Fall 2020

re:search

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

RESPONDING TO COVID-19

Missouri S&T

MILESTONES IN HISTORY

In 2020–21, Missouri S&T marks a 150-year legacy of discovery, creativity and innovation.

2020 is a historic year. It marks the 150th anniversary of our founding.

Missouri S&T was chartered on Feb. 24, 1870, as the Missouri School of Mines and Metallurgy. Classes were called to order on Nov. 6, 1871. Since then, S&T has produced over 70,000 graduates, many of whom have gone on to help build and economically stimulate the state and nation. S&T's impact on the state, regional and national economy has been far-reaching over its history.

100 years of oil and gas industry leadership

In 1920, Missouri S&T started a petroleum engineering program in its highly respected mining engineering department — the fifth such program in the nation. In 2020–21, we will celebrate the petroleum engineering program's 100th anniversary.

20 years of systems engineering

Since 2000, when Missouri S&T established its systems engineering program, the university has prepared more than 500 graduates. S&T is the only university in the world to have four recipients of the International Council on Systems Engineering (INCOSE) Stevens Doctoral Award, and it's one of five programs in the world that meet INCOSE standards.

We can't wait to see what the next 150 years will hold.

150.mst.edu

DEAR FRIENDS OF MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

It is my honor to share with you this annual report, which highlights some of the outstanding research performed by the Missouri S&T faculty, staff and students.

In this issue of *re:search,* you will read how Missouri S&T responded to the coronavirus in many ways, including researching technologies to screen for the virus, evaluating the efficacy of masks and 3-D printing PPEs for use by our local medical center. You will see the breadth of Missouri S&T research: from learning about aging by studying the naked mole rat to developing a "bionic bowel," and from sensors that work inside 1,600-degree-Celsius molten steel to understanding the effect of thawing permafrost.

You will also get a glimpse of our student and faculty successes: Dr. Frank Liou won the SME Frederick W. Taylor Research Medal; Dr. Marek Locmelis became the latest S&T faculty member to receive an NSF CAREER Award; and Ph.D. student Andrew Hinkle received the NASA Space Technology Research Fellowship.

These research projects and awards are just a sample from this year's Missouri S&T *re:search* publication.

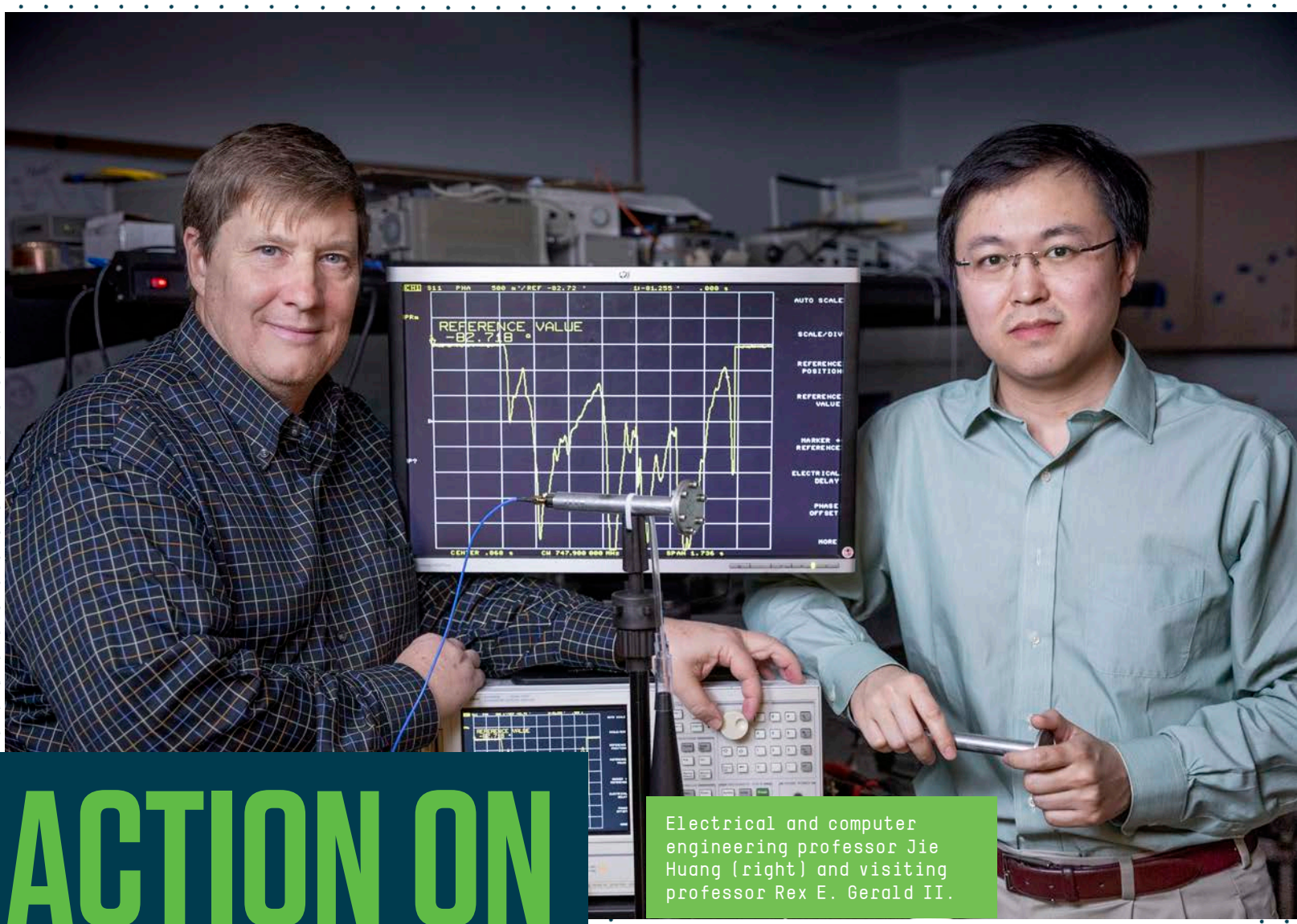
And they, in turn, are a small part of the overall Missouri S&T research performance for 2019–20: 186 of our faculty were awarded more than $48.5 million in research funds. The federal government funding comprises 85% of all sponsored research awards at the university, and industrial funding comprises an additional 11%. In 2019–20 Missouri S&T submitted 23 patent applications, was awarded 25 patents, and received $650,000 in royalty income from its inventions — a clear sign of the university's impact on the regional and state economies.

I hope that the stories in this newsletter offer you a snapshot of Missouri S&T as we continue to excel in our mission to perform research that serves the state and the nation.

Costas Tsatsoulis

Vice Chancellor of Research

INSIDE THIS ISSUE



Electrical and computer engineering professor Jie Huang (right) and visiting professor Rex E. Gerald II.

ACTION ON COVID-19

In labs and online, Missouri S&T took swift action in response to the pandemic

As the coronavirus pandemic swept across the globe last spring, Missouri S&T faculty and students responded swiftly. S&T adapted and adjusted its approach to research, education and outreach in efforts to stop future spread on airlines, build community online and equip medical workers on the front lines.

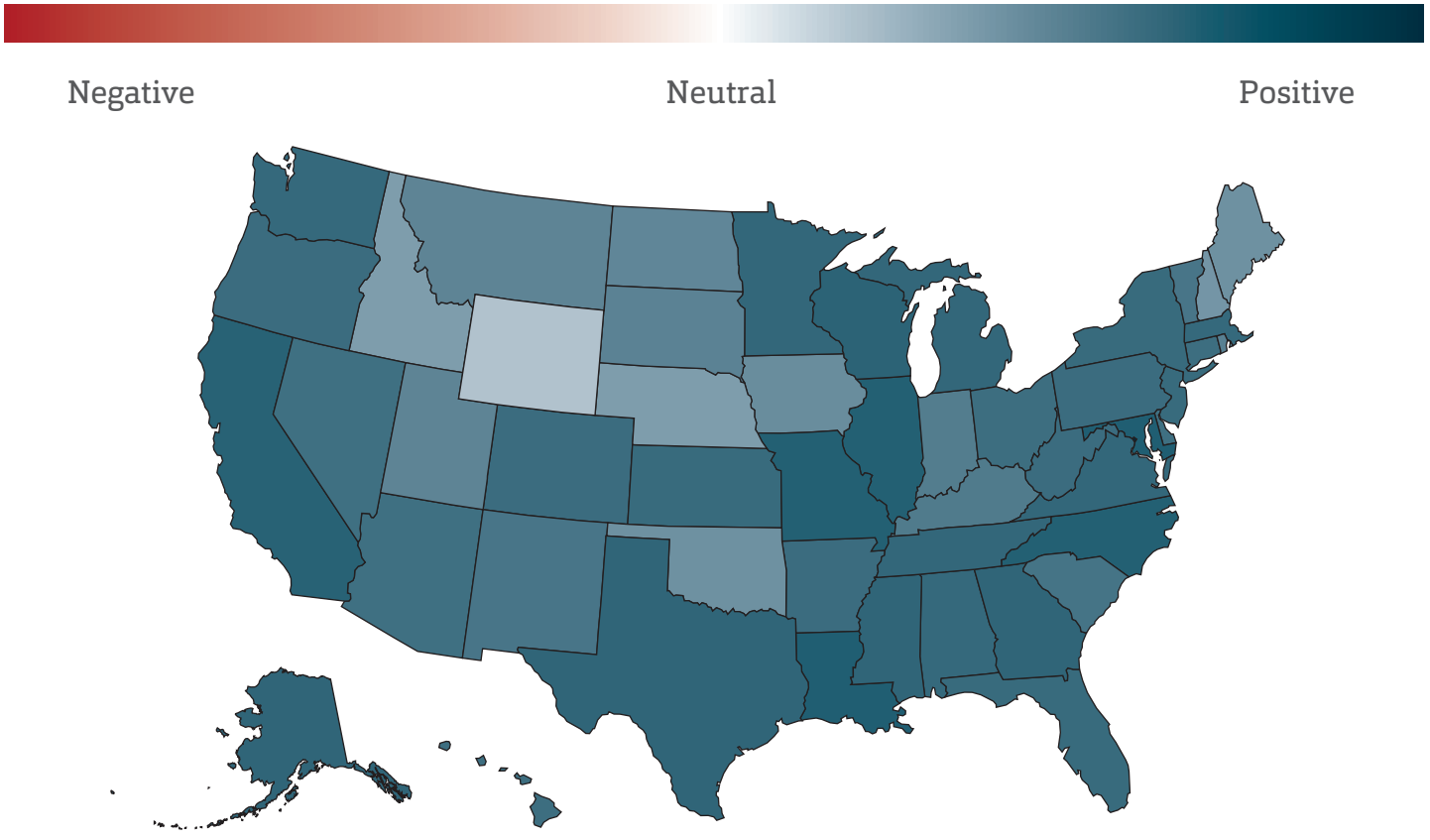
Airport screening

Even before the U.S. imposed travel restrictions in an attempt to halt the virus's spread, **Jie Huang**, an assistant professor of electrical and computer engineering at Missouri S&T, was devising a way to screen for the virus at airport security checkpoints. Now after several iterations of the prototype, Huang and his team are fine-tuning their airborne-biohazard detection system in hopes of getting it into airports and other venues soon.

Here's how the system works: A person exhales into a sensor that can detect viruses in the tiny aerosols emitted. If a virus is detected, a breath sample is chemically tagged for further testing in a spectrometer. The process would take less than a minute and could eventually differentiate between a cold, flu or coronavirus, Huang says.

Huang believes that the front-end sensor, which would indicate whether someone is sick or healthy, could be ready for clinical trials in about a year, adding that the full system with chemical tagging and a spectrometer will take longer. He was recently awarded $200,000 in Rapid Response (RAPID) funding from the National Science Foundation for the work.

Polarity (sentiment) over time



Polarity (sentiment) over time, captured August 14 from Kabir's interactive website detailing the information he has collected from his analysis — **mykabir.github.io/coronavis/**

Twitter tracking public sentiment

Much like headaches or queasy stomachs send many of us to WebMD or Google to self-diagnose our maladies, so the coronavirus drove millions to social media to post concerns, questions, rumors and hot takes about the virus. **Yasin Kabir**, a Ph.D. candidate in computer science at Missouri S&T, also took to Twitter — not to opine, but to analyze.

Kabir studied millions of coronavirus-related tweets last spring as part of his research on how attitudes toward COVID-19 change as information is spread on social media.

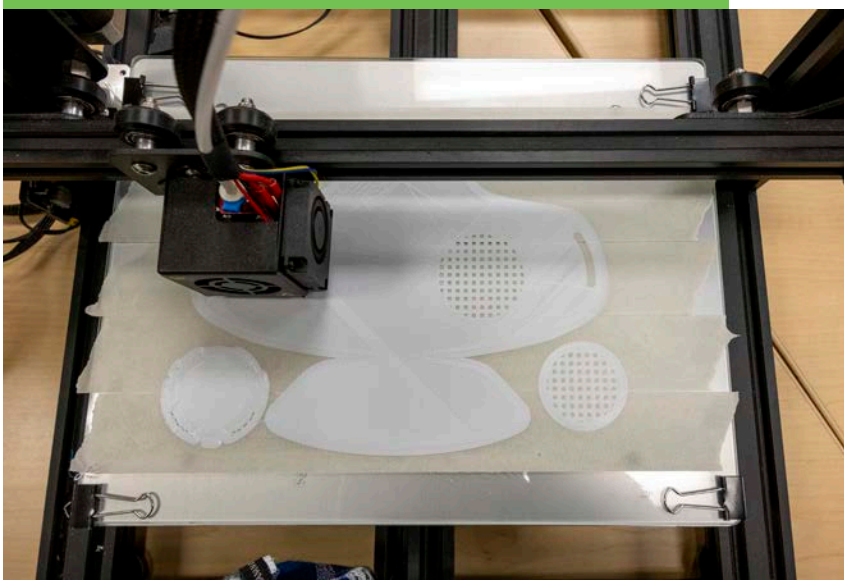
"We can see how people are reacting to news and officials' briefings about COVID-19. Are they comfortable, or are they more panicked?" Kabir says. "If we can understand that, we can help officials know how to share news in a way that avoids panic."

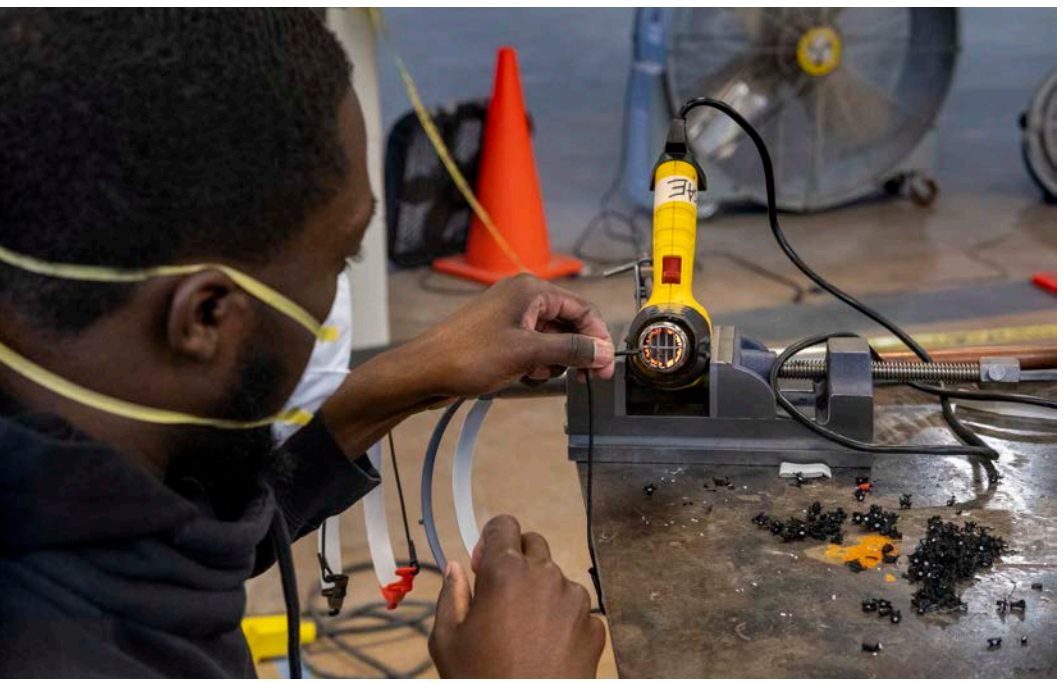
Kabir set up a website detailing the information he began collecting in early March. The site highlights trending topics and public sentiment, which portrays how attitudes shifted as the disease continued to spread.

"Early on, many people were skeptical of reports about the seriousness of the disease, and their sentiment was subjective rather than fact-based," says **Sanjay Madria**, Curators' Distinguished Professor of computer science, who worked with Kabir on the research. "Slowly they realized this is real, and their outlook has become more fact-based."

"As we analyze trending topics, we can see how thinking and behavior change over time," Kabir says. "That can help decision makers because they know how people are feeling."

From design to delivery, S&T partnered with Phelps Health to fabricate face masks and shields for the hospital and first responders.





To find a fitting filter

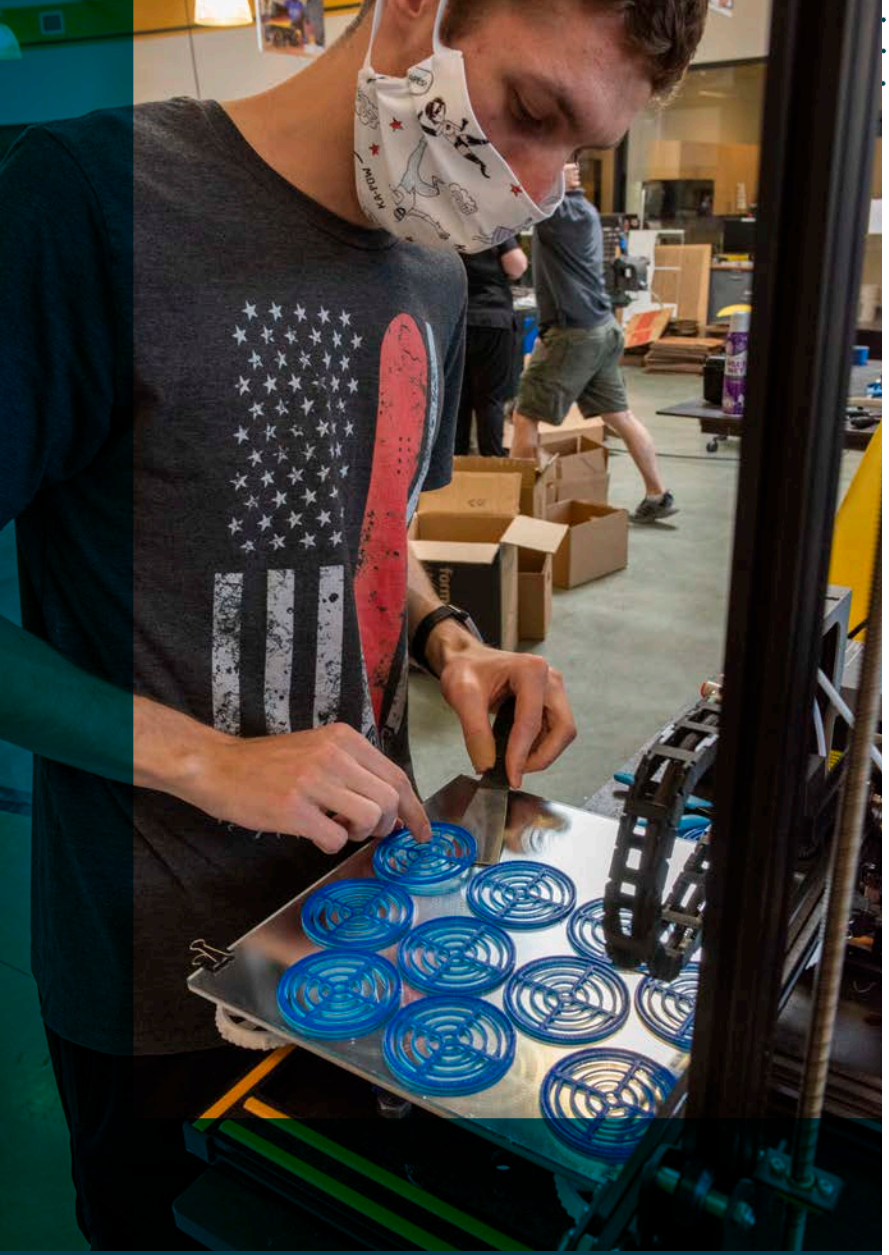
What is the best material for a face covering? People all over the U.S. have been asking that question since at least last April, when the federal government first suggested that cloth face coverings might help slow the spread of the coronavirus. The same question sent environmental engineer **Yang Wang** on his quest for an answer.

Intrigued by tweets about different types of cloths for face coverings, Wang decided to test a few common household materials, such as pillowcases, scarves and furnace filters. The assistant professor of environmental engineering studies how fine particles like aerosols are transmitted, and he wanted to apply his expertise to this problem, not only to satisfy his own curiosity, but also perhaps to help do-it-yourself mask makers.

Wang and Ph.D. student **Weixing Hao** tested various fabrics and materials and compared the "filtration efficiency" of multiple layers of each material against different aerosol particle sizes, ranging from a few nanometers to over 400 nanometers. Wang shared their preliminary results on Twitter and with numerous media outlets who first encountered his off-the-cuff study on that social network.

Wang and Hao found that the layers of scarves and bandanas did a poor job of filtering out aerosols. Pillowcase fabric fared somewhat better, depending on thread count. A 600-count pillowcase filters better than a 400-count one, the researchers determined.

But the best aerosol-blocking material of those Wang tested comes from commercially available household air filters. The multi-layered air filters work almost as well as n95 medical masks to block aerosols, especially smaller particles, according to Wang's initial findings.



Mask production

Even for a weekend before spring break, the Missouri S&T campus was abnormally quiet. Most students had left the campus for the semester as a precaution against the coronavirus. Most faculty and staff had also departed as they began to work and teach remotely. But 3-D printers in a couple of buildings on campus were humming away that weekend, fabricating prototype masks and face shield brackets for physicians and medical staff in the area.

Inside the Kummer Student Design Center, where S&T students usually work on rockets, solar cars, Mars rovers and other design projects, a few students, faculty and staff outfitted one room with a dozen 3-D printers to produce prototype masks for employees of Phelps Health, a medical center based in Rolla. Across campus, students at Missouri S&T's Makerspace were using their 3-D printers to fabricate prototypes of the face shield brackets. The project continued throughout the semester, resulting in hundreds of pieces of personal protective equipment for healthcare providers and local police and fire departments.

"This has re-energized our design team students," says **Chris Ramsay**, director of the Kummer Student Design Center at Missouri S&T. Hundreds of them had worked on entries for design competitions that were canceled due to coronavirus concerns. "This community need fulfills a hunger that they have to do something positive and meaningful in this crisis."

Teaching STEM to kids online

Members of Missouri S&T's Mars Rover Design Team spend a lot of time taking their robotic creations to elementary schools to pique children's interest in science, engineering and space exploration. This year, however, they adapted their traditional outreach visits to the world of Zoom and created virtual sessions for curious kids who were housebound during coronavirus pandemic school closures.

"Teaching future engineers and STEM innovators about space exploration is a big part of the Mars Rover Design Team's mission," says **Téa Thomas**, a senior in business and management systems at Missouri S&T. Thomas is public relations lead for the team, which is in its eighth year of rover-building for the University Rover Challenge. The international robotics competition is held in a barren desert area outside Hanksville, Utah, where the landscape simulates the surface of the planet Mars. Missouri S&T won the international event in 2017.

"We want to help parents and teachers who are homeschooling right now and need a break, and the outreach is a lot of fun for us," Thomas says. "We were all pretty sad when we couldn't visit the schools and groups like the Boy Scouts and Girl Scouts for our presentations."

In mid-March, Thomas issued a Facebook invitation to parents and teachers offering virtual outreach sessions about the team's Mars rover. She heard from almost 200 parents and teachers across five countries and 12 U.S. states. The sessions drew small groups of inquisitive children, mainly ages 6 to 9, who asked questions about the rover's assemblies, autonomous navigation system, programming languages and wheel construction, and its 15 motors.

Leonardo Sent, a fourth-grader from Orange County, California, attended all the S&T virtual sessions. "I liked it a lot," he says. "I learned how to use the Mantis suspension and how the many different assemblies you have work inside the body off the Linux operating system." ◻

NEW RESEARCH CENTERS BUILD ON CAMPUS STRENGTHS

The Center for Glass Science and Technology will draw on S&T's glass science expertise. Shown here: examples of specialty bioglasses developed at S&T.

Four new research centers and laboratories are building on Missouri S&T's strengths in materials science and engineering, civil infrastructure, and electrical power systems. The new efforts are supported by a University of Missouri System initiative.

The Center for Glass Science and Technology (CGST) provides equipment and lab space for the UM System NextGen Precision Health Initiative and Institute, which is expected to accelerate medical breakthroughs for patients in Missouri and beyond. The CGST builds on Missouri S&T's success in glass research, including the development of bioactive glasses to treat cancer and open wounds. Richard Brow, Curators' Distinguished Professor of materials science and engineering and interim deputy provost, leads the center.

The Center for Novel Carbon-Efficient Binders for Sustainable Infrastructure will focus on developing more sustainable and efficient binding agents for concrete. The bonding agents hold promise as being stronger, more durable and longer lasting. **Kamal Khayat**, the Vernon and Maralee Jones Professor of Civil Engineering, leads the center.

The Center for Infrastructure Preservation and Resilience brings together experts in data analytics, robotics and artificial intelligence to develop new approaches to the design, inspection and maintenance of infrastructure — from roads, bridges, buildings and tunnels to electrical power grids. The center is led by **Genda Chen**, the Robert W. Abbett Distinguished Professor of Civil Engineering.

A project titled "Energy Reliability and Resilience of Electrified Transportation Infrastructure" and the affiliated Electrified Transportation Distribution System Laboratory will be used to demonstrate and test new devices and systems for electric transportation, including light rail, electric ships, renewable energy systems and electric vehicle charging stations. **Mehdi Ferdowsi**, professor of electrical and computer engineering, leads the project.

In addition, Missouri S&T faculty are involved in two research efforts led by the University of Missouri-Columbia. Khayat is involved in a project to develop future urban infrastructure, and **Stephen S. Gao**, Curators' Distinguished Teaching Professor of geology and geophysics, is part of a team that will develop capacity for using geospatial-enabled data for a breadth of research across the four-university UM system.

Students use a driving simulator on the Missouri S&T campus to test the Route 160 roadway design before construction.

ROAD RESEARCH WARRIORS

Before they graduated, S&T alumni **David Doell** and **Matt DeMoss** used a driving simulator to help a civil engineering firm test the safety of a Missouri highway expansion before roadwork began.

Civil engineering firm Crawford, Murphy and Tilly Inc. (CMT) invested funds from its Springfield, Mo., office to allow S&T students to develop simulations of the current Route 160 from Springfield to Willard as well as the proposed roadway design, and test them with actual drivers using a simulator on campus. The testing allowed CMT to establish a baseline of data on driver behavior before and after the improvements.

"It's a high-crash area with numerous fatalities," says Steve Prange, regional office manager for CMT in Springfield. "There is a lot of traffic with young inexperienced drivers going from Springfield to Willard for high school."

Doell taught himself a coding language called Python to program the driving simulator. DeMoss prepared and converted CMT's design drawings for input into the simulator's software.

Then they recruited 27 participants from ages 16 to 67 drive the simulations. They collected data about each volunteer's driving habits as well as their verbal comments while driving.

"The simulator provides a much cheaper way to evaluate the roadway and how it will interact with real drivers without having to spend millions of dollars to build it and then having to go back and make changes afterwards," says DeMoss.

"Especially with new ideas," says Doell. "If they're building another intersection, engineers have done quite a few of those, and they have data. But for something like the roundabout that's new to this area, it helps a lot to have this simulation."

WHAT CAN THE NAKED MOLE-RAT TELL US ABOUT AGING?

Common theory suggests that aging is caused by accumulated cellular damage from the byproducts of oxidative metabolism — or the way our bodies burn oxygen to produce energy. Once a certain threshold of oxidative damage is reached, we die.

But that theory doesn't seem to apply to naked mole-rats, which can live 10 times longer with higher oxidative damage than mice of comparative weight.

To explain the contradiction, **Chen Hou**, an associate professor of biological sciences at Missouri S&T, and his team developed a data-based theoretical model that estimates oxidative damage accumulation with age.

During growth, naked mole-rats expend more energy than mice, and by the end of their growth, they have accumulated more oxidative damage. During adulthood, the low metabolism of naked mole-rats significantly slows the speed of damage accumulation to less than that of mice.

Hou says the observation led to his hypothesis that mice have lower oxidative damage than naked mole-rats for most of their life, but they will also reach the oxidative damage threshold sooner than naked mole-rats, which causes them to die sooner.

"If our hypothesis is proven, the model can become a theoretical framework to learn how differences in children's developmental traits — such as growth rate, birth-to-adult weight ratio, and the energetic cost of biosynthesis — will affect their adult health and lifespan," says Hou.

Balancing TECHNOLOGY'S TRADE-OFF

As many working Americans retreated to home offices during the coronavirus outbreak, Zoom gatherings became a way of life. Faculty taught courses via Zoom and university staff filled their calendars with online meetings. Of course, there were glitches. Many of us had that sneaking suspicion that these video meetings were somehow lacking.

Turns out, we may be right.

Inspired by research showing people had more trust in robots in the same room than robots observed on video, three psychology faculty members set out to determine if the same holds true for humans.

Clair Kueny, Denise Baker and **Devin Burns** (above, left to right) use the job interview process to define the potential dehumanizing effects of video-mediated communications or VMC tools. So far, results show that passive observers viewing an applicant by video have more negative perceptions than passive face-to-face (FTF) observers.

"This finding has relevance for higher education, where courses are offered as distance classes, and students can watch them live from anywhere in the world," says Kueny. "The distance students may form more negative impressions of the instructor than the in-class students, for no other reason than the medium of communication."

In the next phase, the team will look at how the effect is influenced by additional variables like gender and interview quality. Participants will wear mobile eye-tracking glasses to examine whether the visual cues people pay attention to differ between VMC and FTF observation.

THE SEARCH FOR CHEMISTRY'S HOLY GRAIL

In the chemical process, catalysts cause or accelerate chemical change, which makes them central to the chemical and energy industries. Creating stable catalysts that are highly active (increasing the rate of chemical reactions) and highly selective (able to direct a reaction to a desired yield) is essential to future sustainability.

Normally there is a tradeoff between activity and selectivity, but with funding from the National Science Foundation, S&T researchers **Xinhua Liang** and **Jee-Ching Wang** are developing catalysts that are highly selective, highly active and highly stable. These catalysts will dramatically increase reaction selectivity without significantly decreasing catalyst activity, the researchers say.

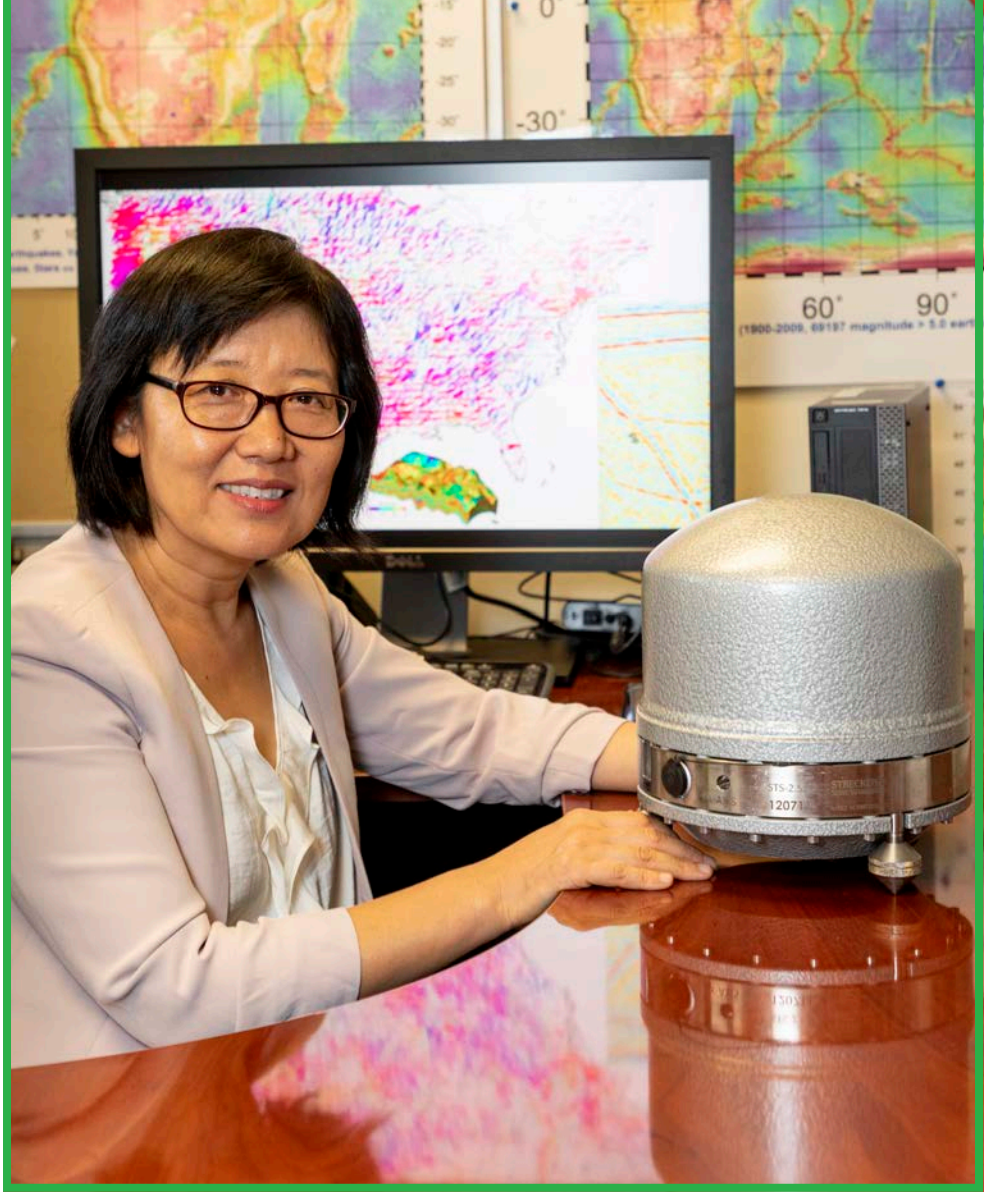
"This is the holy grail of various research in the chemical process industry carried out by chemical engineers and scientists," says Wang, an associate professor of chemical engineering.

Using molecular layer deposition (MLD), the researchers create ultra-thin overlayers with precise thickness control and well-defined porous structures. Pore size is controlled by altering MLD chemistry, oxide types and methods of forming porous structures.

"Like traffic controls, only the reactant molecules with proper sizes and orientations would be allowed to reach the reaction sites through pores with specific sizes," Liang says.

Their objective is to create these catalysts, but also to understand the relationships between structure, activity and selectivity using experimental and molecular modeling.

The research will advance knowledge of the fundamental science of surface chemistry, heterogeneous catalysis and the development of new materials. But because the proposed strategy is universal, it can be applied to nearly any kind of supported metal catalyst or in other energy-related fields, like sensors, fuel cells, batteries and supercapacitors.



PREDICTING EARTHQUAKES BY ANALYZING THE PAST

The southern California earthquakes of summer 2019, one a 6.4 magnitude and another a 7.1 magnitude, make accurately predicting when and where the next one will occur more important than ever.

Kelly Liu, a professor of geosciences and geological and petroleum engineering at Missouri S&T, is doing just that. With funding from the National Science Foundation Geophysics Program, Liu is digging deeper into the earth's past data by analyzing shear-wave splitting.

Shear-wave splitting occurs when a wave originating from an earthquake travels through a directionally dependent area formed by plate motion, causing it to split into two waves.

"The relative movement of the tectonic plates against each other produces majestic mountains and deep ocean basins, but also causes earthquakes and volcanic eruptions," says Liu. "Improving our understanding of such processes is essential not only for understanding how the earth works, but also for reliably predicting and mitigating natural hazards."

Liu is analyzing wave data from 1980 to present. She says most previous studies relied on the assumption that there is only one layer of anisotropy and the tendency for waves to travel along certain areas, much like wood tends to split along the grain.

"The recent dramatic increase in the number of seismic stations and recorded earthquakes suggests that the actual situation is more complicated," says Liu.

Because the seismic processes that lead to tsunamis, earthquakes and volcanic activity happen deep in the earth's core, they can't be directly observed. That's where Liu's work comes in.

"Indirect tools, such as relying on computer analyses of a large amount of geophysical data collected at the earth's surface, are essential for accurate and useful predictions," she says.

THE POWER PLANT OF THE FUTURE

The power plant of the future could be smaller, highly efficient and even portable, and S&T researchers in materials science and engineering are helping make this transformation happen.

With $1.45 million from the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E), **David Lipke** is leading a team to develop more efficient heat exchangers for energy production. The devices are commonly used in chemical plants, petroleum refineries, and refrigeration and air-conditioning systems.

Lipke's team is using advanced manufacturing processes to construct compact heat exchangers from ceramic materials that can operate in the extreme environments of next-generation power cycles.

"Operation of a heat exchanger under these extreme conditions has never before been attempted," says Lipke, an assistant professor of ceramic engineering and the project's principal researcher. "Missouri S&T is uniquely poised to overcome long-standing materials challenges because of our expertise in ceramic additive manufacturing and joining methods and our unique facilities to test materials in extreme environments."

Future power plants will be designed to operate at extremely high temperatures and pressures to maximize thermal efficiency. The high temperature reduces emissions and water consumption; high pressures increase power density and dramatically reduce the size of turbomachinery components.

The researchers are using the ARPA-E funding to build recuperative heat exchangers that operate at temperatures from 1,292 degrees Fahrenheit up to 2,012 degrees F by replacing high-strength metallic superalloys with ultra-high-temperature ceramics.

BROADBAND INVESTMENT = ECONOMIC IMPROVEMENT

The FCC is investing $176 million over 10 years to connect Missourians in rural areas to high-speed internet as part of the Rural Digital Opportunity Fund. But with more than 1 million residents who need access, systems expert **Casey Canfield** says bridging the digital divide will also take an investment in broadband research.

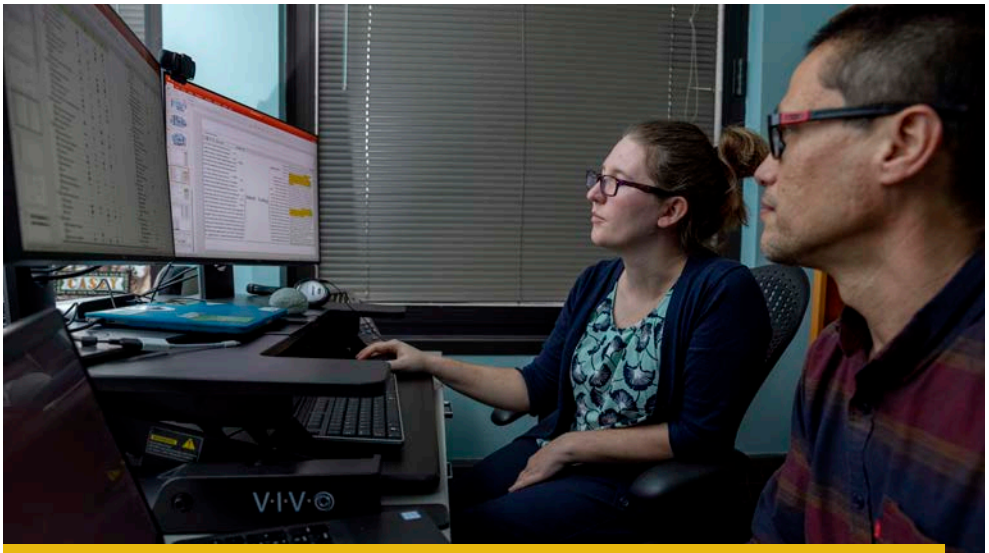
Canfield, an assistant professor of engineering management and systems engineering, interviewed officials from 16 of Missouri's 19 regional planning commissions (RPCs) to determine what prevents rural broadband access.

Hardware costs and financing are the biggest barriers to broadband deployment in rural communities, Canfield says. And that's where current research has been focused.

"But we could also move the needle in bringing down the soft costs or non-hardware costs of broadband," says Canfield.

The soft costs include helping public-sector groups learn as much about broadband as private-sector firms like telecommunications companies. Canfield says that better data and analysis could help those groups make more strategic decisions.

"If people agree that RPCs should be an important group in planning broadband efforts, they need funding to do that," says Canfield. "Pretty much everyone understands that rural broadband access is a problem, but some RPCs feel more able to take action in solving it than others.



Missouri S&T systems expert Casey Canfield (left) and graduate student Javier Valentín-Sívico review data on broadband in Missouri.

"Broadband is critical infrastructure for economic development in rural communities," Canfield says. "Attracting new businesses and enterprises without reliable high-speed broadband access is very challenging."

HIGH-PERFORMANCE SUPER RESEARCH

High-performance computational (HPC) simulations have become a third, independent scientific method that can complement — or even replace — traditional laboratory experiments and theoretical studies.

Missouri S&T is leading a multi-institution partnership to enhance HPC-enabled research and educational activities across the state of Missouri. And now, thanks to a $1.96 million grant from the National Science Foundation, the university has a new supercomputer on campus to help.

"The explosive growth in computing power now lets us tackle problems that would be almost unsolvable without a computer because they would be too expensive or dangerous to study through experiments," says **Thomas Vojta**, Curators' Distinguished Professor and chair of physics at Missouri S&T.

The system, named "The Foundry" in reference to S&T's origin in 1870 as the Missouri School of Mines and Metallurgy, will operate at a speed of 320 TFlops, or trillion floating point operations per second for mathematical calculations using decimals.

"The Foundry will support research in materials science, physics, chemistry, biology, mathematics, geoscience and engineering, focusing on computational simulations that explore the properties of matter and materials starting from the atomic level," Vojta says.

He says the supercomputer will also allow researchers to develop new simulation algorithms suitable for the exascale supercomputers of the future. Exascale supercomputers are systems capable of processing a quintillion — or a billion billion — calculations per second.

WORKING WITH YOUR HANDS AND YOUR MIND

Growing up in the rural Missouri farming town of Princeton, **Joshua Schoonover** developed a healthy respect for manual labor and a love of nature and outdoor activities. His love of math and science led him to engineering.

"I was looking for a field of study that balanced manual labor and outdoor work with design and engineering challenges," Schoonover says. "To me, mining is the perfect balance. This has been the type of work I have seen myself enjoying and being around, and that idea has been reinforced through my internship experiences."

In late 2019, Schoonover interned at Cleveland Cliffs, an Ohio-based iron ore mining company. He worked at the company's Hibbing Taconite Mine near Hibbing, Minn.

Schoonover says mining is one of the most underrated industries, but he hopes to change that.

"Public knowledge regarding mining appears to be lacking," he says. "Most people don't understand the importance of mining to economies, infrastructure and technology. I want to help bring that awareness to as many people as I can, and becoming a part of the mining industry is the best approach."

When he graduates, Schoonover plans to get a job as a mining engineer. In the meantime, he's soaking up all the experience he can get. He's the immediate past president of the S&T student chapter of the Society for Mining, Metallurgy and Exploration, and he's a member of the Mine Rescue Team.

"I am the first aid position on the Gold Team," says Schoonover, who previously served as captain of the Black Team. "I am on the team to get more involved in the department and learn more about mine rescue operations. It exposes me to industry teams and MSHA (Mine Safety and Health Administration) personnel as well."

His hard work is already paying off. This past fall, he received the Allen J. Hale scholarship for the second consecutive year.

The scholarship, established in Hale's memory in 2008, helps undergraduate engineering students work toward a minor in explosives engineering. Hale, who died in 2007, worked for Dyno Nobel Inc. His son, Joe, a 2002 mining engineering graduate, is assistant superintendent of Bussen Quarries.

Schoonover says the more he learns about mining engineering, the more excited he gets about the opportunities in Rolla and beyond.

> "I WAS LOOKING FOR A FIELD OF STUDY THAT BALANCED MANUAL LABOR AND OUTDOOR WORK WITH DESIGN AND ENGINEERING CHALLENGES."

"This industry is the perfect blend of working with your hands as well as your mind," Schoonover says. "It's an industry I am excited to become a part of, and one that the country relies on more than most know."

A GEM OF A SCHOLAR

Jose L. Corchado-Albelo joined Missouri S&T last fall as the first GEM University Fellow in over a decade.

As a member of the National GEM Consortium, S&T is working to encourage students like Corchado-Albelo and others from underrepresented groups to pursue master's or Ph.D. degrees in engineering or science disciplines.

Corchado-Albelo is pursuing a master's degree in mining engineering. He earned a bachelor's degree in geology from the University of Puerto Rico at Mayaguez in July 2018 following an internship at the University of Texas-Austin, where he worked in the Jackson School of Geosciences' UT Chron Geo-Thermochronometry Laboratory.

At S&T, Corchado-Albelo studies mining reclamation — the process of restoring land that has been mined. He's also interested in rock mechanics, mineral characterization and mine planning. As a GEM University Fellow, Corchado-Albelo holds a 50% graduate research assistantship position and receives full coverage of tuition and fees.

THE SKINNY ON THE WORLD'S THINNEST HOLOGRAM

By reconstructing tiny holographic images of the Chinese character for the word "light," two mechanical engineering researchers demonstrated their concept for creating holographic images that could lead to the creation of smart watches with holographic displays, printed security cryptograms on bank notes and credit cards, and new possibilities for data storage.

Researchers **Xiaodong Yang** and **Jie Gao**, both associate professors of mechanical and aerospace engineering, reconstructed several kinds of holographic images with tungsten disulfide monolayers of the thickness of around 0.7 nanometer. A nanometer is one billionth of a meter, and a tungsten disulfide monolayer only contains one layer of tungsten atoms sandwiched between two layers of sulfur atoms.

Their work was published in the research journal *Nano Letters*.

FACULTY KUDOS

In 2019, NASA honored five S&T researchers with the Group Achievement Medal for their participation in the NASA/DLR (German Aerospace Center) Multidisciplinary Airborne Experiment. The team was recognized for outstanding achievement conducting cruise-altitude and ground experiments to characterize fuel effects on aircraft engine exhaust composition and contrail microphysics.

Philip Whitefield, Chancellor's Professor and professor emeritus of chemistry, directed the S&T portion of the project in a mission held in Germany. Team members included assistant research professor **Wenyan Liu**, senior electronics technician **David Satterfield**, Cloud and Aerosol Sciences Laboratory (CASL) senior research specialist **Max Trueblood**, and **Steven Achtenberg**, senior research specialist for CASL and the Center for Research in Energy and Environment.

RECYCLE YOUR SOLAR PANELS

The U.S. gets about 2.3% of its electricity from solar energy, and solar energy use is only expected to grow. By some estimates, nearly half a million solar panels are installed every day. But what happens to all those panels once they're no longer usable in 20-30 years?

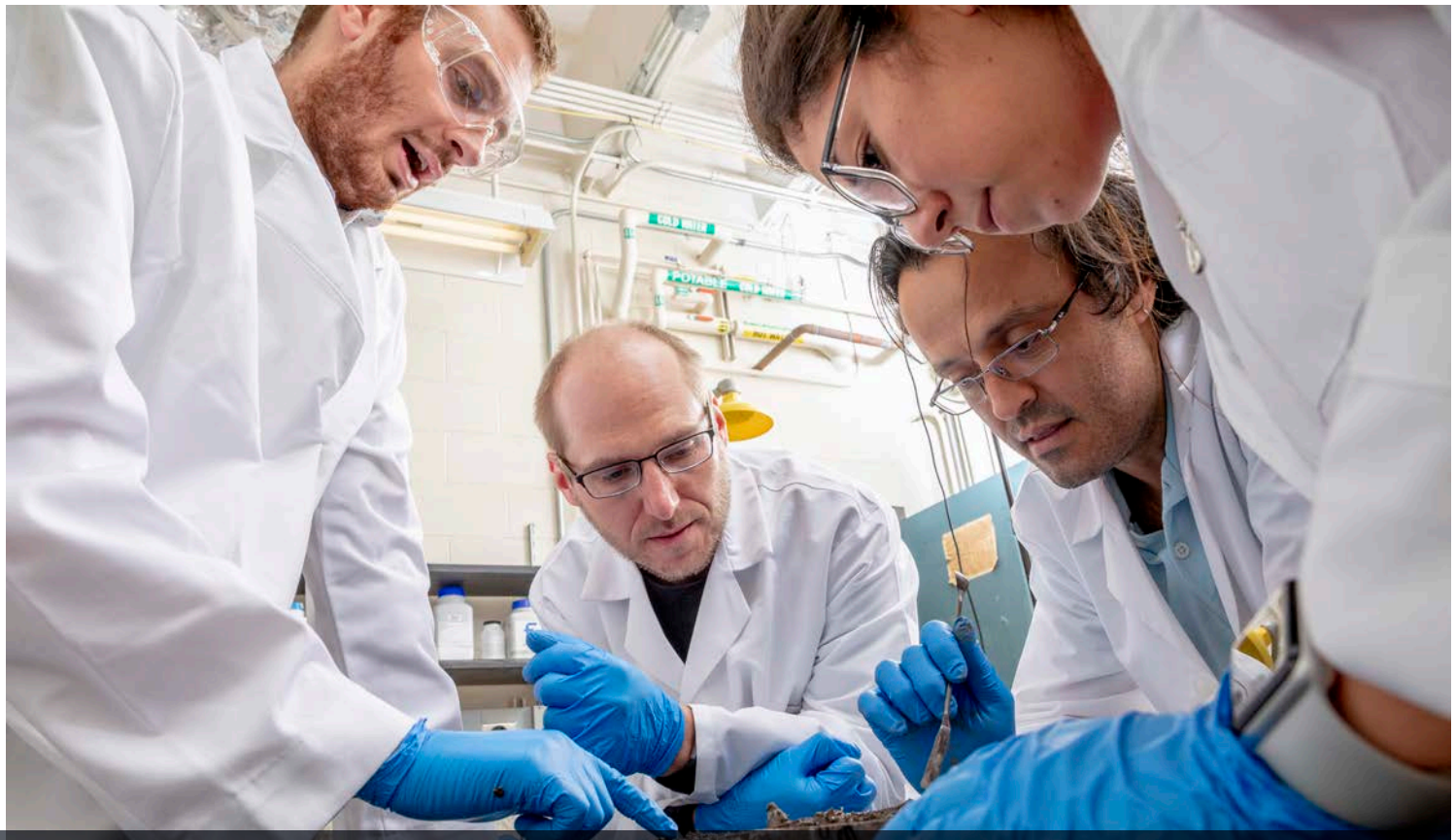
S&T Ph.D. student **Thomas Yarbrough** (above, right) is working with architectural engineering assistant chair and associate professor **Stuart Baur** (above, left) to help modify state- and local-level recycling efforts by educating current owners about disposal options.

"People don't realize the sheer number of panels that are installed each year," Yarbrough says. "In just the past few years, the solar panel industry has averaged half a million panels being installed each day — eventually we will have piles of these things lying around."

By providing a better understanding of current salvaging options, they hope to improve recycling efforts and to establish a baseline measure for what solar panels are still usable. They also hope to create new public awareness programs focused on reusing and repurposing panels.

Working with the Ozark Rivers Solid Waste Management District, Bauer will form potential guidelines and procedures that the industry and state could use to increase reuse.

"Unchecked, the current direction could lead to a crisis in waste management, where unprepared regions will see large amounts of under-utilized, discarded paneling," Baur says.



MAREK LOCMELIS: GEOSCIENCES ROCK STAR

What do flood-water contamination, mineable platinum deposits and the trigger for human life on Earth have in common? Answer: **Marek Locmelis**, Missouri S&T geosciences researcher.

Locmelis is an economic geologist with expertise in geochemistry, petrology, planetary evolution and analytical chemistry. His current research spans a variety of topics.

In a 2019 paper published in *American Mineralogist*, Locmelis examined if and how oxygen bound in minerals and magmas in the interiors of planets can affect the composition of oceans and atmospheres and contribute to whether a planet is habitable.

The work uncovered possible clues into the rise of oxygen-based life forms on our planet. Known as the Great Oxidation Event, changes to our planet some 2.4 billion years ago paved the way for the rise of all lifeforms that use oxygen to break down nutrients for energy.

"Without the Great Oxidation Event, there would be no plant and animal life on Earth or at least no life on Earth as we know it — including us," says Locmelis, who also studies how metals and other contaminants are redistributed during catastrophic flood events, such as the 2019 floods along the Missouri and Mississippi Rivers.

Researchers know little about how these materials may affect public health and safety in rural and urban areas. But Locmelis leads a team, with funding from an NSF rapid response grant of almost $45,000, to identify floodwater contaminants, understand how they are transported and deposited, and determine any potential public health risks.

The team gathered samples of soils and water from floodplain and non-flooded areas around the Missouri and Mississippi rivers — upstream and downstream — near St. Louis to analyze the pH and metal composition and search for other organic materials that point to a loss or enrichment of nutrients.

They hope to help leaders in the region better understand how floods affect the soil and water and better recover from these increasingly common natural disasters.

Locmelis also studies supply chain resilience for critical minerals, such as cobalt and rare earth elements, as well as economically important metals such as nickel, copper and platinum — where they come from, how they are transported, and where they are most likely to be concentrated in mineable deposits.

That research led to a five-year, $550,000 Faculty Early Career Development (CAREER) award from the National Science Foundation.

"Most known world-class metal deposits formed relatively close to the Earth's surface," says Locmelis. "However, a recent decline in major discoveries suggests that most of the easily accessible, near-surface deposits have already been found. To guarantee a steady metal supply in the future, we must look at deeper levels in the Earth, which the CAREER award will help me to do."

THE GAME OF BIAS

Teaching about hot-button topics like gender bias is challenging because they can threaten the way students view themselves and provoke defensiveness.

To help overcome this, **Jessica Cundiff**, an assistant professor of psychology, and a colleague at Ramapo College of New Jersey developed a game to teach about gender bias in an interactive, engaging and non-threatening way.

The game is called *WAGES: Race to the Top*. WAGES stands for Workshop Activity for Gender Equity Simulation. Players are randomly divided into two teams they later learn represent women's experiences and men's experiences.

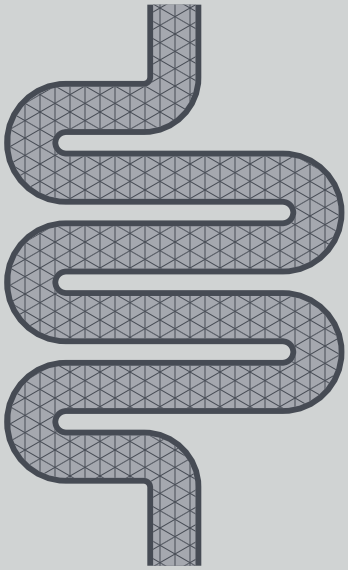
The concept was originally developed by a Pennsylvania State University psychology professor, Cundiff says. The original game targets faculty and university administrators, but Cundiff's version is designed for students.

"The object of the game is to climb the corporate ladder to be the first player with CEO status and a corner office," Cundiff says. To advance, participants draw cards describing issues that contribute to gender inequity, like gender role expectations, salary, mentoring, workplace climate, and token status.

"A side-by-side comparison of the cards illustrates the seemingly minor biases women experience compared with men's experiences," Cundiff explains. "For example, a women's card might read 'A men's team coworker gets credit for something you said at a meeting' while the men's card would read 'You get credit for something you said at a meeting.'

"The discrepancies seem small and innocuous at first, but over the course of the game, they grow to produce large disparities between the two teams," Cundiff says. "In this way, the game simulates how small gender biases accumulate to negatively affect women in the workplace."

At the end of the game, players participate in a structured group discussion that reveals how the game represents the experiences of women and men in the workplace. They also discuss how gender bias intersects with racial and other forms of bias.

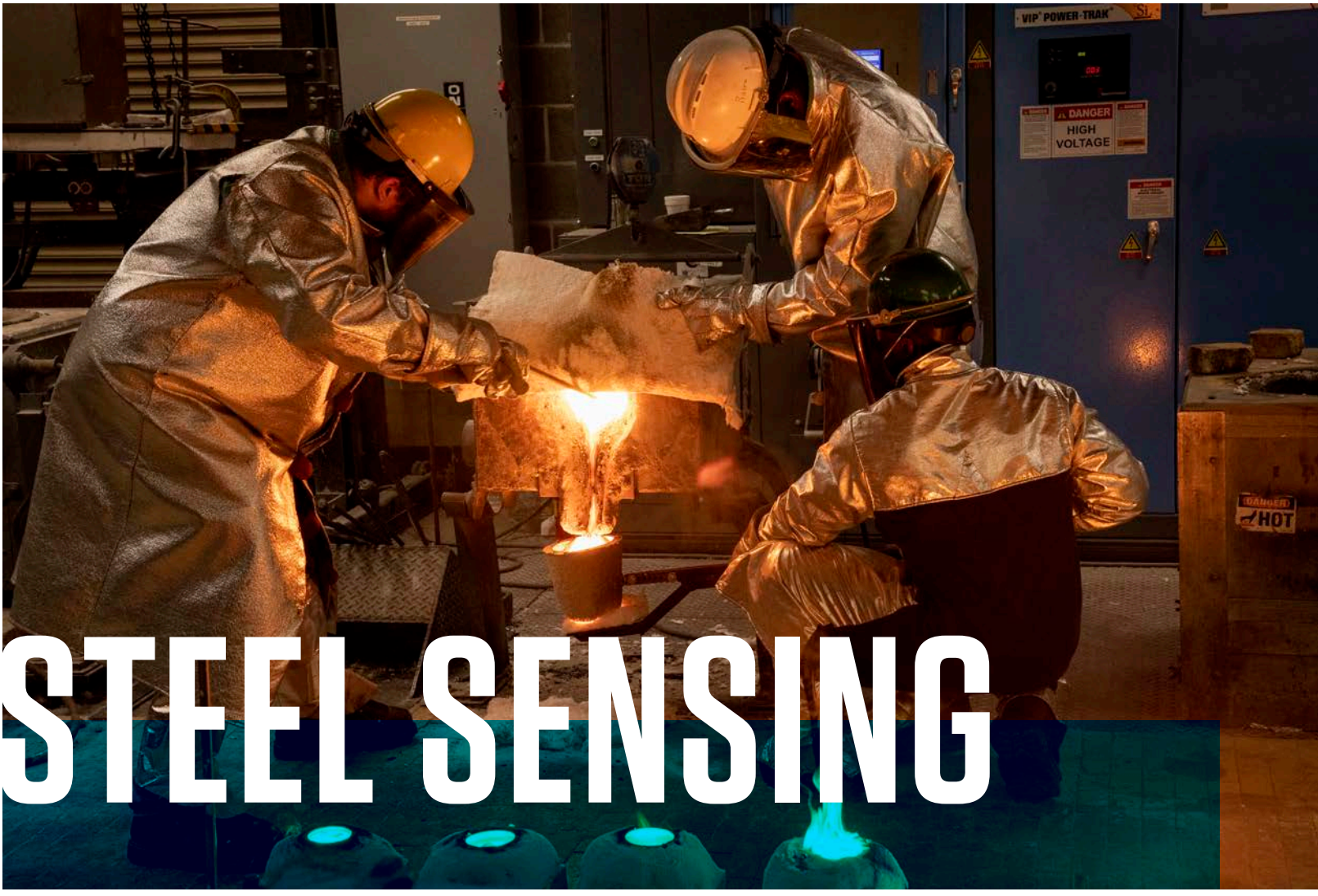


'BIONIC BOWEL' COULD SPARE CROHN'S SUFFERERS

Combining biology theory with ceramic engineering ideas, S&T senior **Vanessa Mahan** developed a way to change the pH level in the body of a Crohn's disease patient using bioactive glass.

The chronic inflammatory bowel disease typically causes irritation that can lead to ulcerations and scarring. Mahan found she could repair the damaged tissue by including the biomaterial in an oral medicine that dissolves and prevents scar tissue. The method would allow physicians to implant bioactive glass in the human body noninvasively.

Mahan's idea earned second place in a "Shark Tank" style competition through the University of Missouri System's Entrepreneur Quest program. In addition to an award, she received a business model and an educational program plan, as well as mentorship from executives, leaders, investors and subject matter experts. She will also have a chance to participate in other pitch and demonstration competitions.



STEEL SENSING

Steelmaking requires handling corrosive metal and oxide fluids at extremely high temperatures — about 1,600 degrees Celsius, which is several hundred degrees hotter than fresh lava from Mount Kilauea in Hawaii. Measuring the temperature, chemistry and fluid flow of molten steel under these conditions in real time is important to allow rapid response to any changes in the steel during its production.

With a $2.2 million grant from the U.S. Department of Energy, **Ronald O'Malley** is leading a team of S&T researchers to develop new, efficient ways to record those measurements during steelmaking. The work will cut costs and improve worker safety.

"We use embedded fiber-optic sensors to provide high-resolution, real-time measurements at high temperatures," says O'Malley, the F. Kenneth Iverson Endowed Chair of Steelmaking Technologies at Missouri S&T. "Fiber optics traditionally used for temperature and strain measurements use silica fibers, which can withstand 600 to 800 degrees Celsius. We have an approach that allows us to use high-temperature alumina fibers that can withstand temperatures of greater than 1,600 degrees."

Jie Huang, assistant professor of electrical and computer engineering and director of S&T's Lightwave Technology Laboratory, invents and develops fibers and the associated analysis equipment, and O'Malley and his team test the fiber sensors in applications conducted in S&T's high-temperature foundry.

The sensors also give information about the life expectancy of equipment, O'Malley says. Fiber-optic sensors can be used to measure temperatures in the linings of vessels used in steelmaking and to gauge wear and erosion, he says.

A single optical fiber can provide tens of thousands of measurements along its length, as opposed to traditional single-point sensors, to feed artificial intelligence control systems that use the data to control the process as it occurs. This could result in cost savings, O'Malley says.

Fiber optics can also be used for real-time chemical analysis of slag systems by sending spectral measurements directly to a spectrometer. Currently, samples must be extracted, cooled, crushed and ground for analysis, which takes time that could be saved by using fiber optics.

The research is generating greater interest in university-industry collaboration, O'Malley says. Of two research programs underway, one is funded by industry members of the Kent D. Peaslee Steel Manufacturing Research Center at S&T. O'Malley, who is director of the center, says most of the major steel producers in the U.S. are members.

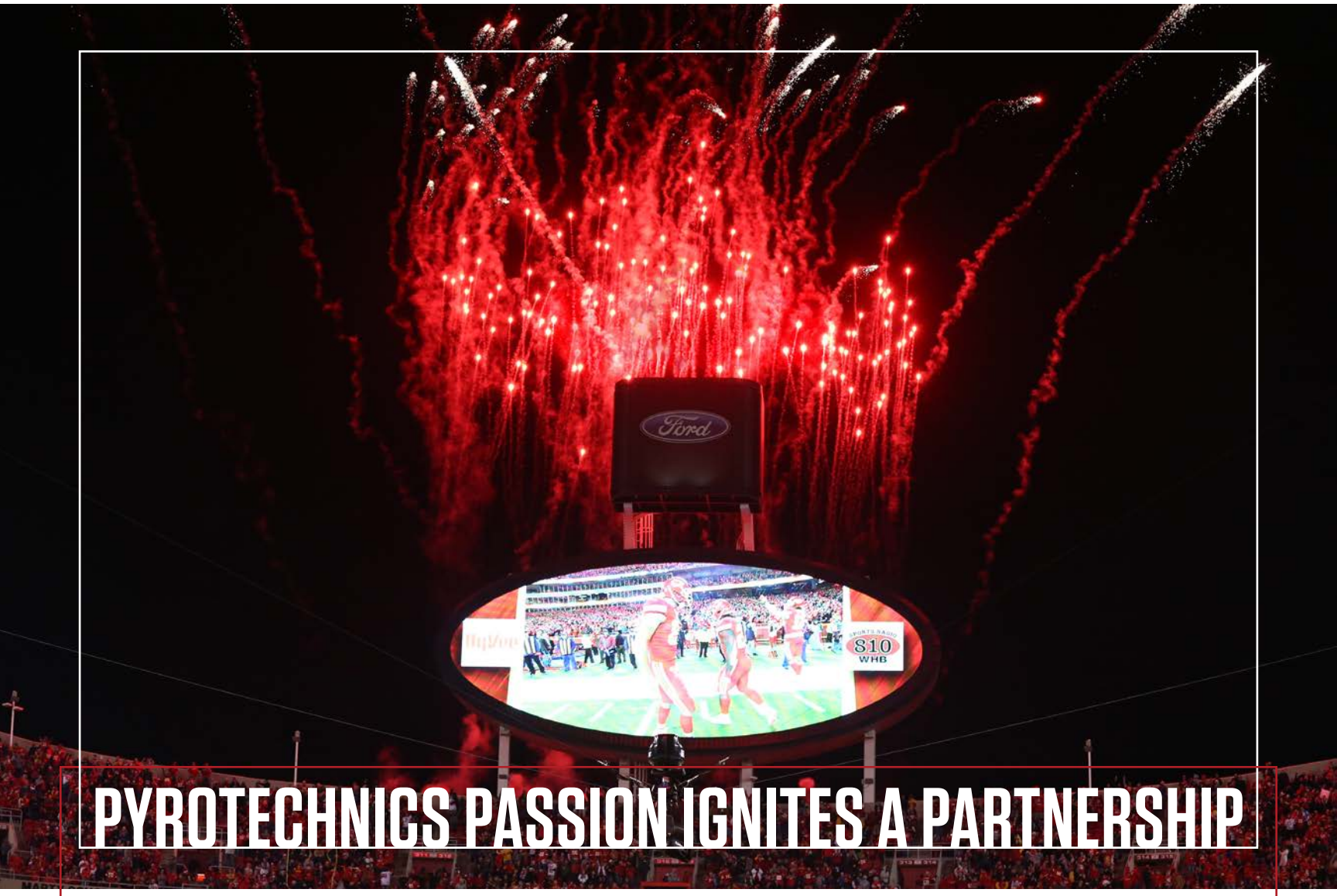
AT THE JUNCTION OF HUMANITIES AND TECHNOLOGY

Missouri S&T is building a 1,150-square-foot communication hub where students and faculty can work together to study how science, technology and the humanities shape — and are shaped by — society, culture, politics and the environment.

"We envision faculty and students using this space to apply cultural, historical and scientific analysis to some of the world's most pressing concerns," says **Kate Drowne**, interim vice provost and dean of the College of Arts, Sciences, and Business. "We want to create a collaborative space that integrates creativity, critical thinking and digital literacy, and allows us to share humanities-based research with today's technologically driven world."

Called the Collaboratory, the lab will be divided into three distinct areas. One section will house educational displays and will be open to the campus and members of the community. A separate collaboration room will have large monitors and whiteboards and feature 3-D scanning and printing capabilities. This space will allow faculty and students to plan digital pop-up museums, podcasts, oral histories and geographic information system (GIS) mapping projects. The third space will include a digital production studio to create podcasts, professional-quality presentations and green-screen video recordings.

"S&T students are some of the best and brightest from around the world," says Drowne. "They're studying engineering, humanities, sciences and business disciplines, and we want them to understand how different elements of their curriculum are interconnected."



PYROTECHNICS PASSION IGNITES A PARTNERSHIP

Jerry Vaill had just retired from the U.S. Geological Survey after a 30-year career as a hydrologist when he caught an episode of "The Detonators" on the Discovery Channel in 2009. He was surprised to find that the hosts of the documentary series, **Paul Worsey** and **Braden Lusk**, had ties to his alma mater, Missouri S&T.

But what caught his attention was something else: the university offered a certificate program in explosives engineering — and had just launched the nation's first master's degree.

"Within a few weeks, I was enrolled," says Vaill, an S&T civil engineering graduate who earned a master's in explosives engineering in 2012. "Every kid loves fireworks and some of us never grow out of it."

S&T mining engineering graduate **Matt Coy** seconds that. As a teenager, he helped his dad put on Fourth of July fireworks shows for the local Masonic lodge.

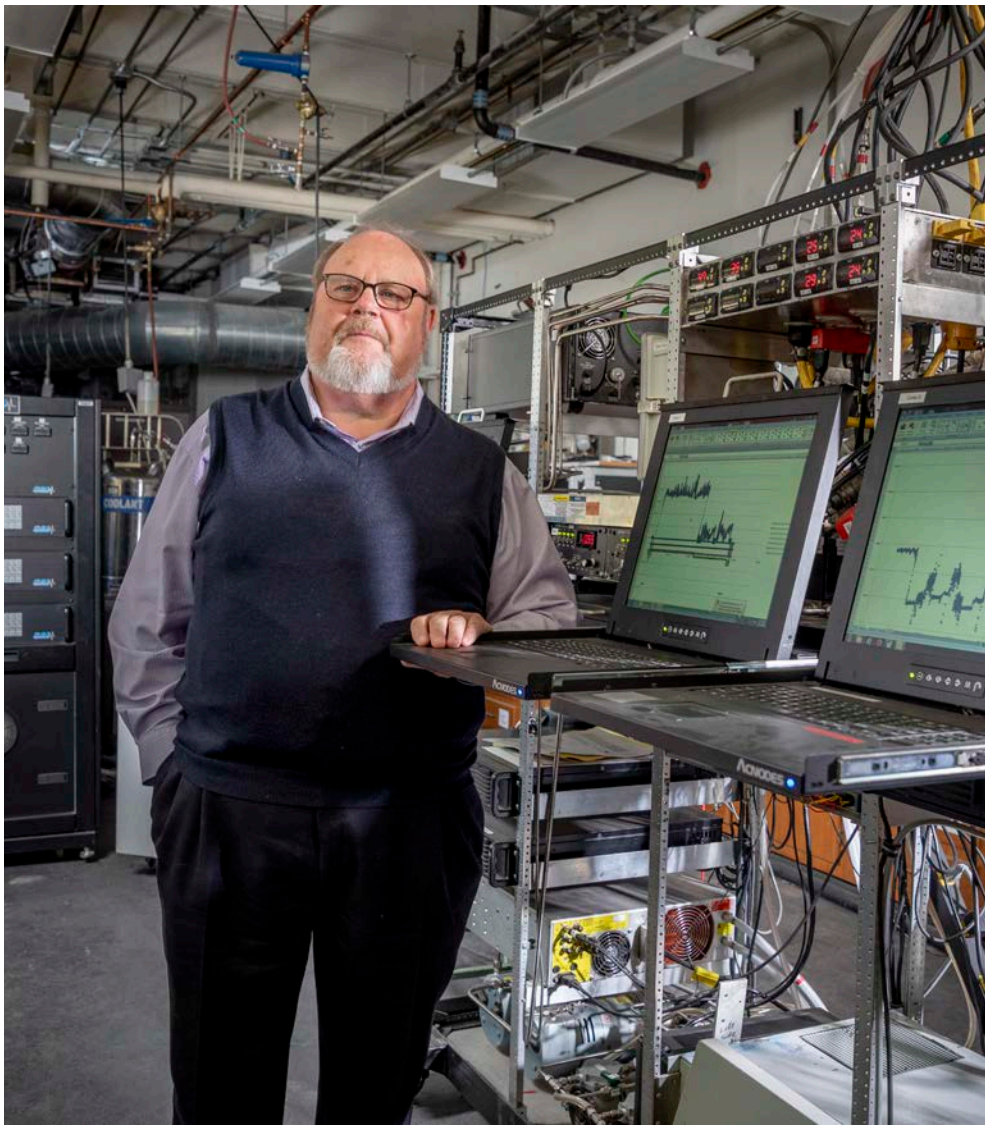
"That was right up my alley," says Coy, who holds both master's and Ph.D. degrees in explosives engineering from S&T.

Coy's passion for pyrotechnics took a high-profile turn when national visual effects company Image Engineering found his résumé on LinkedIn and contacted him about handling pyrotechnics for a client, the Kansas City Chiefs. Coy took the job with one requirement: "I'll need my buddy Jerry to help me."

For the past four years, Coy and Vaill have produced the pyrotechnics for the Chiefs' home games in Arrowhead Stadium. Coy creates the flame effects on the field — including the tallest flame in the NFL at 80-100 feet — and Vaill handles the aerial displays from the roof.

"We are probably the best-educated explosives team in the nation," says Vaill. "I don't think there are any other teams with licensees who hold graduate degrees."

As S&T adjunct faculty members, Coy and Vaill bring the advantage of professional experience to pyrotechnics classes, where hands-on training is essential. "You can learn from books and lectures, but you really don't know what's going on until you do it," says Vaill.



REDUCING BLACK CARBON EMISSIONS

Growing research confirms the adverse effects of particulate matter from aircraft emissions on human health, as well as their potential to affect climate change. Missouri S&T researchers are helping mitigate the damage by developing a system to quantify emissions data.

"Regulators like the FAA and EPA are working with other federal and international agencies, equipment manufacturers, and universities to develop a method and standard to reduce these emissions from growing global commercial aviation," says **Phil Whitefield**, Chancellor's Professor of chemistry at Missouri S&T.

S&T recently received $1.2 million from the U.S. Department of Transportation to determine emissions characteristics of non-volatile particulate matter (nvPM), or black carbon, from burning conventional and sustainable alternative jet fuels (SAJFs) in jet engines at cruise altitudes.

The project will use Missouri S&T's mobile North American Reference System (NARS) to characterize and quantify emissions from Jet-A fuel, a standardized international aviation fuel for gas-turbine engines, and three SAJFs in a series of combustor rig tests conducted by an engine manufacturer.

Missouri S&T designed and built the NARS in collaboration with the Society of Automotive Engineers, and Whitefield says it's now the gold standard for quantifying exhaust particulates in the U.S. and Canada. Whitefield is a former director of the Center for Research in Energy and Environment at Missouri S&T.

With the addition of SAJF testing, the project expands the scope of the FAA's recent ASCENT Project 02 Ambient Conditions Corrections for Non-volatile PM Emissions Measurements, which quantifies emissions data from various aircraft engines and fuels. Whitefield leads both projects.

A FISHY DISCOVERY

Last September, Bob Hrabik, the recently retired head ichthyologist for the State of Missouri and author of the third edition of *Fishes of Missouri*, led the students in S&T's Ichthyology 5001 class on a fish collecting trip in the remote habitats of Big Cane Conservation Area in Butler County, Missouri.

The students were sampling and learning about lowland fishes and working in wetlands, swamps, meandering and sluggish lowland creeks, and ditch habitats. During the excursion, Hrabik identified specimens of the pallid shiner that was assumed to be extirpated, or locally extinct.

Pallid shiners were last reported in Missouri waters in 1956. The species was once widespread over the eastern half of Missouri, but over time it became increasingly less common, then vanished.

Causes of the disappearance are unknown, but changing land use and the channelization of the Mississippi River are possibilities.

Photo by Benjamin Jones, USGS

WHAT HAPPENS WHEN PERMAFROST WARMS?

As global temperatures warm, Arctic communities in Alaska face long-term changes to their way of life. Missouri S&T researchers are part of a $3 million National Science Foundation project to help those communities plan for the future.

Xiong Zhang, associate professor of geotechnical engineering, and a Penn State University colleague are developing a geotechnical hazard map to predict the effects of warming and thawing permafrost.

Permafrost provides a solid foundation for roads, airports, oil pipelines and railroads. But as the soil warms and softens, infrastructure can be damaged or destroyed. Along Alaska's coastline, loss of land mass could force entire communities to relocate.

Zhang's research will help determine where and how much damage could occur.

"The Arctic is very sensitive to climate change," Zhang says. "It's estimated that by 2050, 30% of permafrost could be affected."

Permafrost covers about 24% of the Northern Hemisphere. To investigate the effects of its degradation, researchers will use special equipment to mimic the behavior of permafrost soils at different temperatures, ice contents and water contents.

They will then measure the volume of change in each soil specimen using a mapping tool Zhang developed, called ultra-high-resolution photogrammetry. The results will be used to develop a permafrost model, which will be validated against results from previous lab and field tests.

STUDENT KUDOS

Andrew Hinkle, a Ph.D. student in aerospace engineering at Missouri S&T, is part of a select group of graduate students across the U.S. to receive a NASA Space Technology Research Fellowship (NSTRF). Through the award, Hinkle plans to help advance the agency's understanding of how particle flows such as Martian dust storms could affect spacecraft landings.

Hinkle's research will focus on modeling and simulating the impact of particle flows and their effect on spacecraft heat shields, also known as thermal protection systems. He says planetary reentry in dusty environments poses difficult challenges to both human and robotic spaceflight because the thermal environment is dangerous and difficult to predict and analyze.

QI, JUNG NAMED TO NATIONAL ACADEMY OF INVENTORS

Yihong Qi, adjunct professor of electrical and computer engineering at Missouri S&T, is one of 136 inventors named to the 2019 class of Fellows of the National Academy of Inventors (NAI). NAI Fellowship is the highest professional distinction awarded solely to inventors.

Qi, who teaches in the Electromagnetic Coompatibility Laboratory, is a leader in advanced electromagnetic design in wireless communications. He holds more than 400 patents, according to IEEE. His research in cell phone antenna placement led to changes that netted millions of dollars in additional revenue for BlackBerry (originally known as Research in Motion) and are used in most cell phone designs today. His technical contributions have also benefited wireless testing technologies.

Steve Jung, an adjunct professor of ceramic engineering at S&T and chief technology officer at specialty glass manufacturer Mo-Sci Corp., is one of 38 inventors named to the 2020 class of NAI Senior Members, who are faculty, engineers and scientists from NAI member institutions who demonstrate innovation in producing technologies for society's welfare.

Jung holds 26 patents. His research as a graduate student at S&T resulted in the Mirragen Advanced Wound Matrix, a glass-based, customizable wound care product that has been commercially available since 2017. The research also resulted in a similar product used in veterinary medicine. Jung has also discovered new ways to process other bioactive glass powders that have created new biomedical applications that promote tissue regeneration.

LIOU WINS TAYLOR RESEARCH MEDAL IN MANUFACTURING

Frank Liou, the Michael and Joyce Bytnar Professor and director of manufacturing engineering at Missouri S&T, won the 2020 Frederick W. Taylor Research Medal from SME.

The award honors significant published research leading to a better understanding of materials, facilities, principles and operations and their application to improve manufacturing processes. Liou's research in hybrid additive manufacturing and advanced materials and the industrial impact of the research were the basis for the award, according to SME.

"Frank has been the world's leading researcher for the past two decades in the field of metal additive manufacturing, particularly blown metal powder processes, and the integration of metal additive manufacturing with machining," says **Robert Landers**, Curators' Distinguished Professor of mechanical and aerospace engineering. "His truly pioneering contributions span the entire range of the field, from fundamental academic discovery to industrial implementation."

Liou studies metal additive manufacturing process design, modeling, integration, monitoring and control, and computer aided design (CAD) and computer aided manufacturing (CAM). He is the author of *Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development*.

GOOGLE FUNDS ELECTRONICS RESEARCH

As electronic devices become more complex, the printed circuit boards (PCBs) they use need more components, including capacitors that prevent voltage fluctuations. Researchers say there is a gap between the theoretical understanding of the physics of designing and placing the capacitors and how to leverage that understanding to create the real product.

That gap is the focus of research by **Chulsoon Hwang**, assistant professor of electrical engineering at S&T, and Google recognized his work with a nearly $43,000 Faculty Research Award.

The Google award recognizes research that will influence how future generations use technology and is structured as seed funding to support one graduate student for one year. Only 15% of applicants receive the award following a rigorous, months-long review.

Hwang uses machine learning to bridge the gap between the limits of PCB design theory and the requirements of more complex electronics. He says machine learning algorithms can help improve capacitor placement in practical board designs to save space for other components and to cut costs.

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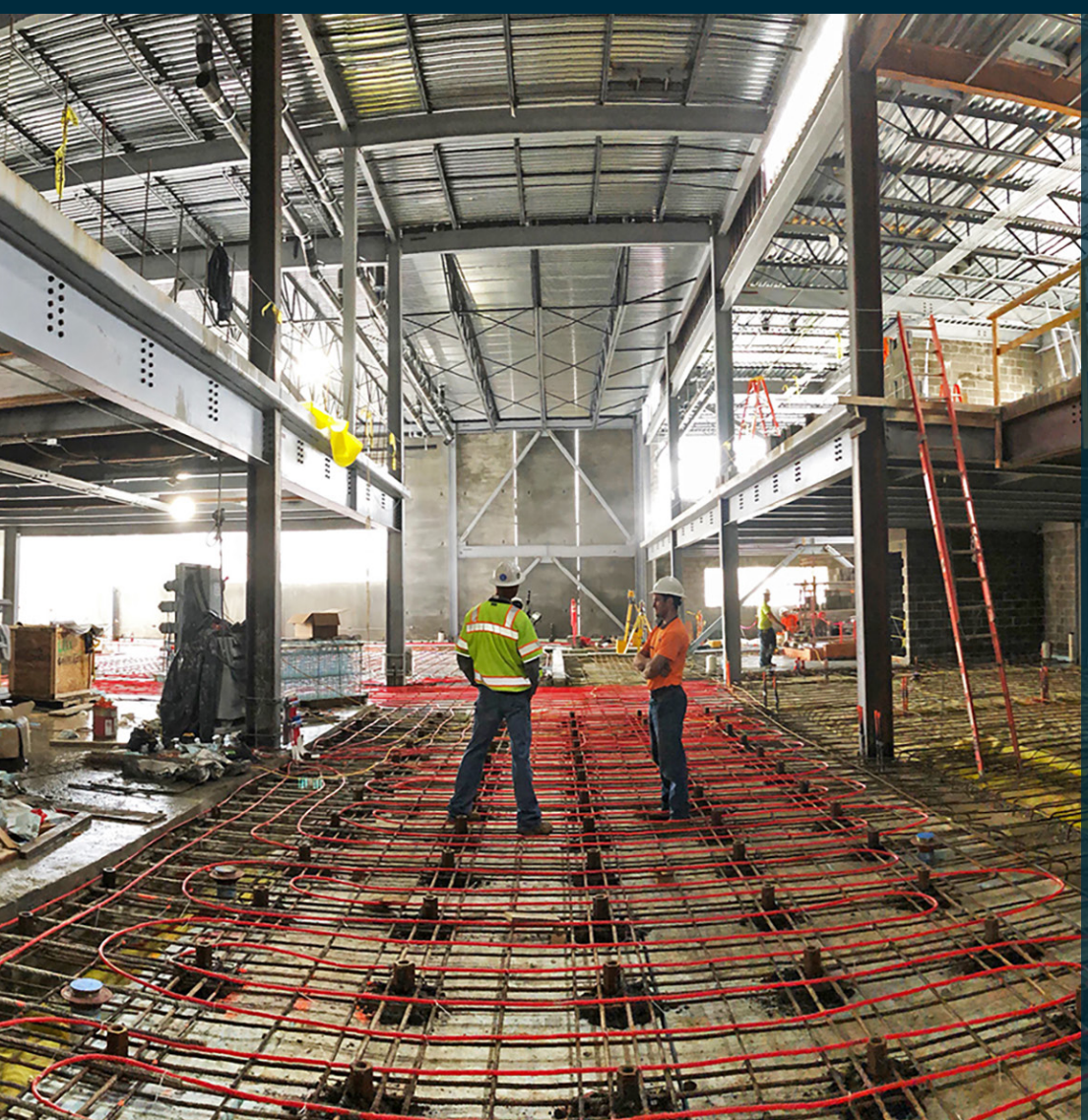

When completed this fall, the Clayco Advanced Construction and Materials Laboratory (ACML) will position Missouri S&T as a global leader in infrastructure research and will help realize our long-term vision of making civil infrastructure safer, more durable and longer lasting.

Research conducted in the ACML will lead to the development, manufacturing, and implementation of new highly sustainable materials for civil infrastructure, with an emphasis on cement-based materials.

The 16,000-square-foot addition to Butler-Carlton Hall marks the final phase of a $10.5 million initiative. The first phase consisted of a $3 million U.S. Department of Transportation grant for testing equipment, with the second phase adding new faculty positions in civil, architectural and environmental engineering as well as materials science and engineering.

The ACML will house over 35 pieces of highly specialized testing equipment that are currently scattered across several buildings on campus and an industrial park east of Rolla.

"The addition of this premier facility will position Missouri S&T as a global leader in infrastructure research and will help us realize our long-term vision of making civil infrastructure safer, more durable and longer lasting," says **Kamal H. Khayat**, the Vernon and Maralee Jones Professor of Civil Engineering at S&T and ACML director.