Fall 2016

re:search

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

PREVENTION WITH A CAPITAL 'P'

Dr. Yinfa Ma introduces a fast, point-of-care method for detecting cancer through urinalysis.

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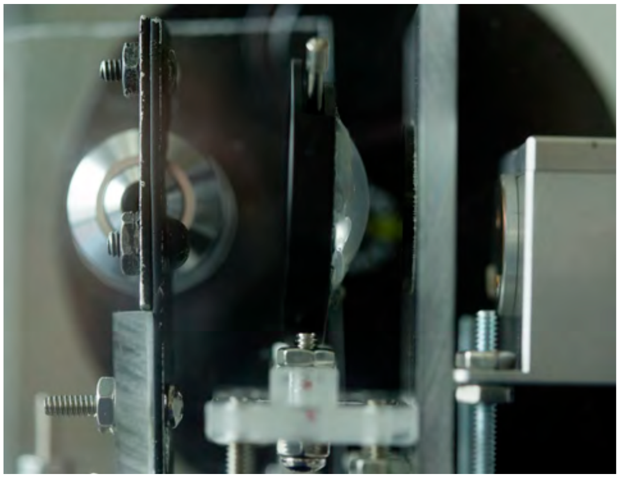
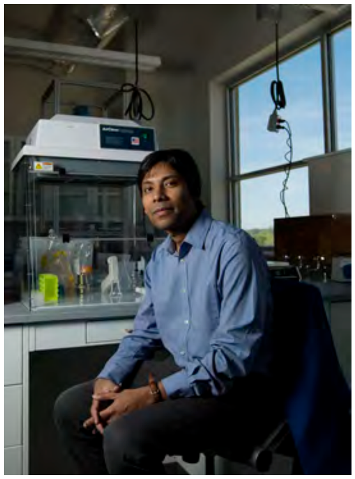
MISSOURI S&T

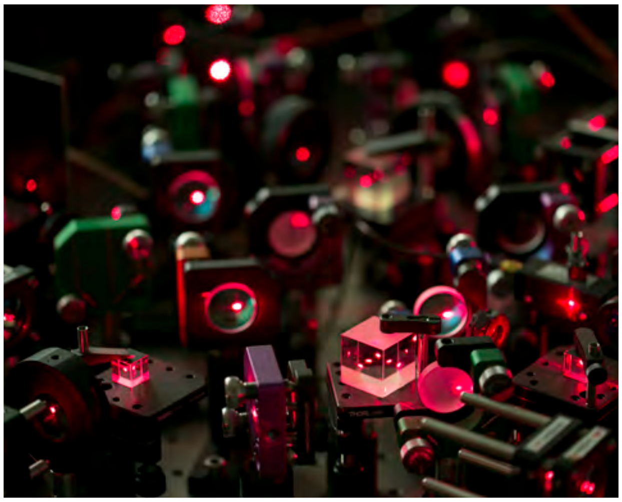
LEARNING BEYOND THE CLASSROOM

Working with the Missouri Department of Conservation and the family of Dr. George Bohigian, a St. Louis ophthalmologist, Missouri S&T is turning 10 acres of land southwest of Rolla into a living laboratory and classroom for students in a variety of majors.

"This field station idea goes hand in hand with the S&T concept of taking learning out of the classrooms and out of the labs and into the real world," says **Stephen Roberts**, vice provost and dean for the College of Arts, Sciences, and Business.







INSIDE THIS ISSUE

INTRODUCING DR. MARIESA CROW

Mariesa Crow's mantra for promoting research at Missouri S&T isn't complicated: lead by example and foster innovation by providing faculty with the tools to succeed.

The F. Finley Missouri Distinguished Professor of Electrical Engineering, appointed in March to a two-year term as vice provost of research, Crow is a national leader in the study of energy storage systems, including renewables. Her 25-year tenure in Rolla includes four years as a dean and five years as founding director of the Energy Research and Development Center.

She continues to help oversee a U.S. Department of Energy-funded consortium as well as another multi-campus collaboration to develop an energy network on the scale of the internet.

"My job is to help as many people be successful as possible," she says. "We're all part of the university family."

Those success stories include **Yinfa Ma**, a Curators' Distinguished Teaching Professor of chemistry at S&T whose work in developing a cancer-screening tool through urinalysis is featured in this issue of *re:search*.

You can also read about Missouri S&T's efforts to tap asteroids as an intergalactic fuel source, a National Science Foundation-supported study of quantum states of matter, the use of microwaves to test bridge safety and the world's first engineering management program, which this year celebrates its 50th anniversary.

PREVENTION WITH A CAPITAL 'P'

TECHNOLOGY DETECTS CANCER RISKS THROUGH URINALYSIS

The early detection of cancer through screening techniques such as mammograms saves thousands of lives annually. **Yinfa Ma** is out to save thousands more through an easier and less costly approach.

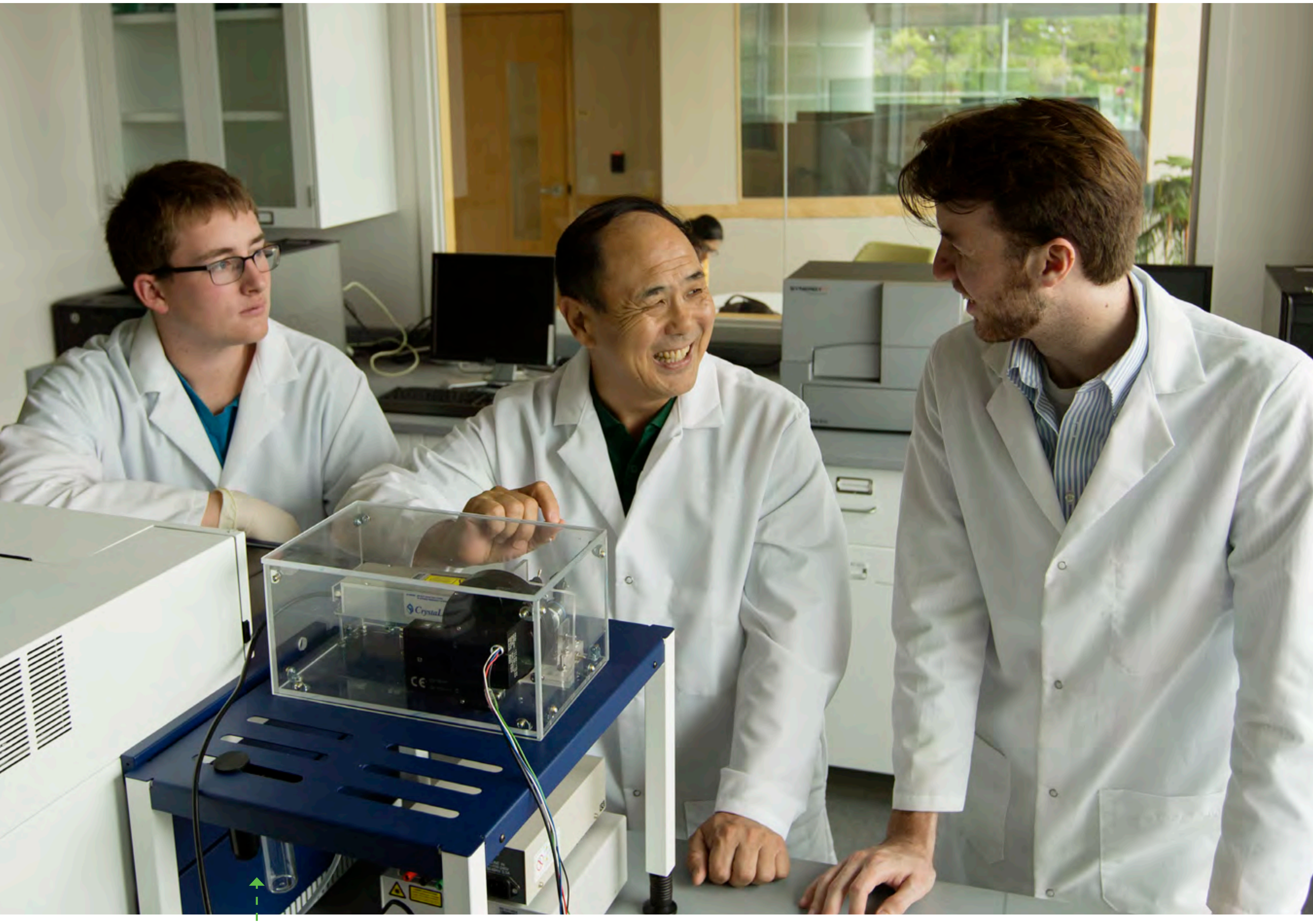
Ma, a Curators' Distinguished Teaching Professor of chemistry at Missouri S&T, developed the "P-scan," a fast, point-of-care method for checking urine samples for biomarkers of the protein pteridine. Ma's research shows that higher levels of certain pteridine metabolites occur in urine samples from women who have been diagnosed with breast cancer.

In February, Missouri S&T entered into an agreement with Cancer.im Inc. to commercialize the P-scan. Cancer.im is a Viratech Corp. company and social network for cancer patients, survivors and caretakers.

Ma hopes his invention will soon replace — or at least supplement — the mammogram for early detection of breast cancer. The P-scan could also make it easier for doctors and clinicians to diagnose women who do not have easy access to mammograms, such as those in rural settings or in developing countries.

"The mammogram is not perfect," Ma says. "Many early cancers cannot be detected by the mammogram, while other benign tumors are falsely detected. The P-Scan technology will help alleviate this problem by using molecular biomarkers in a detection method that can be easily integrated into a routine physical screening.

"A patient donates urine, and 10 minutes later she has a result. This will be an amazing diagnostic tool."



The P-Scan, developed by **Yinfa Ma** (center), could save thousands of lives by detecting breast cancer earlier than a mammogram. With Ma are **Alex Cristea**, a sophomore in chemistry, left, and Ph.D. student **Casey Burton**, right.

The P-scan works by passing the urine through a small tube and detecting the fluorescence given off by the pteridine biomarkers. The advantage of this technique is that it delivers excellent sensitivity without the need for costly instrumentation. The P-Scan can detect over 70 unique compounds in urine, many of which Ma believes may also be indicators of other specific cancers, which he hopes to study in future clinical trials.

"Cancer cells grow much faster than normal cells," Ma says, "so they release more waste into the urine and we begin to see a rise in certain metabolite levels."

Ma's research suggests that two of these pteridine metabolites — isoxanthopterin and xanthopterin — are present in elevated levels in the urine of women with newly diagnosed breast cancer. New clinical trials are underway at Missouri S&T to verify these findings and to test whether pteridine biomarkers can be used to detect other types of cancers.

"We will go cancer by cancer until we know," Ma says.

"Cancer cells grow much faster than normal cells so they release more waste into the urine and we begin to see a rise in certain metabolite levels."

The National Cancer Institute estimates that more than 1.6 million people will be diagnosed with cancer this year. Nearly one in eight women will develop invasive breast cancer during her lifetime. Roughly 85 percent of women diagnosed with breast cancer have no family history of the disease.

"I am very excited about this project," Ma says. "It will save lives. That's my motivation."

A GLASS SOLUTION TO NUCLEAR STORAGE WOES

Stored in steel drums and buried in mountainsides, nuclear waste can remain radioactive for tens or hundreds of thousands of years. Reducing the space needed to store the waste saves time and money and will reduce the overall environmental impact, says **Richard Brow**, Curators' Distinguished Professor of ceramic engineering and interim vice provost of the College of Engineering and Computing.

With funding from the U.S. Department of Energy's Office of Nuclear Energy, Brow is working to find a way to make the waste vitrify — turn into glass — more efficiently. Using surrogates in place of radioactive isotopes, Brow melts borosilicate glass (similar to the material Pyrex glassware is made from) and the surrogates in hopes of finding the sweet spot where a process known as phase separation and crystallization can capture the most waste in the smallest volume of a chemically stable glass.

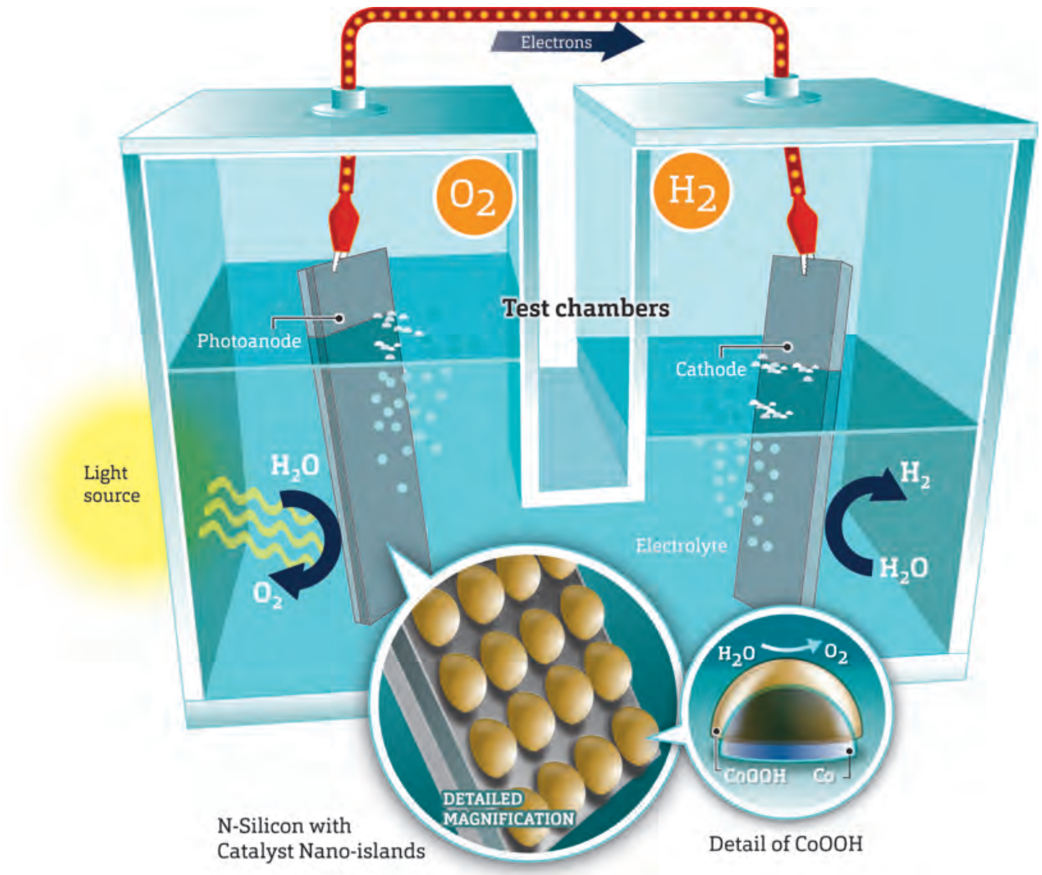
Brow uses techniques developed in part by researchers in the Peaslee Steel Manufacturing Research Center at S&T.

"To understand how fast these processes occur, we will quench the melts — probably from 1,450 degrees, Celsius — at different rates to freeze in different microstructures, ranging from phase-separated droplets, known as fast quench, to fully crystallized phases, or slow quench," he says.

It's all to get to the point where the borosilicate glass concentrates the radioactive components into micro-phases within the glass. And when that happens, the benefits will be substantial.

"We could possibly double our waste loading," Brow says.

Richard Brow and Xiaoming Cheng, a recent Ph.D. student in Materials Science and Engineering, study samples of borosilicate glass.



Nano-islands to solve the solar storage problem

Nanometer-scale islands of cobalt on a silicon wafer could lead to solar cells with more storage and more staying power. By using electrodeposition to split water into its elements — hydrogen and oxygen — while creating highly efficient solar cells in the process, investigators in S&T's Materials Research Center are finding a more reliable way to store solar energy.

"The work helps to solve the problem that solar energy is intermittent," says **Jay A. Switzer**, the Donald L. Castleman/Foundation for Chemical Research Professor of Discovery at Missouri S&T. "Obviously, we cannot have the sun produce energy on one spot the entire day, but our process converts the energy into a form that is more easily stored."

Switzer and his team describe their research in a paper published in September 2015 on the *Nature Materials* website. It begins with a silicon wafer submerged in water, its front surface exposed to a solar energy simulator and the back surface covered in electrodes to conduct the energy. Through electrodeposition, cobalt nano-islands grow on the silicon. These tiny cobalt dots were found to produce even more voltage than the more conventional approach of covering the entire surface of the silicon with cobalt. The voltage generated by the solar rays splits liquid water into hydrogen and oxygen.

"Initially, we had set out to produce a uniform layer of metal that both catalyzed and protected the silicon but found that this method actually produces a higher voltage and did not need an additional step that typically has to be applied to the silicon," says Switzer. "These nano-islands of cobalt produce a much more efficient cell."

In addition to solar panels and energy cells, Switzer sees potential use in large-scale hydrogen collection and even a fully carbon-neutral travel solution. "If we use this process in hydrogen-fueled vehicles, the hydrogen would be used as fuel and the only thing dripping out of the tailpipe of the car would be water," he says.

Switzer's co-authors are **James C. Hill**, an S&T post-doctoral fellow, and **Alan T. Landers**, a 2015 S&T chemistry graduate. Their research is sponsored in part by the U.S. Department of Energy.

LESS ENERGY, LONGER LIFE

DO LITTLE DOGS LIVE LONGER THAN BIG DOGS?

Chen Hou says they do, and the reason lies in a complex relationship between energy usage and lifespan.

Hou, an assistant professor of biological sciences, is using the principles of energy conservation and allometric scaling to measure aging on the basis of energy expenditure. His research shows that energy used during growth is key to understanding longevity.

Hou compares the birth mass of a greater Swiss mountain dog to that of a silky terrier as an example. While the birth weight of a greater Swiss is typically only 1 percent of its final, full-grown weight, a newborn terrier already weighs in at 8 percent of its final weight. That means that the greater Swiss has to use more energy to grow to full adulthood, leaving relatively less energy for health maintenance. As a result, the greater Swiss would have a shorter lifespan than the terrier.

"If you were able to suppress or manipulate growth to maintain a smaller stature, the animal would live longer and have more energy for health maintenance – the way the body repairs itself," says Hou. "On the other hand, 'catch-up' growth, referring to individuals with low birth weight reaching or exceeding normal weight later in life, often has negative impacts on adult health outcome and lifespan."

Hou's research paper, "On the complex relationship between energy expenditure and longevity," was published in 2015 in the journal *Mechanisms of Ageing and Development*.

OUT OF THIS WORLD ENERGY

With human missions to Mars possible within decades, the prospect of finding enough fuel for the journey remains a major challenge. After all, there aren't any fueling stations between here and the Red Planet.

But perhaps there could be. **Leslie Gertsch**, an associate professor of geological engineering, envisions the possibility of interplanetary fueling stops on asteroids.

"If you can stop at a gas station, a gas asteroid, it would make [space travel] more efficient," Gertsch says. "You wouldn't have to carry all your fuel."

Gertsch has been baking actual and artificial meteorites in her lab to learn how to produce water and other easily evaporated compounds from asteroids. She cooks the rocks in a vacuum chamber to simulate the zero-gravity conditions of space. When gases are released from the samples, they are collected and analyzed.

"This is one of the processes called in-situ resource utilization (ISRU) — collecting resources from NEOs (near-Earth objects), or the moon or Mars, and making useful things like spacecraft fuels and propellants," says Gertsch. "Some NEOs contain up to 22 percent water locked within minerals. Our job is to predict how much water we can actually get out of them in space."

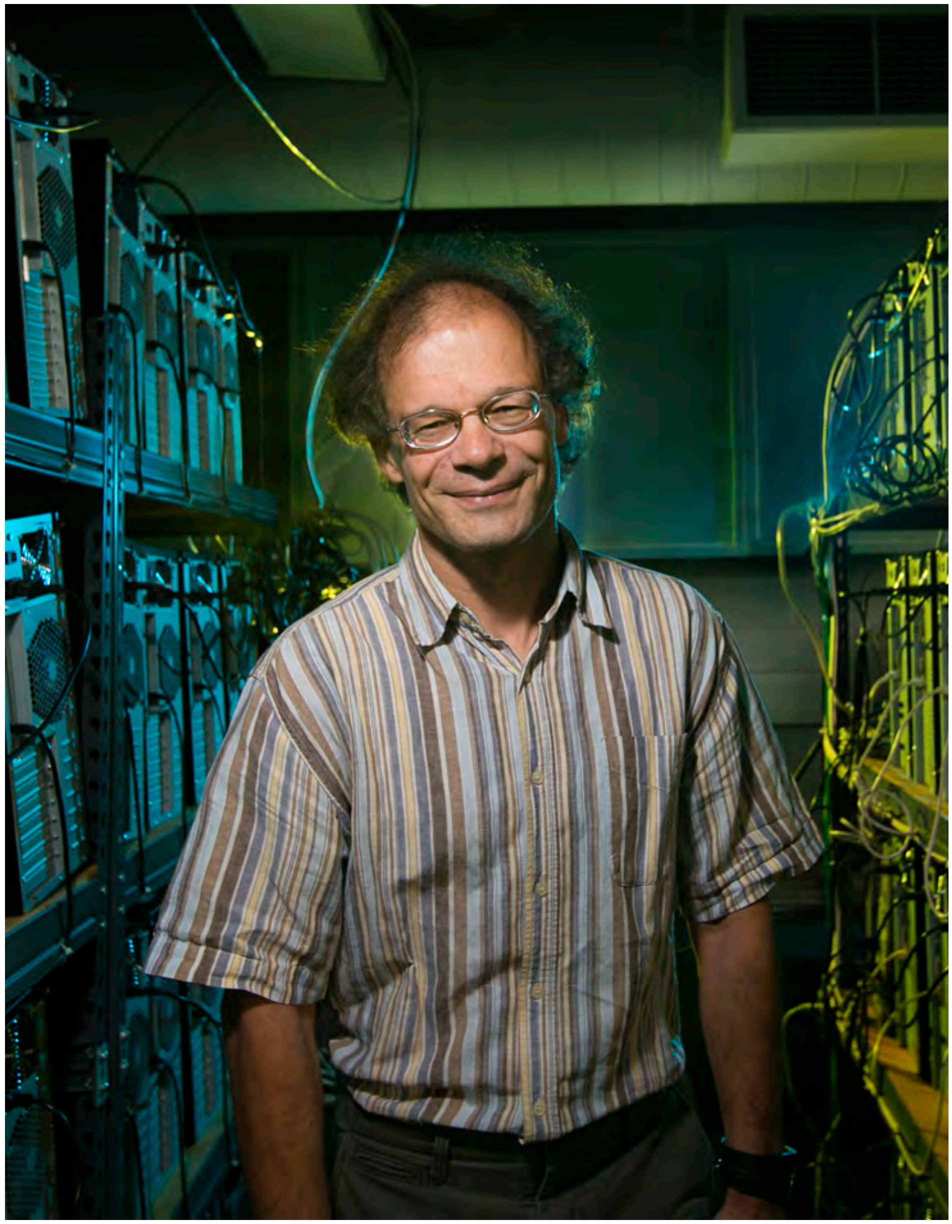
Leslie Gertsch is baking asteroids in search of an interstellar water source that could one day lead to industrialized space travel.

> "ISRU like this will reduce payload needs and boost planetary exploration. This work could change the way we view space travel."

Gertsch's research suggests that other gases contained in NEOs — like carbon dioxide, sulfur dioxide or carbon monoxide — could also be processed to fill up the tank in space. To process the fuel, the rocks would need to be baked. The hot gases coming off the meteorites, trapped inside the bag, could be sent to space refineries, or siphoned directly into fuel tanks designed to be meteorite-gas-compatible.

Gertsch's research is supported through a NASA Early Stage Innovation Research Grant. The NASA grant program funds innovative early-stage research that addresses high-priority needs of America's space program. She's working with NASA's Kennedy Space Center and Glenn Research Center as well as the Colorado School of Mines, the University of Hawaii and Integrated Concurrent Systems Associates Inc.

"This is an interdisciplinary project. Our researchers have backgrounds in planetary geology, meteoritics, mineral processing, chemical engineering, mechanical engineering, mining engineering and astrophysics, among others," says Gertsch. "ISRU like this will reduce payload needs and boost planetary exploration. This work could change the way we view space travel." ◻



Studying super-cool superconductors

By studying how materials change at ultra-low temperatures, theoretical physicist **Thomas Vojta** hopes to discover new states of matter.

Through a National Science Foundation grant, Vojta is studying how slight changes in the chemical composition of materials can dramatically change their properties.

"My research looks at quantum phase transitions — transformations of materials occurring near absolute zero — and how they take place," says Vojta, a Missouri S&T professor of physics. "In connection with these transformations, exotic new quantum states of matter can appear — for example, superconductors that can carry electric current without any losses."

It's that period of transformation, when new states of matter develop, that most interests Vojta.

"Quantum property phase transitions are similar to the changes that occur when you boil water," he says. "These abrupt transformations directly affect superconductivity, and we want to find out exactly how and why."

Vojta uses a supercomputer he built with his colleagues and students to model these quantum phase transitions and to compute various materials' properties. The custom-built computer, called the Pegasus IV High-Performance Computing Cluster, is made up of 156 quad-core computer nodes that are used for computational research in condensed matter and statistical physics.

IMAGING THE FINAL FRONTIER

A new microsatellite imager in development at Missouri S&T could keep astronauts from making risky exploratory missions when something goes wrong in space. It also could be used to check out satellites, make small repairs or refuel spacecraft, says **Hank Pernicka** (right), associate professor of mechanical and aerospace engineering. He and his students, including aerospace engineering graduate students **Yezad Anklesaria**, AE'07, MS AE'09 (left), and **Katelyn Boushon**, AE'15 (center), won the final round of an Air Force competition to develop the spacecraft.

Now the team will build two working microsatellites based on that winning model for delivery to the Air Force. If all goes well, they will be launched to rendezvous with the International Space Station.

One of the microsatellites will dock to the other during the launch to the space station. After a space station arm pushes the craft away from the station, the first test begins. One satellite will push away from the other and use its 12 micro-thrusters to maintain a 10-meter distance between the two. If that's successful, the first satellite then will begin to orbit the second, taking pictures of it with two stereoscopic lenses.

Although the two satellites are designed to be in orbit for only four months, Pernicka expects to be able to communicate with the orbiting microsatellite for two to four years as it begins a decaying orbit around the planet. At some point in the future, it will fall harmlessly back to Earth, just one more shooting star in the night's sky.

A COMPUTERIZED QUEST FOR CURES

Researching ways to cure cancer and neurodegenerative diseases in the lab is painstaking, time consuming and expensive. But a Missouri S&T researcher's computerized approach to testing new drug therapies could lead to a faster, less costly path to finding new treatments for maladies that kill millions each year.

Dipak Barua, assistant professor of chemical and biochemical engineering at S&T, is the principal investigator on a U.S. Department of Energy project on countering pathogen interfaces with human defenses.

"We use math and computational modeling as a tool to understand the mechanisms in cells, and we develop computational and mathematical models that make predictions" about what will happen with different therapies, Barua says.

According to the World Health Organization, 8.2 million people worldwide die each year from cancer – and the number of new cases is expected to increase by 70 percent in the next 20 years. In addition, three neurodegenerative diseases – Alzheimer's, Parkinson's disease and amyotrophic lateral sclerosis (ALS) – combined affect 220 out of every 100,000 people worldwide, according to the WHO.

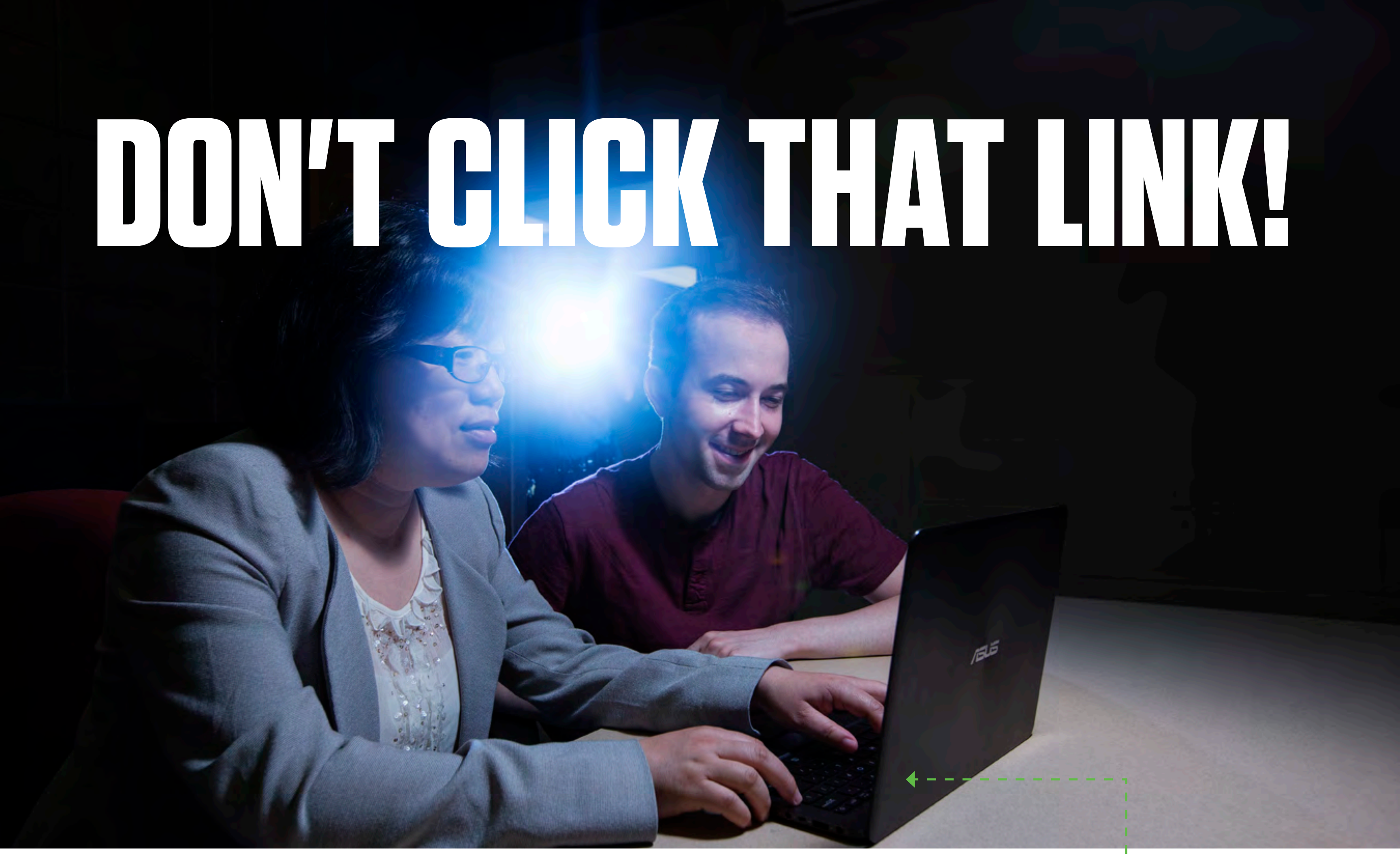
Finding treatments for these diseases is a global concern, and the quest for cures begins at the cellular level. "Our human cells respond and fight when our bodies get infected," Barua says. "We get disease symptoms, and there are interactions at the cell level. Cells get triggered to fight pathogens."

Barua uses models based on the findings of published drug therapy studies as a starting point when running the tests. And unlike lab tests, which can take months or years to complete, his approach takes a fraction of the time to eliminate one avenue or identify another for further study.

Barua hopes to advance understanding of how cells function and how scientists can control those functions. But that's not the only reason for the research.

"Our ultimate goal," Barua says, "is to make cells be able to kill their particular infection."

DON'T CLICK THAT LINK!



Maggie Cheng, left, is studying how human error affects online security with student Sam Smith.

MINIMIZING HUMAN ERROR IN CYBER SECURITY

Whether we're clicking on malicious links from a phishing email, relying on simple but easily determined passwords, or misplacing our smart phones and laptops, we are our own worst enemies when it comes to cyber security. According to a 2014 study by IBM, more than 95 percent of computer security incidents investigated the previous year involved human error.

Two Missouri S&T researchers hope to drastically reduce the impact of human error through research into the online behavior of internet users and how that behavior affects the safety of systems and networks.

Maggie Cheng, associate professor of computer science, and **Fiona Nah**, professor of business and information technology, are designing experiments to study the characteristics of user behavior. "We're trying to consider in what ways user behavior can change the network state," Cheng says. Their work is funded by the National Science Foundation.

As the IBM study showed, users are not always conscious of cyber security risks. But a person's psychological state and cognition capacity also affect cyber behavior. For instance, a user may not want to click on a link received in from an email when fully risk-conscious, but when under time pressure, or when the email comes from what appears to be a trustworthy source, the user may fall for the scam.

Cyber behavior may also vary with the network and device the user is on. Cheng says that people probably are more conscious of risk on networks and devices that have higher security requirements, such as PCs. Users may not be as aware of risks on mobile devices and may unwittingly install malware from a fake mobile gaming site, for instance.

"The psychology of a hacker is different from an IT person and an ordinary network user," Cheng says. "IT looks at how it can secure the network by improving security policies, but a hacker views the user-caused vulnerability as an opportunity to take what is gleaned and go from there."

MICROWAVING SAFER BRIDGES

Testing the strength of materials is usually about destroying them — because you can't know the breaking point until you reach it. But **Kristen Donnell** has a more efficient and less destructive way of testing materials. It involves zapping them with microwave beams.

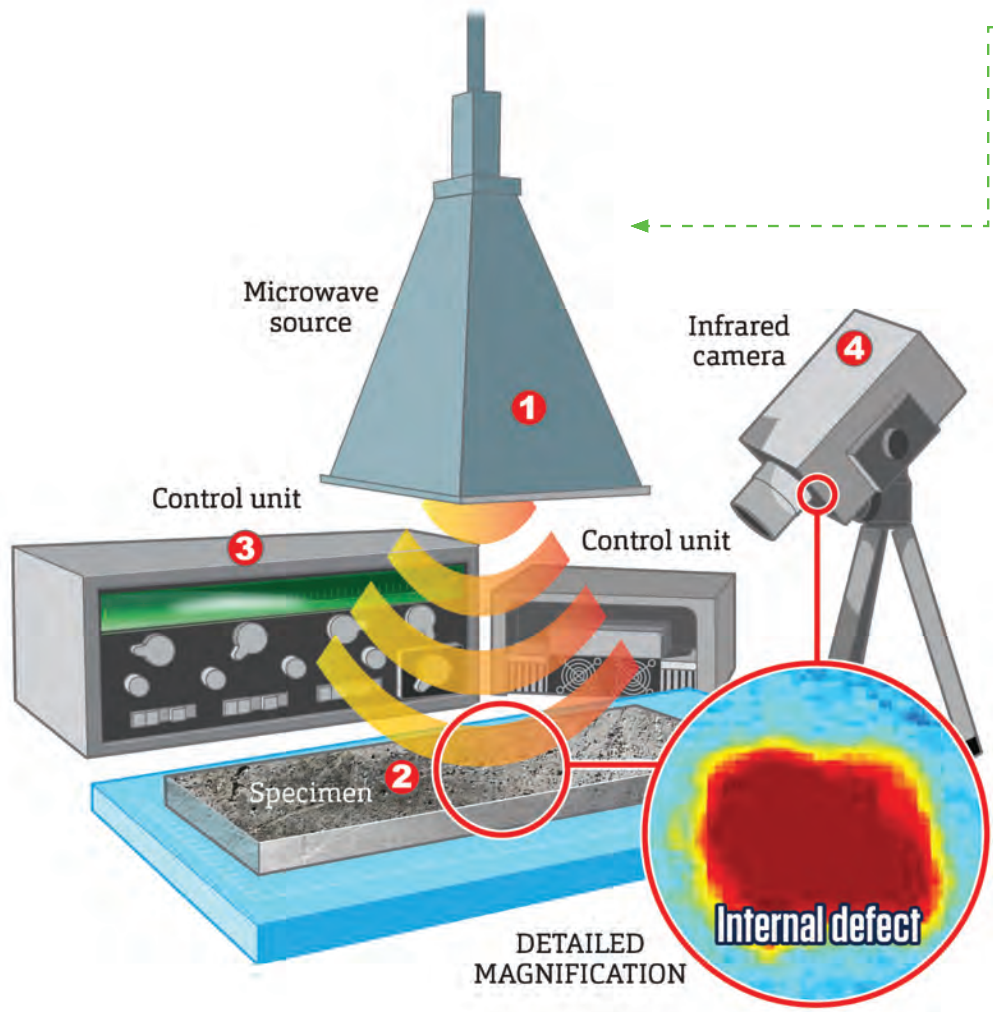
Donnell, an assistant professor of electrical and computer engineering, tests concrete and rehabilitated aluminum using an active microwave thermograph (AMT). The AMT highlights flaws that could compromise safety or effectiveness. It works by using microwave energy to heat a defined section of material so it can be examined using infrared thermography imaging.

Her approach is a fairly recent form of nondestructive testing (NDT).

Donnell uses a 1- to 20-gigahertz high-frequency horn antenna to heat the objects, then views them with an infrared sensor that sends data to a computer. Because the heat burst lasts only a few seconds, Donnell's method reduces the risk of heat damage that can occur with traditional flash heat lamps. AMT also is able to focus the heat at a predetermined depth instead of heating the whole object.

With a flash heat lamp, for example, an entire wall must be heated to examine one portion of it. The AMT method allows researchers to focus heat on a small section. It's not exactly an X-ray, "but it does allow us to look inside the interior of a structure to show defects or problems," Donnell says.

Using AMT, Donnell can focus on the middle of a 4-inch section of concrete. On a computer, the images will show if the rebar inside the concrete is rusted, corroded or broken, or if the concrete has cracks or other defects that could weaken it. Donnell also can use AMT on materials that are wrapped in carbon fiber — a way of reinforcing concrete — to see whether the fiber is adhering properly, and she can use the method to examine rehabilitated aluminum for weak spots.



1. Microwave energy radiates toward the sample under test (SUT).
2. The smaple absorbs the microwave energy and heats up. The amount of energy absorbed depends on the sample's properties. If a defect is present, the properties of the SUT will be affected, along with the subsequent energy absorption and temperature.
3. The control unit controls the amount of power radiated toward the sample and the frequency of operation. It also synchronizes the energy with the infrared camera measurements that are used to capture the temperature of the SUT.
4. The infrared (thermal) camera captures the temperature of the SUT over time. If a defect is present, it will present itself as a "hot spot" in the thermal image.

FOOD AND FAUNA: S&T SCHOLARS' RECENT BOOKS

Among the many books recently published by Missouri S&T faculty members, two stand out for filling unique niches in the academic world:

Communication Practices in Engineering, Manufacturing, and Research for Food and Water Safety, edited by **David Wright**, associate professor of English and technical communication. Covering a range of topics from early 20th-century muckraking to modern-day disease outbreaks, the collection of essays "looks at how technology diffusion, the spread of new technology usage, impacts the decisions people are making in terms of food safety," Wright says. The book includes a chapter by Wright — "Cowboys and Computers: Communicating National Animal Identification in the Beef Industry" — that describes the beef industry's slow acceptance of animal identification and the communications challenges involved.

Success Depends on the Animals, by **Diana Ahmad**, draws on the journals and diaries of pioneers during the U.S. westward expansion of the mid-19th century to tell the tale of their interactions with their animal traveling companions. "Animals were a reminder of home for travelers," says Ahmad, a Curators' Distinguished Teaching Professor of history and political science. "The chances of ever going back to where you came from were low, so if your domestic working animals — like horses or oxen — died, it was like losing a part of your immediate family and former life."

GOING PUBLIC

MILITARY HISTORIAN PART OF A NEW PROGRAM TO BRING SCHOLARSHIP TO A WIDER AUDIENCE

Of the 12 military history books **John C. McManus** has written, seven have focused on the U.S. role in the World War II campaign against Germany.

Now McManus is turning his attention to the Pacific and Asian theater of World War II for a two-volume history of America's war with Japan.

One of the nation's most prominent military historians, McManus's forthcoming work is supported in part through a Public Scholar Grant from the National Endowment for the Humanities.

"The goal of this new series is to shed light on the Pacific and Asian war and its long-term significance, not just for the Army, but for the United States as a whole," says McManus. "This grant makes it possible for me to access previously underutilized primary sources, all of which give me the opportunity to produce a major, original work of scholarship geared for a broad audience."

The NEH grant program is designed to make academic scholarship more accessible to the public. That should be no problem for McManus, who writes in a storytelling style that reveals his undergraduate education in journalism. (He followed his passion for history to earn a master's and Ph.D. in the subject.)

McManus's latest book, *Hell Before Their Very Eyes: American Soldiers Liberate Concentration Camps in Germany, April 1945,* was published in October 2015 by Johns Hopkins University Press.

ENGINEERING MANAGEMENT:

BACK TO WHERE IT ALL BEGAN

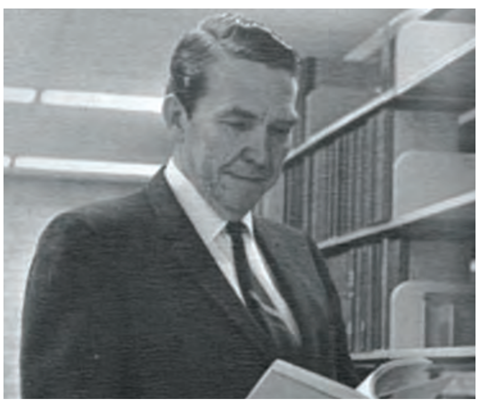
Fifty years ago, a chemical engineer left a 17-year career with a Pittsburgh-based metals and materials manufacturer to create a new academic discipline — one that combined the rigors of business management with engineering process and design.

With **Bernard R. "Bernie" Sarchet**, below left, as the founding chair, the nation's first engineering management program was launched in Rolla.

This year, Missouri S&T is celebrating the 50th anniversary of the program, and Sarchet's legacy figures prominently.

"Bernie Sarchet is considered by many to be the founder of engineering management as a discipline worldwide," says **Suzanna Long**, professor and interim chair of engineering management and systems engineering. In addition to establishing the program in Rolla, Sarchet founded the discipline's professional organization, the American Society for Engineering Management.

Learn more about S&T's engineering management program at **emse.mst.edu**.



A MECHANICAL ENGINEERING CENTENNIAL

In 1916, World War I was raging in Europe, Boeing flew its first aircraft, John D. Rockefeller became the world's first billionaire, Woodrow Wilson was re-elected president after running on the campaign slogan, "He kept us out of war" — and the department of mechanical engineering was established at Missouri S&T. Learn more about the department's 2016 centennial celebration at **mae.mst.edu**.

FROM PUNCH CARDS TO PCS: 110010 YEARS OF COMPUTER SCIENCE

Missouri S&T's computer science department — the first of its kind in Missouri — celebrated its Golden Jubilee last year with special events including a Hackathon for Humanity and gala dinner honoring longtime faculty member **Arlan DeKock**. View the department's interactive timeline commemorating computing milestones at **cs.mst.edu/50years/timeline**.

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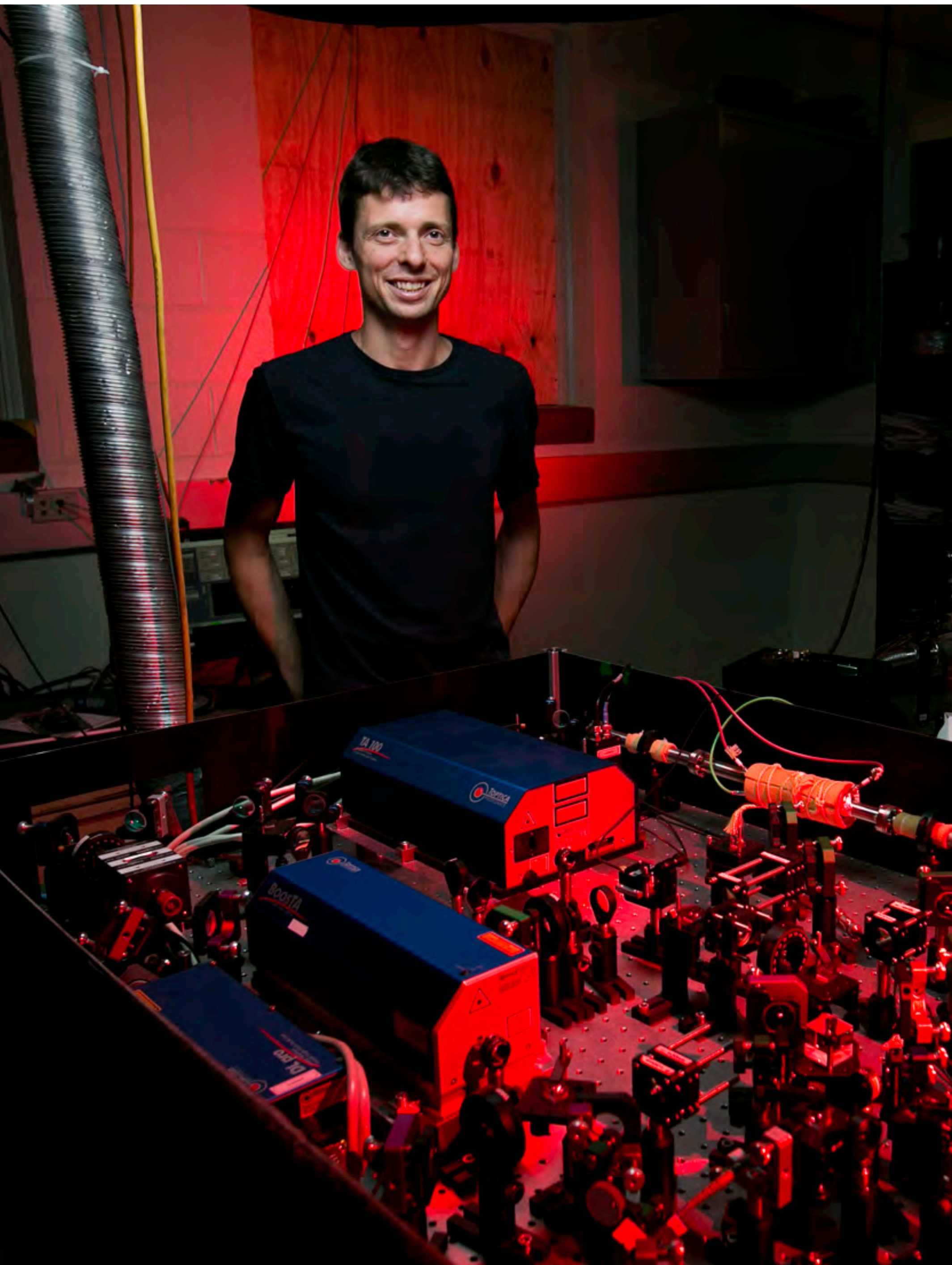

CAREER Award winner Daniel Fischer:

UNRAVELING THE MYSTERY OF MOTION

The “few-body problem” — understanding how particles interact at the atomic level — continues to confound the world of physics. Missouri S&T researcher **Daniel Fischer** hopes to unravel the mystery by laser-cooling atom clusters and studying their movements. “It can be extremely challenging to predict the motion of three or more particles due to their mutual forces,” says Fischer, an assistant professor of physics. “This complex interplay of several particles requires a combination of theoretical and experimental research, because such systems cannot be fully described by mathematical expressions alone.” Fischer recently received a $400,000 Early Career Development (CAREER) Award from the National Science Foundation to support his research on atomic few-body dynamics.