system could also be used to detect contagious particles in a person's breath profile. This could be useful for screening purposes in airports or other areas with large crowds. The National Institutes of Health previously supported Huang's research with approximately $1 million in funding, and he is hopeful the organization will soon be on board to fund the clinical trials as well.

Huang uses microwave sensors that are part of a coaxial cable for this system. The necessary supplies are available at local hardware stores for a minimal cost. He says the technology needed to use breath for diagnostic testing could eventually cost less than $1,000.

"Right now, the most similar technology to our design would be a mass spectrometry instrument, which costs hundreds of thousands of dollars and has significantly slower results than our technology," he says. "Our design could completely change the world of diagnostics and make this type of resource much more available."

Left: Jie Huang, standing, is leading a team of Missouri S&T researchers, including doctoral student Ogbole "Collins" Inalegwu, that is focused on developing a cost-effective microwave sensor testing system to measure the volatile organic compounds in a person's breath.

Matchmaking organ transplants with AI

With close to 100,000 people in the U.S. waiting for a kidney transplant and up to 20 percent of donated kidneys discarded for various reasons, fine-tuning the matchmaking between donated kidneys and transplant centers is a significant challenge. That's why researchers at Missouri S&T are investigating the ways artificial intelligence (AI) can support the process.

Casey Canfield, assistant professor of engineering management and systems engineering, is leading the four-year research project, which received $1.8 million from the National Science Foundation.

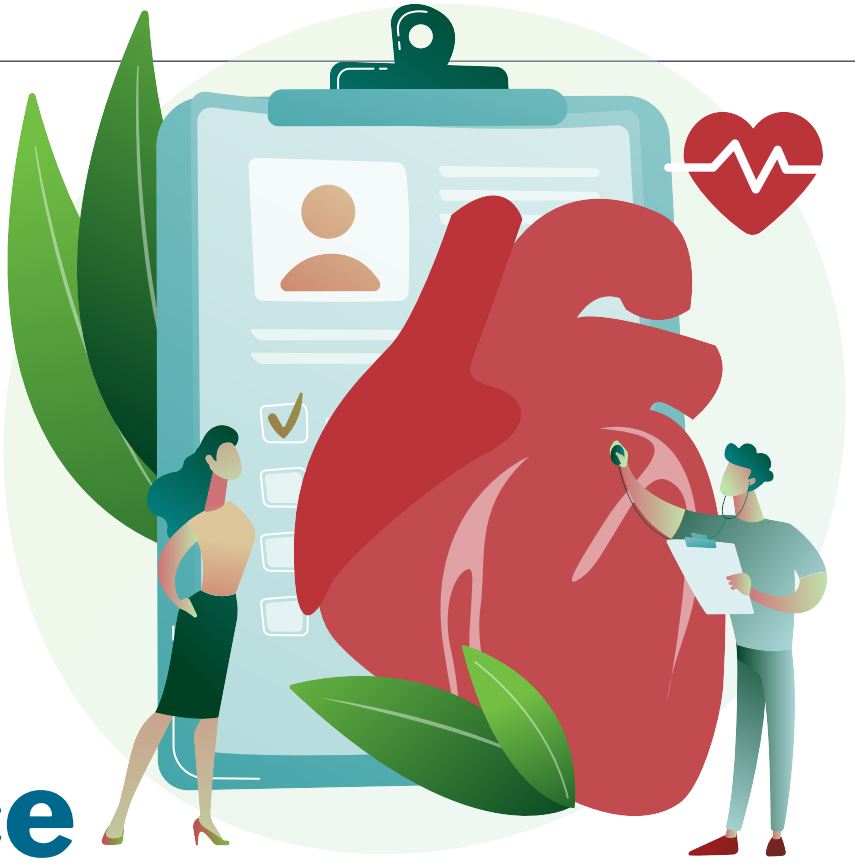
"Decisions in this matchmaking process are made by people with a lot of expertise, and they don't always agree," says Canfield. "The longer it takes to find a transplant center that is willing to transplant a kidney, the more likely the kidney will be discarded. Reducing kidney discard means more people can get off dialysis, feel better and live longer."

Canfield and her collaborators are focused on how surgeons decide whether to accept or reject a kidney offer, and how organ procurement organizations find transplant centers for hard-to-place kidneys. Sometimes it is medically necessary to reject a kidney offer due to posed health risks. This coupled with professional dissention results in lapsed time and the need to discard the donated kidney, which can lead to death. People at the top of the offer list, and their health care providers, often reject a kidney offer that has any risk factors because they are likely to be offered a better kidney relatively quickly.

To mitigate risk factors and preserve life, Canfield and the research team will develop an AI decision support system, identify strategies to increase fairness in the algorithm, account for human preferences and performance, and then field test the system using an existing simulation platform with familiar interfaces.

The research is conducted in partnership with the United Network for Organ Sharing (UNOS) and SSM Health Saint Louis University Hospital, which has a transplant center. In addition, the team works closely with MidAmerica Transplant, a regional organ procurement organization.

Casey Canfield in engineering management leads an S&T research team that investigates how artificial intelligence can improve the organ transplant process. From left: Cihan Dagli in engineering management, Daniel Shank in psychological science, Canfield, and Siddhardh Nadendla in computer science.



Linking race and hypertension

Through funding from the National Institutes of Health, **Jinling Liu**, assistant professor of engineering management and systems engineering at Missouri S&T, is developing a way to customize treatment for hypertension for individual patients based on their unique DNA. She is also studying the correlation between hypertension and race to develop more accurate and timely intervention and prevention strategies for people of different races and ethnicities.

Liu is developing and evaluating a suite of methods to find personalized genomic variants of hypertension. Her work will help deepen the understanding of the genomic basis of racial differences in hypertension.

Liu believes these individualized methods will help facilitate a profound shift in how disease occurrence is understood.

Until recently, most algorithms were population-based, genomewide studies, meaning they find genomic variants that may explain the occurrence of a disease at the population level but not for a single patient.

"We are taking into consideration each patient's specific genomic background to identify their personalized genomic causes," she says. "This individualized method also showed potential for better detecting low-frequency or rare variants when applied to the same moderately sized cohort in our preliminary study."

These individualized methods will also be used to better understand genomic reasons why Black Americans have a much higher incidence of high blood pressure than white Americans. Advanced machine learning and deep-learning techniques will then be used to develop reliable and accurate predictive models for hypertension.

Liu says the methods she develops will be generalizable and can be applied to various diseases to help advance personalized medicine. The project uses the enormous (and growing) body of whole genome sequencing data and other omics data, the recently launched cloud-computing platform, National Heart, Lung, and Blood Institute BioData Catalyst, and advanced machine learning methods.

From left: Biological sciences students Aiden Armstrong and Madison Husereau and chemical engineering student Abby Knoesel developed a way to use spinach leaves and stem cells to heal burns.

Healing burns with spinach

A team of three undergraduate students from Missouri S&T developed a way to use spinach leaves and stem cells to help burn patients and others with wounds that would require a skin graft. They call it Foliagraft.

Chemical engineering student **Abby Knoesel** and biological sciences students **Madison Husereau** and **Aiden Armstrong** won a $15,000 first-place award at the Regnier Venture Creation Challenge held last spring in Kansas City, Missouri.

The S&T team won first place in the BlueKC Healthcare Innovation Awards category. S&T advanced three teams to the semi-final round in the challenge, which comprised 12 teams. In all, the competition featured 90 teams from 11 universities in four states.

"The Foliagraft was inspired by previous vasculature research done by biomedical engineers, and the students wanted to investigate skin treatments," says **Julie Semon**, an associate professor of biological sciences who advised the project. "They got spinach leaves and then removed all the cells from the leaves — the leaves are all white at this point. There are no cells in the veins or in the actual leaf tissue."

The team's next step in research is to see if they can get human vascular cells into the leaf and then put it in an animal model. This step will prove its capability for grafting into the skin, determine if it gets rejected or causes any sort of irritation, and see if it helps to regenerate the surrounding skin.

"The team used the winnings from the S&T competition to develop their prototype, which helped with this larger regional event," says Semon. "It was the perfect way to continue to work on a project."

Q&A

The future of bioengineering

Mark Towler, Doshi Professor of Chemical and Biochemical Engineering at Missouri S&T, shares his thoughts on the importance of bioengineering.

Tell us about your recent work.

I am currently working in the field of orthopedics and trauma surgery. Most recently, I have had patents granted for an adhesive for fracture fixation and stabilization and a powder for staunching bleeding after trauma, such as a gunshot wound. These materials have successfully gone through large animal trials and are now the subject of licensing negotiations with medical device companies.

What could students do with bioengineering knowledge and experiences?

All of my previous graduate students have secured positions in the medical devices field pertinent to their research experience. A background in bioengineering, whether at the undergraduate or graduate level, instills critical thinking, imparts an understanding of end-user needs, and sits at the interface of biology and engineering — both fields of critical importance when considering our aging demographic.

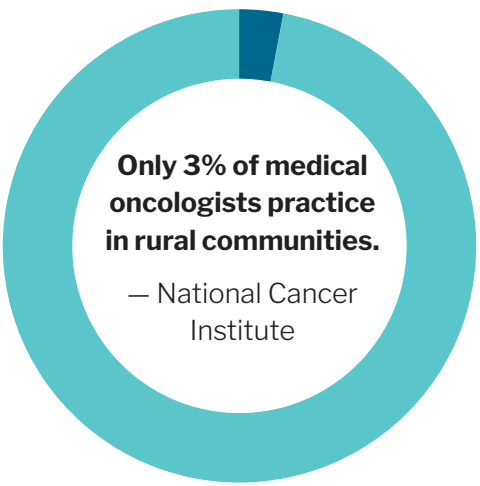
What inspires you about the future of bioengineering? Where do you see this field headed?

Innovation is now driven by academia, often through the start-up route. This new approach has meant more companies have entered the space, which has led to a sea change in the clinical field — seen most recently in the use of robot-driven surgery and non-X-ray-based diagnostic tools. The biomedical field is more innovative now than at any time in the past.

Read more of Towler's thoughts at **rol.la/towler23**.

Taking cancer treatment on the road

Access to medical specialists and customized cancer treatment often means a lengthy drive to a more urban area for people who live in the country or in rural areas. But Missouri S&T Ph.D. candidate **Alex Price** has a solution.



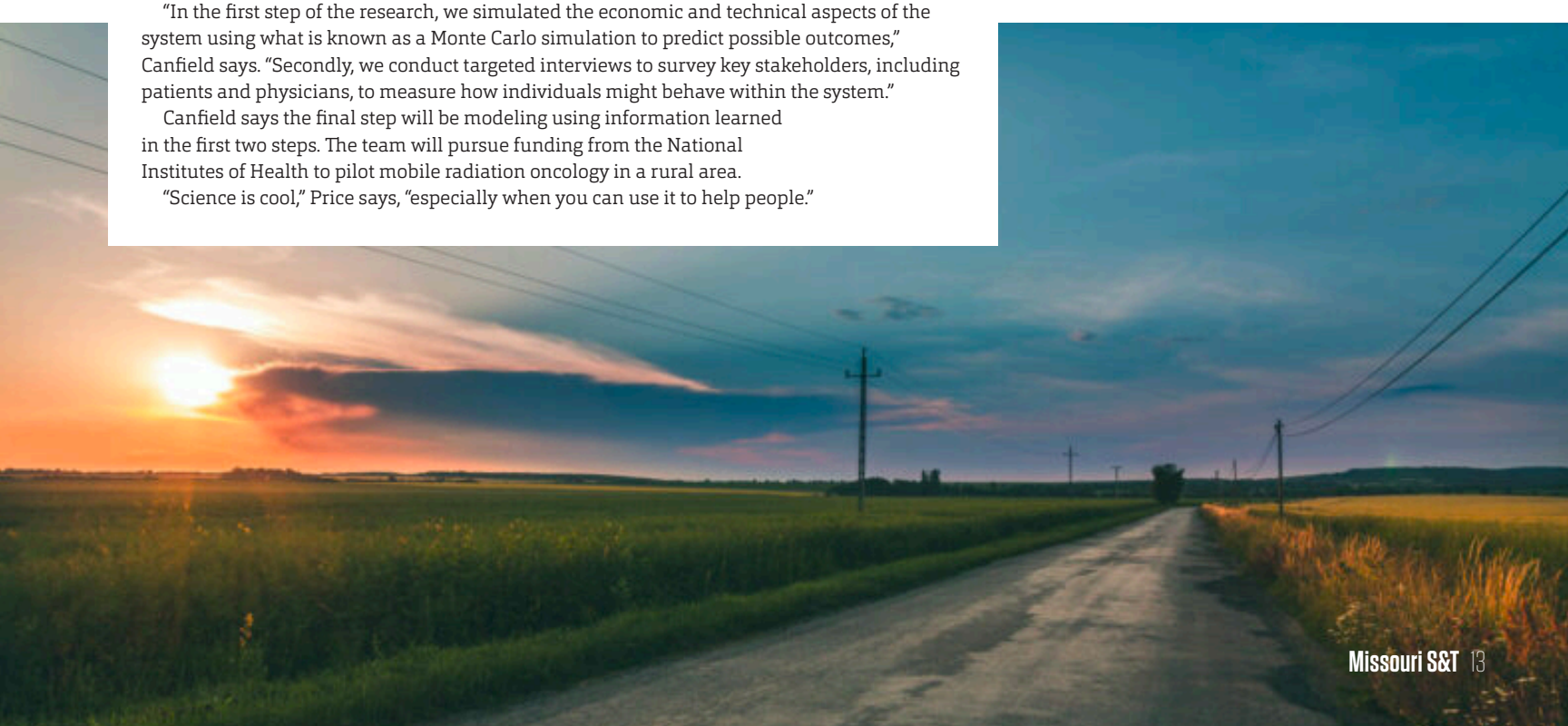
Price works as a medical physicist in radiation oncology at University Hospitals Health System in Cleveland, Ohio, and is pursuing his Ph.D. in systems engineering at S&T. He proposes hospitals bring radiation therapy to rural areas by vehicle, similar to a mammogram van that provides breast cancer screening services in rural communities.

Price is working with a team of researchers at S&T to study the feasibility of a mobile radiation oncology unit and anticipate challenges of his concept using his health care knowledge and systems engineering education. **Casey Canfield**, assistant professor of engineering management and systems engineering, says systems modeling can be a helpful tool when considering changes within many types of systems, including health care.

"In the first step of the research, we simulated the economic and technical aspects of the system using what is known as a Monte Carlo simulation to predict possible outcomes," Canfield says. "Secondly, we conduct targeted interviews to survey key stakeholders, including patients and physicians, to measure how individuals might behave within the system."

Canfield says the final step will be modeling using information learned in the first two steps. The team will pursue funding from the National Institutes of Health to pilot mobile radiation oncology in a rural area.

"Science is cool," Price says, "especially when you can use it to help people."



Biological sciences students Erik Bergstrom, left, and Molly Ripper, right, work with advisor Andrea Scharf to study lifespan and reproductive rates of roundworms in an effort to find a way to counteract age-related diseases.

What can worms tell us about aging?

With age-related decline and disease affecting health care and the nation's aging workforce, Missouri S&T students **Erik Bergstrom** and **Molly Ripper** are researching the ways different reproductive and aging traits affect the way aging occurs.

Bergstrom and Ripper, both undergraduate students in biological sciences at S&T, are searching for ways to counteract age-related diseases by studying the lifespan and reproductive rates of roundworms in the laboratory and through simulation.

They say understanding how aging occurs in various animal populations could help researchers develop treatments for age-related diseases and other conditions in humans.

The students use both long- and short-lived worm mutations with varying reproductive schedules, and they study the populations with varying degrees of food access.

It is currently unknown how various traits affect the survival of these worm populations. Project advisor **Andrea Scharf**, an assistant professor of biological sciences, says this study aims to answer that question.

"We don't yet fully understand the relationship between reproductive and aging traits and how they impact survival," Ripper says. "Birth and death rates control the worms' populations, but there are more interplaying aspects to that relationship that we are trying to discover."

REDDY NAMED AAAS FELLOW

FOR ORGANIC CHEMISTRY RESEARCH

V. Prakash Reddy, professor of chemistry at Missouri S&T, was elected Fellow of the American Association for the Advancement of Science (AAAS) for his contributions to the field of organic chemistry, particularly his work with superacids, carbocations, electrophilic reactions, organofluorine and medicinal chemistry.

Reddy's research group is involved in multiple research areas, including nerve agent decontamination, drug design for neurological disorders, oxidative stress, photoredox catalysis, and advanced glycation end products (AGE) inhibitors and breakers. His group is also working to mitigate the toxic effects of pesticides.

"Our laboratory is currently developing small-molecule-based and polymeric-material-based decontaminating agents," Reddy says. The agents could be used to decontaminate surfaces and to create self-decontaminating fibers and fabrics to mitigate the toxic effects of nerve agents and pesticides, he says.

Reddy earned a master's degree in chemistry from the University of Hyderabad in India in 1979 and a Ph.D. in organic chemistry from Case Western Reserve University in 1986. After earning his Ph.D., Reddy served as a research associate at Syracuse University and then as a senior research associate at the University of Southern California. He joined Missouri S&T in 2001 as an assistant professor, was promoted to associate professor in 2006, and to professor in 2015.

He has been a NASA Jet Propulsion Laboratory Faculty Fellow, an honorary member of the Golden Key National Honor Society, earned three patents, written two books and has over 100 published articles. Reddy is senior investigator in the Center for Research in Energy and Environment at S&T and a research investigator in the Center for Biomedical Research at S&T.

FIGHTING ELECTRIC VEHICLE FLAMES

Like flames in the wall of a structure fire, fires in electric vehicle (EV) batteries burn unseen. Firefighters can squelch the visible flames, but chemicals inside the battery continue to burn because firefighters can't reach their source. Missouri S&T researchers are finding ways to plan for and mitigate these fire risks.

"EV battery fires start with an uncontrolled chemical reaction inside the battery that releases a huge amount of heat and continues until the reaction has completed," says **Guang Xu**, associate professor of mining engineering. "Also, a chemical fire releases more toxic gases than a gasoline- or diesel-powered vehicle fire."

Xu says mine operators are particularly concerned about fire because of the mining industry's growing use of EVs in everything from development to production. Miners trapped underground by an EV fire are exposed to toxic amounts of hydrofluoric acid that can cause lung injury, pulmonary edema or death.

The risk extends to city bus fleets, ships that carry EVs, airports and parking garages. Xu says no standard procedure exists to calculate and prepare for the risk. His research evaluates risk preparation to minimize human danger and property damage.

Xu works with S&T researchers **Jonathan Kimball**, chair of electrical and computer engineering, and **Jonghyun Park**, associate professor of mechanical and aerospace engineering.

"The chemistries used for making batteries are combustible and bring a new source of fire risks," Xu says. "We want to develop preparation and mitigation standards to help EV users, firefighters and others know what to do."

ON A MOLECULAR MISSION

In recent decades, auto and aircraft industries have been developing technologies to improve engine performance. Missouri S&T Ph.D. student **Adrian Batista** says his research could further those technologies.

Batista's current work focuses on long-range interactions between molecules. He calls molecular dynamics the perfect mixture of physics, chemistry, mathematics and computer science.

"I like to think of science as an ensemble rather than a particular domain," says Batista, who is pursuing a doctorate in chemistry after earning an undergraduate degree in physics.

"One of those technologies being developed is low-temperature combustion, where the system's low temperature makes long-range molecule interactions essential," Batista says. "The transportation field is a large aspect of this research's practical applications."

Batista studies these interactions and their evolution over time. Using modeling and simulation systems, Batista can then develop a method of measuring molecules' potential energy surface while considering long-range variables such as dispersion, induction and electrostatic effects. His computer modeling could one day replace costly laboratory experiments.

"Interaction between molecules is a common phenomenon that can affect the state of a system yielding different final products depending on their initial conditions," Batista says. "I am researching special cases when two molecules interact at low temperature and a wide range of pressures — conditions found in many places in nature like the stratosphere or nebulae where ozone and star formation occur."

Batista's research advisor is **Richard Dawes**, an adjunct professor of chemistry.

This nearly 3.2 megawatt solar farm owned by the Missouri Public Utility Alliance and located east of Rolla sells power to the city utilities.

CHANGING THE LANDSCAPE FOR LOCAL UTILITIES

More businesses and households are using solar panels to generate their own electricity and selling the surplus power back to utility companies. This could cause company profits to drop and force utilities to consolidate. Changes in renewable energy integration and regulatory changes could also lead to shrinking profits and consolidations.

Mahelet Fikru, an associate professor of economics at Missouri S&T, is studying hypothetical energy oligopolies, small groups of companies with little competition, to see if they could help the electricity industry remain profitable through the move to more renewable energy sources such as solar power.

"Our study examines distributed energy resources, which are small-scale and local energy generation units connected to the grid at the distribution level," Fikru says.

She says these resources can help meet energy demand where traditional power supply is low and allow consumers to access renewable energy, but it will affect utility companies' costs and revenue streams.

Fikru studies the rate at which renewable energy raises grid integration costs and the extent to which renewable energy reduces pollution. This could also lead to savings in the cost of investment to upgrade and maintain existing power infrastructure.

"We find an increase in energy produced from distributed sources reduces the profitability of profitable mergers and reduces losses from unprofitable mergers," says Fikru. "The model also shows that the variability in electricity produced from renewable sources encourages utilities to produce more, which in turn magnifies the extent that extra renewable energy affects merger profitability."

SPEEDING UP CONCRETE PRINTING

A Missouri S&T research team is leading three projects to make 3D-printing of concrete faster, stronger and more resilient for the U.S. Army Corps of Engineers.

Kamal Khayat, left, and Alfred Addai-Nimoh, examine 3D-printed concrete in the Clayco Advanced Construction and Materials Laboratory at S&T.

In one project, researchers are examining three strength categories of concrete to develop quality control test methods for 3D printing.

Another project examines ultra-high-performance concrete and how it can be used for 3D printing with three different construction methods: layer-by-layer, sprayed concrete and stay-in-place formwork systems.

"For both projects, we are aiming to print fiber-reinforced concrete into intricate shapes with no formwork and with little or no reinforcing steel that is typically required to resist tensile stresses in reinforced concrete structures," says **Kamal Khayat**, S&T vice chancellor for research and innovation and the Vernon and Maralee Jones Professor of Civil Engineering. "Using ultra-high-performance concrete with 3D printing is a new concept, and we are leading the charge on this work at Missouri S&T. There are many technical challenges that we will need to solve, but there are also many opportunities that lie ahead once we master this construction process."

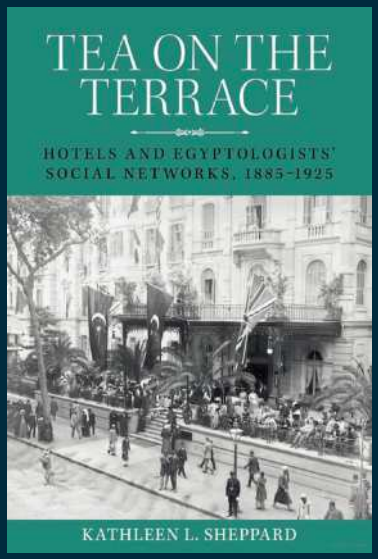
Khayat is also developing an artificial intelligence program to determine the best locally available materials for 3D-printing concrete.

Khayat says this research will benefit the U.S. military and the construction industry for multiple reasons.

"This is something that could be done quickly and can overcome weight and logistics obstacles associated with using concrete for rapid construction or the repair of needed battlefield infrastructure," he says. "3D-printed concrete can also be crucial for humanitarian assistance and disaster relief applications. People will be able to use materials that are locally available, such as natural pozzolans, dune or crushed sand, and natural fibers to make a cost-effective fiber-reinforced concrete for 3D printing."

BOOKCASE

Below are a few examples of books authored by Missouri S&T faculty researchers.

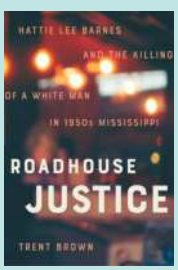


Egypt by word of mouth

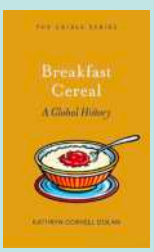
European-style hotels and the social interactions formed there were essential in disseminating knowledge about ancient Egypt unearthed by archaeologists and their crews, says Kathleen Sheppard, professor of history and political science, in her book *Tea on the Terrace*, published by Manchester University Press.

"The work Egyptologists did in the social spaces of hotels reveals more about how scientific inquiry is done in the field: it has never been all about the trowel, the artefacts, or the subsequent reports," writes Sheppard, who also holds S&T's Lawrence O. Christensen Endowed Faculty Fellowship.

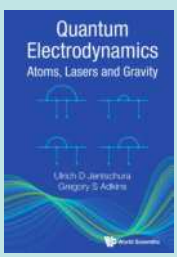
"Egyptologists and archaeologists met on the terrace for tea, in ballrooms during dances, in dining rooms for meals, and in their private rooms, all to discuss scientific matters," Sheppard writes. "In doing so, they turned hotels into scientific institutions."



Trent Brown, professor of English and technical communication, published *Roadhouse Justice: Hattie Lee Barnes and the Killing of a White Man in 1950s Mississippi.*

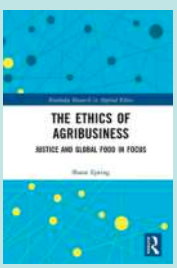


Kathryn Dolan, associate professor of English and technical communication, published *Breakfast Cereal: A Global History.*

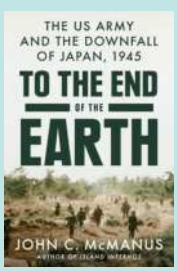


Ulrich Jentschura, professor of physics, published *Quantum Electrodynamics: Atoms, Lasers and Gravity.*

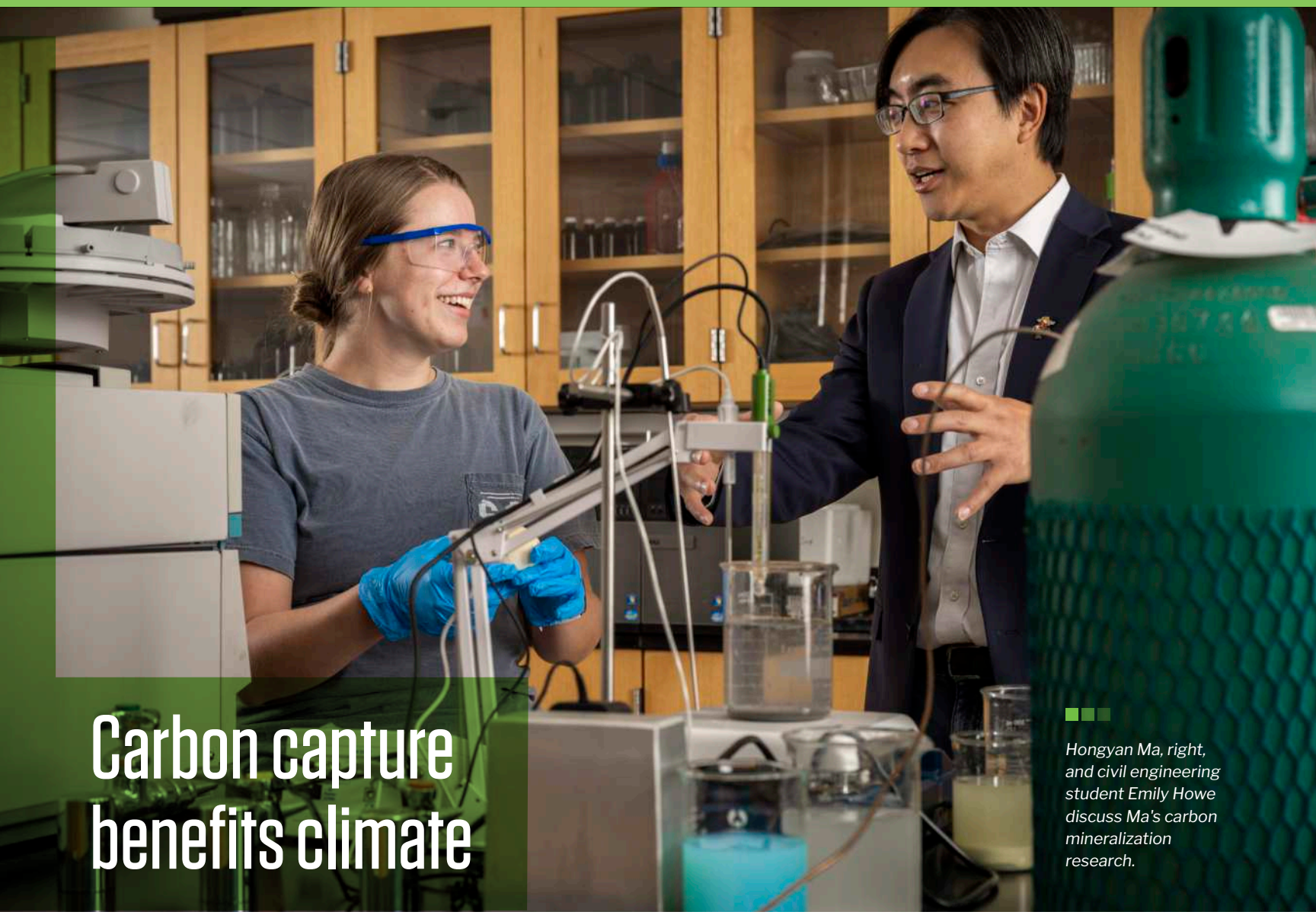
Petra DeWitt, associate professor of history and political science, published *The Missouri Home Guard: Protecting the Home Front During the Great War.*



Shane Epting, assistant professor of philosophy, published *The Ethics of Agribusiness: Justice and Global Food in Focus.*



John C. McManus, Curators' Professor of history and political science, published *To the End of the Earth: The U.S. Army and the Downfall of Japan, 1945.*



Carbon capture benefits climate

Hongyan Ma, right, and civil engineering student Emily Howe discuss Ma's carbon mineralization research.

With $2 million in funding from the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E), Hongyan Ma is studying how carbon mineralization could improve the yield of critical minerals recovered from silicate found in mine waste.

Since the silicate reacts with carbon, his team can use it for carbon capture and storage as well.

The project is funded through ARPA-E's Mining Innovations for Negative Emissions Resource Recovery (MINER) program, which promotes developing technologies to immediately increase U.S. supply of critical minerals needed to transition to clean energy.

The U.S. Geological Survey says 50 of the elements used for manufacturing count as critical minerals. Ma works with nickel and cobalt.

He says his team's process begins with the carbon-negative mineralization reaction of silicate materials. The reaction converts hard silicate into relatively soft materials that allow trapped critical elements to be easily leached out, separated and purified using hydrometallurgical approaches.

"The carbon-negative mineralization reactions that occur will allow us to create a billion-ton-scale trapping system for carbon," Ma says. "Many other researchers are working on carbon capture and storage as well as critical mineral recovery, but we are unique in our approach, which features 10 times faster reaction kinetics, two times more carbon storage capacity and 50% higher recovery rates of critical elements" than other approaches.

THE THEORY OF MAGICAL MATHEMATICS

Mathematics Ph.D. student **Nicholas Fleece** studies magic at Missouri S&T.

At least, that is what he will tell you. Fleece studies magic squares he describes as similar to a sudoku puzzle or other math game.

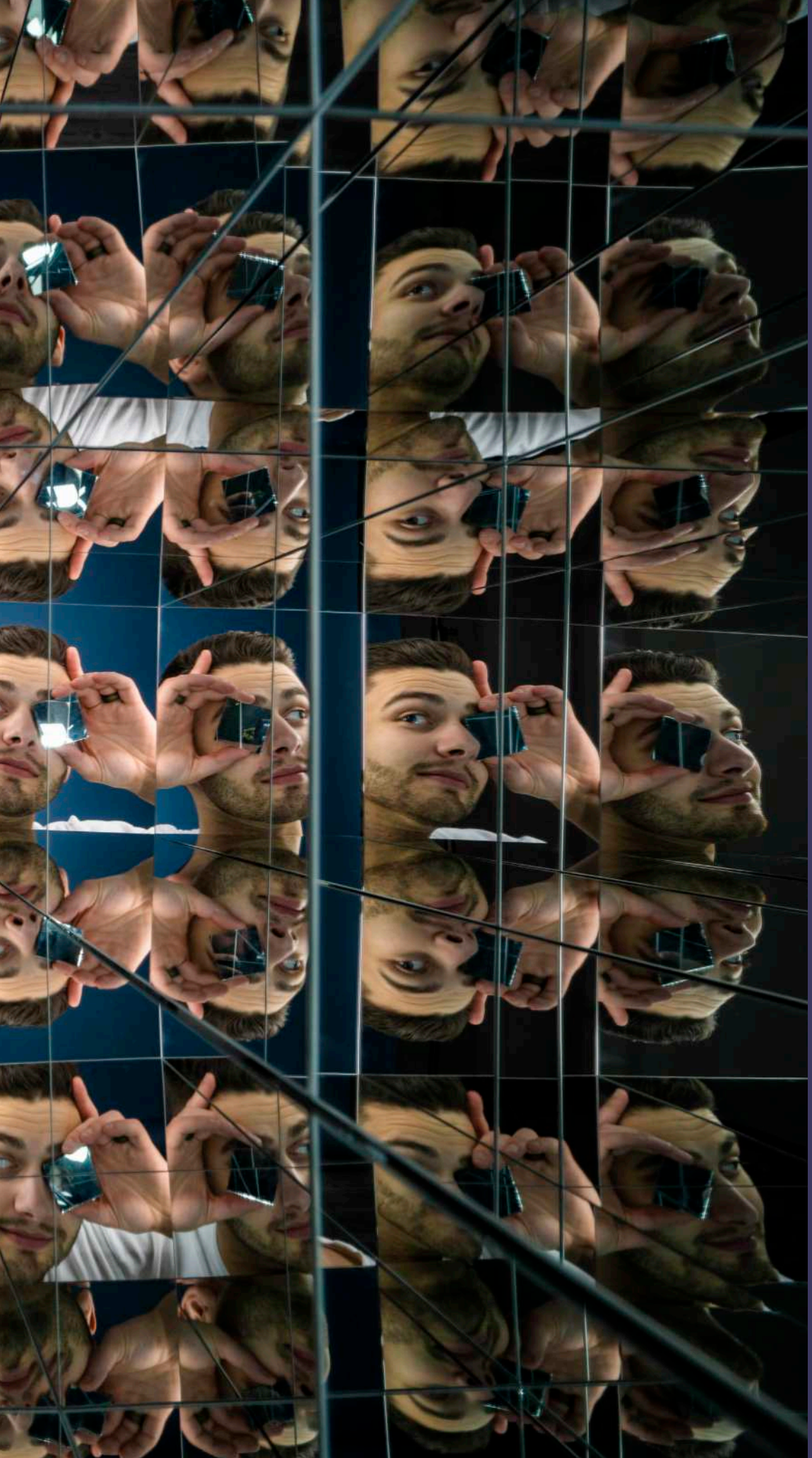
A magic square is a theoretical square of numbers where the sums of the numbers in each row, column and both diagonals are the same. Fleece wants to learn more about their implications in the field of mathematics and statistics. He says it could lead to innovations in actuarial work and equity trading, including calculating financial costs of risk for businesses.

"Some types of magic squares have never been created, but we cannot prove that it cannot be done," Fleece says. "My research team aims to attack this problem using nonstandard methods, something we haven't seen much in the literature. Answering this question would solve a decades-old problem — a mathematician's dream."

Magic squares are classified as "recreational mathematics" and not traditionally researched in formal education. But that hasn't stopped Fleece from pursuing his research at the highest level.

"I fell in love with math while earning my master's degree," he says. "Given how much I enjoyed this experience, there was no doubt in my mind that I had to pursue a doctoral degree.

"I think everything I study and learn about is recreational mathematics," he says, "because it is all fun to me."



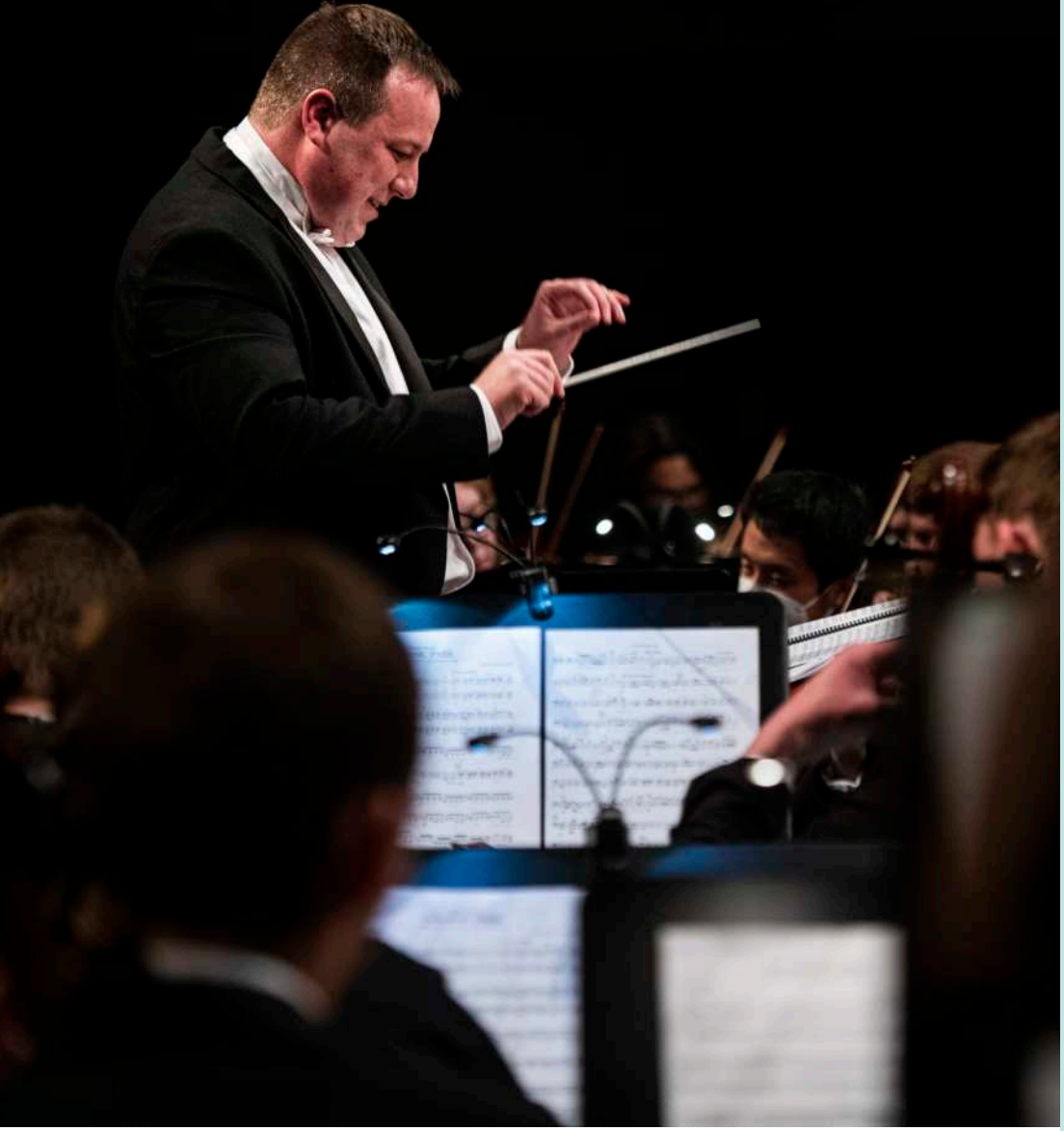
NUCLEAR ENGINEERING SENIOR EARNS MARIE CURIE FELLOWSHIP

Missouri S&T nuclear engineering graduate **Narrie Loftus** was chosen for the Marie Sklodowska-Curie Fellowship Programme sponsored by the International Atomic Energy Agency. She plans to do her part to close the gender gap in her field.

"Some young women may be intimidated to enter the nuclear engineering field, but that was never a barrier for me," Loftus says. "I find this field fascinating, and this fellowship will help me advance my studies and be a role model for future female students."

Loftus, who was notified of the fellowship when she was a senior, is using the funding to pursue a master's degree at S&T. She is focusing on nuclear materials, particularly how silicon carbide mechanical properties are affected by highly radioactive, high-temperature nuclear environments.

"The future of the nuclear industry is going to heavily rely on international collaboration," she says. "Thanks to the IAEA, there are internship opportunities I can consider around the globe to further my career."



COMPOSING AN AWARD WINNER

Kyle Wernke, assistant professor of music at Missouri S&T, has won the American Prize in Composition, 2022, in Orchestral Music (Professional Division) from the American Prize National Nonprofit Competitions in the Performing Arts.

Wernke's 2021 piece "Da Vinci at the River: Cantata for Bass, Chorus, and Orchestra," created in part to celebrate Missouri S&T's 150th anniversary, was nominated for the 2022 Pulitzer Prize in Music.

"Every time a composer hears that their work is being performed, I think the first thought is to be grateful," says Wernke. "Grateful that the work is being performed, that there are those who are enjoying the piece and feel it is worth sharing, and for the players who are going to put practice time and effort into the piece."

Wernke's 2017 work "Burst" was recorded by the Brno Philharmonic for Ablaze Records' album "Orchestral Masters, Vol. 6" and had subsequent performances by the Tampa Bay Symphony and the Musique en Seine Orchestre in Paris.

IN BRIEF

Belfi named Psychonomic Fellow

Amy Belfi, associate professor of psychological science at Missouri S&T, was named a Fellow of the Psychonomic Society, an international community of cognitive psychologists.

Belfi's research covers a broad range of topics in the field of music cognition, including music and autobiographical memory, musical imagery, aesthetic judgments of music, and musical anhedonia. She uses various techniques to investigate these subjects, including behavioral studies, functional neuroimaging, psychophysiology and neuropsychological approaches.

Geohazard expert wins Schuster Medal

J. David Rogers, the Karl F. Hasselmann Missouri Chair in Geological Engineering at S&T, was awarded the Schuster Medal from the Canadian Geotechnical Society and the Association of Environmental and Engineering Geologists.

Rogers is an internationally known expert on geohazards like landslides, floods and earthquakes.

Oerther to lead AAEES

Daniel Oerther, professor of environmental engineering at Missouri S&T, was named executive director of the American Academy of Environmental Engineers and Scientists.

A member of the academy since 2005, he has earned several awards and served in multiple leadership positions. His three-year term began in early 2023.

Critical minerals expert testifies before House subcommittee

Michael Moats, chair of materials science and engineering at Missouri S&T, appeared before a U.S. House of Representatives panel in February. He provided expert testimony on critical minerals production in the United States and the impact of foreign production of these minerals to the U.S.

Moats was invited to appear before the House Committee on Natural Resources Subcommittee on Oversight and Investigations for its hearing, "Dependence on Foreign Adversaries: America's Critical Minerals Crisis."

‘STEELING’ THE SHOW

A Missouri S&T research team was awarded $2 million from the U.S. Department of Energy to improve the operating efficiency of electric arc furnaces (EAFs) used in steelmaking.

“It takes a tremendous amount of power to run an EAF, and we are looking for new ways to lower that energy footprint,” says **Ronald O’Malley**, the F. Kenneth Iverson Endowed Chair of Steelmaking Technologies and director of the Kent D. Peaslee Steel Manufacturing Research Center at Missouri S&T. “We are working toward implementing a next-generation dynamic control system for the EAF so we can optimize operating efficiency under changing input conditions using new sensor systems.”

O’Malley says two partner steel plants — Big River Steel in Osceola, Arkansas, and Commercial Metals Co. in Birmingham, Alabama — will implement new fiber optic sensing technologies along with new control systems, directed energy input and EAF slag property models.

“The fiber optic system will provide a whole new set of tools for EAF optimization,” O’Malley says. “We will be able to better examine the condition of the EAF and the impact of operating variables on the process in real time to provide feedback to the operator and improve energy efficiency, operating cost and yield.”

After the systems go live, the researchers will begin collecting data to learn how effective the new process is. Throughout the process, plant employees will be trained on how to use the new technology. In the final stage, the researchers will analyze the performance improvements and determine what further improvements should be made.

MANUFACTURING MOON METAL

Missouri S&T aerospace engineering Ph.D. student **Jacob Ortega** is leading a team of students to develop a method for producing metal on the moon. The group received funding through NASA’s 2023 Breakthrough, Innovative, and Game-Changing Idea (BIG Idea) Challenge: Lunar Forge.

“We are working to develop a new method for metal production on the moon, which could eventually allow buildings to be constructed on the lunar surface,” Ortega says. “The ultimate goal is to have a sustained presence on the moon.”

The students are working with anorthite, which is abundant on the moon and contains large amounts of aluminum. They will use a type of electrolysis to reduce the aluminum oxide in the anorthite into aluminum that could then be used for other purposes.

In June, the team provided NASA with a mid-project report. Team members will submit a technical paper in October and then advance to the 2023 BIG Idea Forum in Cleveland, Ohio, in November.

Jacob Ortega, right, with faculty advisor Daoru Han inside a plasma vacuum chamber.

Dustin Peterson, left, with Kwame Awuah-Offei, chair of mining and explosives engineering, and Spot, the robotic dog.

BETTER THAN LASSIE?

Dustin Peterson, a recent mining engineering graduate of Missouri S&T, was part of a nearly $4 million partnership with the National Institute for Occupational Safety and Health to determine if a robotic dog could help miners escape perilous situations.

Most of Peterson's research focused on understanding the perspectives of miners about the potential to use the four-legged Boston Dynamics Spot robot dog in their escape.

"For this project, we worked with several focus groups made up of industry professionals," he says. "We hosted Zoom meetings before the groups went down into the mines and asked them to discuss what different uses they could envision for the Spot robot for emergency situations."

His primary focus was having the Spot robot dog navigate ahead of miners after an emergency, such as a mine collapse, to find safe escapeways.

"Just imagine how dangerous of a situation it could be for miners who are trapped," he says. "The robot could help them. It could go into areas that humans could not access. It could have a thermal camera. It could have a gas monitor. There are several beneficial possibilities."

PREVENTING MINING POLLUTION

A Missouri S&T research group was recently awarded a grant from the Environmental Protection Agency (EPA) that is aimed at preventing pollution in the mining industry.

"What is exciting about this grant award is that we will be able to work to reduce pollution related to acid mist, while also providing assistance and suggestions to the mining industry," says **Guang Xu**, associate professor of mining engineering. "We will also focus on environmental justice and promoting this concept."

Xu will explore acid mist suppressants for the copper electrowinning industry that are more environmentally friendly than FC-1100, which is a fluorochemical reagent known as a "forever chemical" that can cause serious environmental issues.

Electrowinning refers to the process of adding ore into a chemical solution and introducing an electric current to separate the metal from the ore. One side effect of this process is the production of acid mist, made up of sulphuric acid and copper sulfate, which can be harmful for the environment.

REDUCING MANUFACTURING'S CARBON FOOTPRINT

With funding from the National Science Foundation, **Abhijit Gosavi**, professor of engineering management and systems engineering at Missouri S&T, is finding ways to reduce fossil fuel use in manufacturing.

His goal is to reduce the carbon footprint of manufacturing, which by some estimates accounts for up to 24% of fossil fuels burned in the U.S. If successful, less polluted air would be among the many benefits.

At the heart of his research is the development of methods of reinforcement learning, a subfield of artificial intelligence, to address inventory-control problems that arise in the remanufacturing industry.

Remanufacturing — a term that is not interchangeable with recycling — is a complex process in which parts that have not yet reached the end of their lifespan are used in product manufacturing.

Remanufacturing is in its early stages in the U.S., but Gosavi believes it presents opportunities, particularly for researchers. That community, he says, has taken it upon itself to set the goal to completely or partially remanufacture 70 percent of products made in the U.S.

"If we're serious about this, our goal should be to achieve that in 10 years," he says.

PHOTO FINISH

This close-up view of a detonator explosion inside ballistics gel is an example of explosives expert **Catherine Johnson**'s research. Johnson is the Robert H. Quenon Associate Professor of Mining Engineering at Missouri S&T.

MISSOURI S&T

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HELPING TEACHERS TEACH STEM

The Kummer Center for STEM Education provides students and teachers throughout Missouri with opportunities to learn about science, technology, engineering and math.

With the goal of widening and diversifying the pipeline of STEM educators and professionals, the STEM Center strives to increase equal opportunity and access.

The STEM Center offers summer camps on a range of STEM-related subjects, hosts field trips to the S&T campus and facilitates teacher training. Its activities focus on underserved, underrepresented and rural communities across Missouri.

In May 2023 the STEM Center expanded its reach with the addition of the STEM Mobile. It enables S&T to introduce young minds to the possibilities of studying and working in a STEM-related field by bringing science projects and experiments to school districts throughout the state.

STEMCENTER.MST.EDU