UNIVERSITY OF WISCONSIN–MADISON
COLLEGE OF ENGINEERING

2024

PERSPECTIVE

COMING SOON

400,000 square feet of future-ready space for a college that's in high demand

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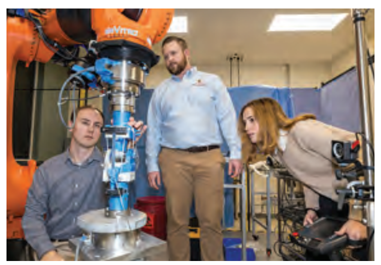

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On the cover: Artist's concept of the new building. Credit: Continuum SmithGroup.

PERSPECTIVE
MAGAZINE

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College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

Greetings alumni and friends!

We've been talking for several years about our college's need to grow. And so I am exceptionally gratified to tell you that in March 2024, Wisconsin's legislature and governor approved construction of a new, almost-400,000-square-foot engineering building on our campus.

If you studied the cover of this magazine, you may have begun to appreciate the aesthetic nature, or perhaps the size, of this engineering building. Maybe you were curious about what it will look like inside, or what programs or research labs it will contain. Perhaps you marveled at how much our campus continues to change.

This big change not only is an enabler of our college's growth—it also is a step forward for our university and our state.

Through partnership and collaboration, our new building will facilitate forward thinking, patented pioneering advances, and solutions to challenges decades into the future.

It will open the doors of engineering to more talented young students—thus, responding to overwhelming demand for an engineering education and answering employers' call for a larger pool of talented engineers. It will give us room—lots of room—to educate all of those promising engineering leaders in experiential classrooms specifically designed for future flexibility.

Over the past five years, nearly 80 faculty have joined our college (you'll meet 18 of our latest hires in this issue). In addition to their passion for inspiring young students through their teaching, they also have added depth and breadth in areas such as energy storage, AI and machine learning, bioengineering, robotics and autonomous systems, quantum and electronic materials, and more. Our new building will provide modern, transdisciplinary research facilities that can evolve along with our needs.

Through dedicated space, the building also will enable industry partners to easily engage with our college—allowing us to translate engineering knowledge and innovation more quickly into beneficial applications.

Our transformative building—an investment in many generations—is on the horizon. We have momentum, and we're pushing the world forward. We're building not simply for our good—but for the public good. We are engineering the future.

Follow along with our progress at **engineering.wisc.edu/new-building.**

On, Wisconsin!

Ian M. Robertson

Ian Robertson
Grainger Dean of the College of Engineering

Dedicated to fostering the highest standards of integrity, ethics, inclusiveness, and service to society.

Spanning the existing Engineering Mall and the space currently occupied by 1410 Engineering Drive, the architecturally stunning facility will be a bold, welcoming gateway into our engineering campus.

Credit: Continuum Smithgroup

Resilient, intentional, reconfigurable, beautiful

Meeting an urgent need, our new building will deliver benefits for generations to come.

All images by Continuum Smithgroup. Artist's concepts of the new building.

With approval from Wisconsin's legislature and governor, the College of Engineering will construct its first new building in a quarter century. The $347 million structure will be funded with $197 million from the state of Wisconsin and $150 million in private giving.

"For alumni, students, faculty and staff, this is an exciting moment in the history of your engineering college—which, for 175 years, has driven discoveries and advances whose benefits reverberate globally," says Grainger Dean Ian Robertson. "Together, we've contributed to the well-being and prosperity of citizens, communities, companies and industries worldwide and made a profound difference in the lives of generations of engineering students. The new facility will enhance our impact and enable us to educate more Badger engineers. The building is an exemplar of innovation and will catalyze faculty recruiting, spark new industry connections, accelerate ideas that lead to economic progress, and extend the opportunity of an engineering education to thousands of additional students."

Our goal is to complete this project expeditiously—with our current target in 2028—in partnership with our A&E firm, Findorff, campus and the state Department of Administration. Thus ... over the next few years, we will be active participants in (or careful observers of) the next chapter in the existence of our vibrant college. Explore more, follow along with the building's progress, and support the project at **engineering.wisc.edu/new-building.**

We currently have room for 1 in 8 undergraduate applicants each year.

In seven stories above ground and one below, the 395,000-square-foot building will greatly expand our current capacity in state-of-the-art instructional laboratories, while its intentional design for reconfigurability will provide us the freedom to pivot and evolve in the future.

The space will empower students to thrive. Importantly, it will allow our college to begin meeting soaring student demand for an engineering degree, as well as industry's burgeoning need for talented, creative engineers. Graduates of Wisconsin's flagship engineering program excel as members of the engineering workforce, as entrepreneurs, and as leaders in academic, industry and government organizations worldwide.

engineering.wisc.edu/new-building

Images are conceptual.

By design, the building will be multidisciplinary and efficient, and its occupants, collaborative. It will feature shared laboratories that unite faculty, staff and students from disparate engineering disciplines around common challenges and goals.

Throughout the planning process, the building's architecture and engineering firms—SmithGroup, Continuum Architects and Planners, and Ring & DuChateau—have focused on sustainability, incorporating aspects like energy-harvesting rooftop photovoltaics and a design that maximizes natural lighting. It will include refreshed green space and indoor and outdoor gathering spaces. The building's learning wing will feature mass timber construction and a green roof to manage stormwater and mitigate the urban heat island effect.

ENERGY RESERVOIRS

We're capturing the potential in a portfolio of new, more sustainable storage technologies.

BY JASON DALEY

Every year, renewable resources like wind and solar become a larger slice of the energy mix in the United States and across the world. But for those technologies to have maximum impact, we will need better ways to store their intermittently generated energy—so that regardless of whether you're microwaving a midnight snack or tuning into the Super Bowl on a gloomy Sunday afternoon, you'll have power anytime you want it.

Energy storage, however, comes in many sizes, shapes and forms. It will take a combination of high-tech batteries, pumped hydropower, electrochemically derived fuels and even some molten salt to make sure renewables continue to provide a stable, affordable electricity supply that can grow along with our energy future.

"While deployment of those generation sources will continue to grow, the technical challenge has shifted to how to provide the energy *when* it is needed. Hence, energy storage," explains Craig Turchi, program lead for the concentrating solar power program and the thermal energy science and technologies group manager at the National Renewable Energy Laboratory, in Golden, Colorado. "While most folks immediately think about batteries—and those play a major role—their modular nature make them best suited for smaller deployments and shorter durations. Much research is now on how to provide long-duration energy storage, greater than 10 hours, for the electric grid."

Much research is now on how to provide long-duration energy storage, greater than 10 hours, for the electric grid.

Breaking up with lithium

Mike Wagner, an assistant professor of mechanical engineering at UW-Madison who works on energy system modeling and energy storage optimization, says it's likely that energy storage will develop in two phases. Currently, wind and solar power are expanding at a rapid rate and are expected to produce about one-third of the world's electricity by 2030. For the most part, these projects will be paired with large lithium-ion batteries (the same technology found in most electric cars and laptops), which will allow them to store energy for a few hours and feed it to the grid during periods of high demand.

But as wind and solar reach their peak, Wagner says other technologies will likely reach maturity, allowing for different types of storage to replace lithium-ion batteries, which have several drawbacks. Not only can lithium-ion batteries overheat, for example, but lithium also is difficult to source and its supply chain is geopolitically complicated. More concerning, the batteries do not scale well, meaning energy costs could add up quickly if they are used for long-term storage.

That's why researchers, including several at UW-Madison, are looking into a whole host of alternatives.

Big batteries that do more with less

Fang Liu, an assistant professor in materials science and engineering, for instance, is working to make sodium-sulfur batteries a viable technology. "This battery variation replaces the lithium, nickel and cobalt in lithium-ion batteries with abundant and cheaper sodium and sulfur," she says. "They are energy-dense and could be used for both electric vehicles and power grids."

Eric Kazyak, an assistant professor of mechanical engineering, is also investigating batteries beyond lithium-ion, including sodium-ion batteries, which are safer and cheaper than the current generation of lithium-ion. **Matt Gebbie**, the Conway Assistant Professor in chemical and biological engineering, is working on new types of electrolytes, or the charge-carrying part of batteries. His new "ionic liquids" (think: electrolytes) could enable safer, more powerful batteries that rely on cheap, plentiful multivalent ions (elements with more than one possible charge) like magnesium, calcium, zinc and aluminum instead of lithium.

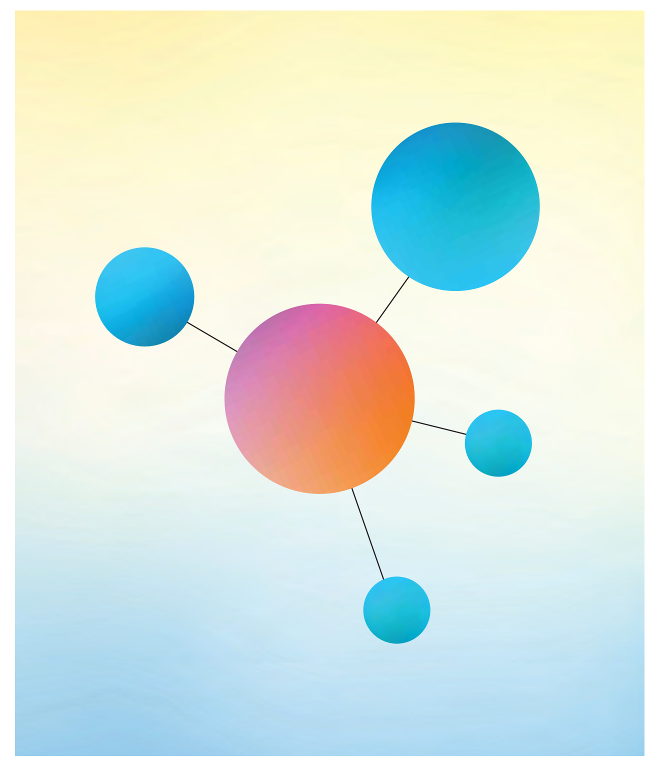
Another alternative to grid-scale lithium-ion batteries is called a redox flow battery, in which the anode (negative electrode) and cathode (positive electrode) are in liquid form. This enables manufacturers to scale the batteries up cheaply and easily by simply making the tanks bigger. **Dawei Feng**, Y. Austin Chang Assistant Professor in materials science and engineering, and **Patrick Sullivan** (PhD MS&E '22) are commercializing an organic redox flow battery through their spinoff company Flux XII.

A current relationship with chemistry

Another emerging option is converting and storing energy chemically, in tandem with renewable sources. Massive amounts of heat and pressure are required to break petroleum into hydrocarbon fuels and chemicals—meaning they create emissions during the production process and also add carbon to the atmosphere when combusted. However, with electrochemistry—chemical reactions created by electricity and a catalyst—it's possible to produce these fuels and other chemicals using carbon dioxide captured from the atmosphere or industrial processes, along with electricity derived from renewable sources. The advantage, of course, is that these energy-dense fuels have a long "shelf life" and can be used to produce electricity or to power transportation.

UW-Madison researchers, including **Marcel Schreier**, the Richard H. Soit Assistant Professor in chemical and biological engineering, are working on methods to interconvert electrical and chemical energy. "We need to even out the immense fluctuations in energy over weeks, months and even seasonally; you need to take some energy from summer into winter," says Schreier. "Batteries are not going to do that. You need something else—and that can be some form of chemical storage."

Similarly, other researchers are looking to convert renewable energy into liquid hydrogen, which also can be stored and used as transportation fuel or to power fuel cells. **Luca Mastropasqua**, an assistant professor of mechanical engineering, is developing electrochemical devices that can produce hydrogen with an eye to using the fuel to power industrial processes like steel and concrete production—both of which are big contributors to carbon dioxide emissions.



Taking the heat (and returning the favor)

While batteries are good for eking a little more life out of your unplugged laptop or contributing a few extra hours of energy to the inevitable evening electricity spike, eventually power systems will need to add technologies that can provide steady, cheap electricity over the course of the day, or even many days.

One potential solution is thermal storage—variations of which have reached the commercial stage in sites across the globe. In general, thermal storage means using excess energy to heat up a large mass, and later converting that heat energy to electricity as needed. In some of the most sophisticated setups, concentrated solar power is used to melt salt, which is then used to produce steam to generate electricity at non-peak hours. In other versions, tanks of water, beds of particles like sand, or even a large concrete block are heated up instead of salt. Several of our mechanical engineering researchers, including Wagner, Assistant Professor **Allison Mahvi**, Consolidated Papers Associate Professor **Mark Anderson**, William A. and Irene Ouweneel-Bascom Professor **Greg Nellis**, and Professor **Doug Reindl**, are involved in research to realize and improve these processes.

Future prospects, on demand

Wagner says that the energy storage landscape looks promising, and most of these and other storage technologies are well on the road to becoming viable. Instead of competing with one another, he thinks most of these approaches will find niches where they make the most sense—whether that's storing energy for the grid, use in transportation, as on-site energy for industrial processes, or something else.

Wagner points out that it took about 120 years for coal technology to fully mature during the Industrial Revolution—yet many emerging storage technologies have gone from an idea to a market-ready solution in a fraction of that time. "With energy storage, researchers are now solving problems that are engineering problems, not fundamental problems," he says. "Energy storage technologies are maturing; researchers are learning how to make cost-effective systems without exotic minerals. I'm optimistic that the current technology options we have available can get us a big step on the way to decarbonization."

KICKING GENERIC KNEES TO THE CURB

How a mechanical engineer hopes to influence the ubiquitous surgery's success, one patient at a time

BY ADAM MALECEK

Deb Constien recalls a time years ago when climbing the stairs of her house to get to her young son's room would trigger jolts of pain in her knee.

"In the year and a half that we lived in that house, I can count on both hands the number of times I was able to go upstairs to my son's bedroom," she says. "That's how bad the pain in my knee was."

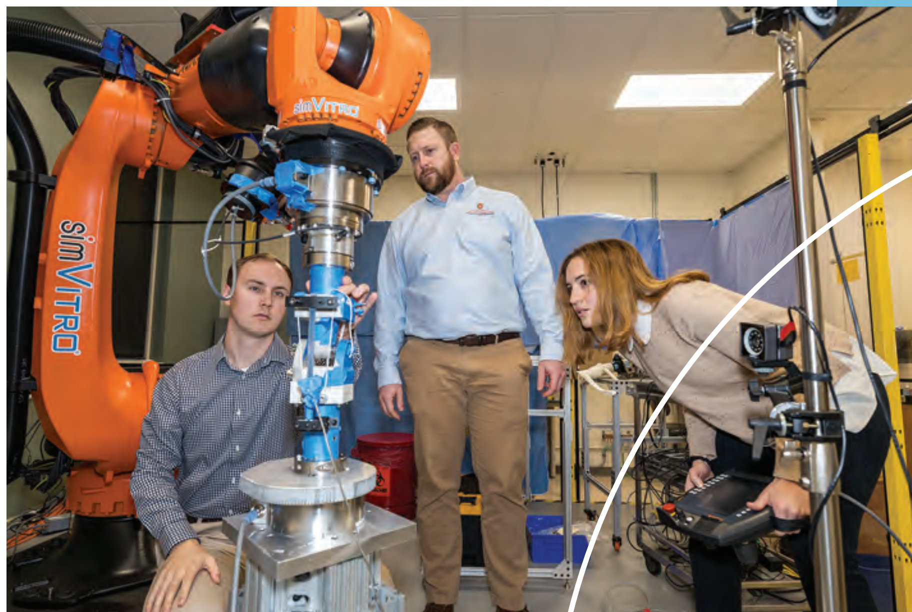
Constien was diagnosed at 13 with rheumatoid arthritis, which causes inflammation in the joints. By age 29, the pain in her left knee had become so severe that she needed a total knee replacement.

The procedure was life-changing. It eliminated her knee pain, allowing her to do many activities again, including using stairs, gardening and going for walks. Now, some 20 years after the procedure, Constien's artificial knee is holding up well—but there are a few nagging issues. Her knee implant sometimes makes annoying clicking sounds. And she is unable to kneel on that knee. "It doesn't really feel like a normal knee, and it doesn't function the same way, so I need to change how I do some activities," says Constien, 54, who lives in Sun Prairie, Wisconsin.

Dr. Richard Illgen, a professor of orthopedic surgery in the University of Wisconsin School of Medicine and Public Health, says Constien's experience after a knee replacement isn't uncommon. "If you ask patients a year after the procedure if their knee feels normal, most of them will say no," he says. "Even if patients are generally satisfied with their knee, it's a far cry from a normal knee for most people."

Right: Biomedical engineering graduate students Matthew Blomquist and Lesley Arant and Mechanical Engineering Assistant Professor Josh Roth (center) set up a surrogate knee joint to conduct mechanical testing using a robotic arm in Roth's lab.

Below: Roth places his ligament tension sensor on a ligament phantom attached to their surrogate knee joint to take validation measurements. In the future, such a sensor could enable surgeons to make crucial measurements during total knee replacement procedures.



Even if patients are generally satisfied with their knee, it's a far cry from a normal knee for most people.

And some patients have much worse outcomes. Up to 20% of patients report not being satisfied with their total knee replacement—experiencing pain, stiffness or limited mobility, according to a 2010 study published in the journal *Clinical Orthopaedics and Related Research*.

That's why our engineers are working on technologies that could unlock better outcomes for most total knee replacement patients.

Making it personal

For patients with osteoarthritis of the knee, which occurs when the cartilage that cushions the ends of bones wears down, a total knee replacement is the final treatment option for relieving the pain. It's a major surgery in which orthopedic surgeons remove the damaged cartilage and bone from the joint and install implants made of metal and plastic to create an artificial knee joint. Approximately 790,000 total knee replacements are performed annually in the United States, making it one of the most common orthopedic procedures, according to the American College of Rheumatology.

Traditionally, surgeons have prepared every patient's artificial knee in the same way, aiming for a neutral mechanical alignment designed to maximize the longevity of the implant.

"However, there's a lot of variability in human anatomy and in how people's joints function," Illgen says. "The next big step for improving outcomes for total knee replacement patients is moving from a general one-size-fits-all approach to more personalized surgical procedures that are tailored to a specific patient's unique anatomy and joint biomechanics."

But there's a barrier to realizing this goal: We don't currently have sufficient biomechanical data to effectively personalize these procedures.

That's where Mechanical Engineering Assistant Professor **Josh Roth's** research comes in. He's working to enhance surgical planning for total knee replacements by characterizing how the joint and ligament biomechanics change as a patient's osteoarthritis becomes more severe. To do this, Roth is developing sensors that will provide better measurements of these biomechanics in the patients themselves.

During a total knee replacement procedure, a surgeon needs to adjust the tension of the ligaments to achieve proper balance and stability in the knee. But that can be a tricky task, as surgeons don't have a way to objectively measure the tension in an individual ligament. So Roth is developing a tool—a novel handheld sensor—that will enable surgeons to make these crucial measurements during the procedure. "Our sensor could be used as a quality-control check during surgery to allow surgeons to identify and correct individual structures that may be improperly tensioned—which should mitigate postoperative pain, stiffness and instability," he says.

In the future, Roth envisions that clinicians could also use this sensor to measure a patient's biomechanics before surgery. These measurements, along with previously collected biomechanical data and medical imaging of the patient's anatomy, would help surgeons decide which implants to use and how to optimally align them on a particular patient's bones.

In addition, Roth's group is working on developing a medical imaging technique that uses ultrasound to view how a patient's joint moves. This imaging technique, which doesn't expose a patient to radiation, promises to provide more detailed information about how a joint behaves. "So, we can have a patient walk, or squat, or stand up from sitting in a chair to get a much better idea of how that patient's joints are moving during daily living activities," Roth says. "This information will enable more personalized surgical plans."

A helping robotic hand

In recent years, the orthopedics industry has introduced computer navigation and robotic assistance technologies that allow surgeons to perform total knee replacements with extraordinary precision. The use of these technologies is growing, with robotic assistance now being used in more than 13% of total knee replacements, according to the 2023 annual report of the American Joint Replacement Registry on hip and knee arthroplasty.

Roth is excited by the possibilities of pairing the tools he's developing with the capabilities of cutting-edge surgical robots.

"The technologies we're developing in my lab will enable us to discover subtle tweaks that can be made to total knee replacements that improve patient outcomes," Roth says. "And now robots are allowing surgeons to precisely execute small tweaks in the procedure that they couldn't do before. By harnessing these technologies, we have a great opportunity to significantly improve patients' satisfaction with their artificial knee."

Qubits, atomic clocks, computing and more

A portal into the promising, uber-tiny world of quantum technology.

Jennifer Choy is an assistant professor of electrical and computer engineering who studies quantum sensing. Quantum sensing is one of several growing research fields that use quantum mechanics for applications ranging from creating nanoscale optical sensors to the supercomputers of the future.

In this interview, Choy discusses the principles of quantum systems and some of the applications of quantum mechanics, including one we use every day.

"Quantum" is a term we hear a lot across a variety of fields, often regarding things happening at a very small scale. But what, exactly, does quantum mean?
Quantum refers to the most fundamental unit of something. In a lot of applications, "quantum" means phenomena or physical systems for which the length scales are so small that you cannot describe their characteristics with classical physics.

The most accessible way to understand quantum behavior is to look at the atom itself. An excited atom (such as one in a gas tube that is heated) will emit light that is quantized (expressed in discrete values) in terms of its energy. Each individual atom, depending on the species, has a length scale on the order of about an angstrom (a hundred-millionth of a centimeter). At that scale, you can describe an atom both as a particle—as its own quantity—but also as a wave.

One of the most basic manifestations of quantum physics is this concept of wave-particle duality: Something has the properties of a wave and a particle at the same time. Through that duality, you can think of an atom as a little wave that is distributed in time and space. However, you also can say that when you're measuring an atom, you have narrowed down its position at a particular location in space, and therefore it is behaving like a particle.

How can quantum mechanics research benefit other fields, like quantum sensing?
The thing that excites me most about quantum mechanics is the ability to bring new functionality to existing technologies. In the case of sensing and metrology (the science of measurement), quantum technologies allow us to make measurements in a much more precise and accurate way.

One such quantum technology is the atomic clock. The way our world runs right now is reliant on using atoms to be able to keep time. Atomic clocks measure the quantized resonance frequency of atoms, often using the element cesium, to keep time with a very high degree of accuracy.

There are 24 GPS satellites orbiting Earth, and there are atomic clocks on each of them. As we receive signals from GPS satellites, they contain information about position, along with a timestamp. Each one of these timestamps has data that comes from the measurement of atoms within the atomic clocks. That allows us to very accurately determine position, with very small degrees of uncertainty.

Leveraging the stability of atoms (and the ability to precisely measure their energy transition resonances), we can also very accurately measure gravity as well as other types of motional forces like acceleration or rotation. This concept can be applied to develop navigational sensors that are reliable even with interruptions in GPS signals.

Additionally, we can use quantized electron energies in atoms to develop ultra-sensitive magnetometers that are precise enough to measure electric currents that come from neurons firing in the brain. Similar concepts can be applied to make atomic-scale probes of electromagnetic fields in solid-state materials. For example, by introducing a defect in a diamond crystal, we can generate an artificial atom that is small and sensitive enough to study electromagnetic and temperature changes in cellular processes.

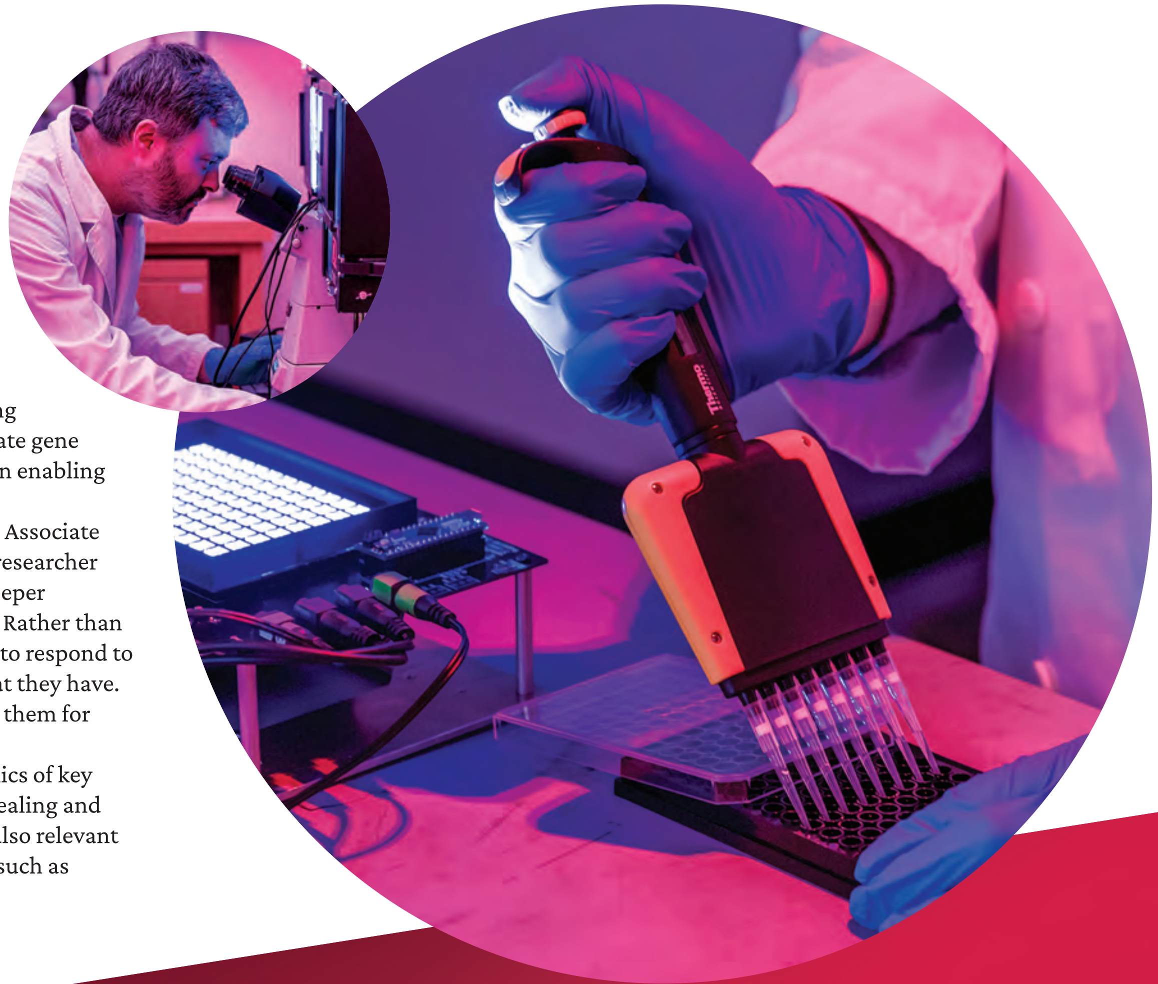
Quantum computing is another area of quantum research that gets a lot of buzz. What are some advantages quantum mechanics brings to that field?
Quantum computing takes advantage of the quantum nature of devices at very small scales, and the ability to control and measure the states of quantum systems, to create quantum equivalents to classical bits like 0 and 1.

The state of a quantum system—for example, whether it is 0 or 1—is described probabilistically until it is measured. This enables the use of superposition, the idea that a quantum system probabilistically occupies multiple states at the same time until it's measured.

Additionally, it is also possible to generate correlations in the measurements of multiple quantum systems through a unique quantum phenomenon called entanglement. This phenomenon occurs when, for a pair of quantum particles, measuring one determines the result of measuring the other even if the particles are separated. So in quantum computing, these quantum bit analogues, which are called "qubits," may then have the properties of being 0 and 1 superimposed, and the states of the qubits correlated.

This can be handy for parallel computing. If we can scale up the number of qubits, we could solve problems that are considered too computationally intensive for classical computers. One example of this concept is being able to factor very large numbers, which has implications for security applications.

A quantum computer can also be used to simulate quantum behavior in materials. One example is to use such quantum simulators to study chemical processes on the individual molecule or atomic level and how those processes happen as a function of time. That could help further our understanding of chemical and biological processes and make it faster to perform synthesis of chemicals and develop new types of medicine.



Stressed cells just deal with it

When a cell's environment changes, it responds with signals internally that turn various cellular machinery on and off, expressing some genes while repressing others. Transcription factors, which regulate gene expression and bind DNA, play a key role in enabling responses specific to each stress.

In a study with Biomedical Engineering Associate Professor **Megan McClean**, postdoctoral researcher **Kieran Sweeney** (PhDBME '22) gained deeper understanding of how this process works. Rather than leaning on a different transcription factor to respond to each signal, cells make the best use of what they have. "You can take your components and reuse them for different situations," says Sweeney.

The research could apply in the mechanics of key transcription factors involved in wound healing and in suppressing cancer tumor growth. It's also relevant to synthetic bioengineering applications, such as ethanol production.

A better biofertilizer, biologically

Excess nutrients—like phosphorous from manure spread on farm fields—wreak havoc on the world's water. They run off into streams, rivers, lakes and oceans and can lead to massive sargassum blooms, ocean dead zones, and algae blooms that consume oxygen, kill aquatic life, and sicken people and animals. "This nutrient pollution is not staying local—it's propagating to places that are not responsible for it," says **Victor Zavala**, the Baldovin-DaPra Professor in chemical and biological engineering.

Zavala, Karen and William Monfre Professor and Vilas Distinguished Achievement Professor **Brian Pfleger** and their collaborators want to reduce those environmental costs. With some innovative biological engineering, they're designing a system in which they collect and process manure to produce concentrated streams of nitrogen and phosphorous. Then they feed those nutrients to specially tuned cyanobacteria, which concentrate the nutrients in their cells. Finally, they harvest the cyanobacteria and transform it into a balanced biofertilizer.

The team also is gathering input from farmers to inform how to efficiently collect and transport manure, determine where to site equipment, and make the most effective fertilizer.

Wearable work assist

Though they have yet to leap tall buildings in a single bound, construction workers still get a boost from wearing an EXO—the soft, flexible fabric exosuit or its more rigid counterpart, the exoskeleton.

In partnership with construction firm Mortenson, a multidisciplinary team of researchers asked workers wearing EXOs to perform various tasks like pushing a gondola or raising an object overhead. They focused on passive EXOs, which use springs and tension to support the wearer's movement and focused on suits that aid with back and shoulder support.

While the EXOs did help to reduce task completion time, workers responded differently to them—and overall, their opinions were mixed. The researchers are confident that as EXOs improve, they can benefit construction workers, especially those who are older or who have health issues.

Graduate students **Wei Han** (civil) and **Tyler Bennett** (mechanical) led the study, with **Peter Adamczyk**, the Mead Witter Foundation Associate Professor of mechanical engineering; **Zhenhua Zhu**, the Mortenson Assistant Professor of civil and environmental engineering; **Michael Wehner**, an assistant professor of mechanical engineering; **Raj Veeramani**, the E-Business Chair Professor of industrial and systems engineering, and other collaborators.

Tyler Bennett, left, and Wei Han

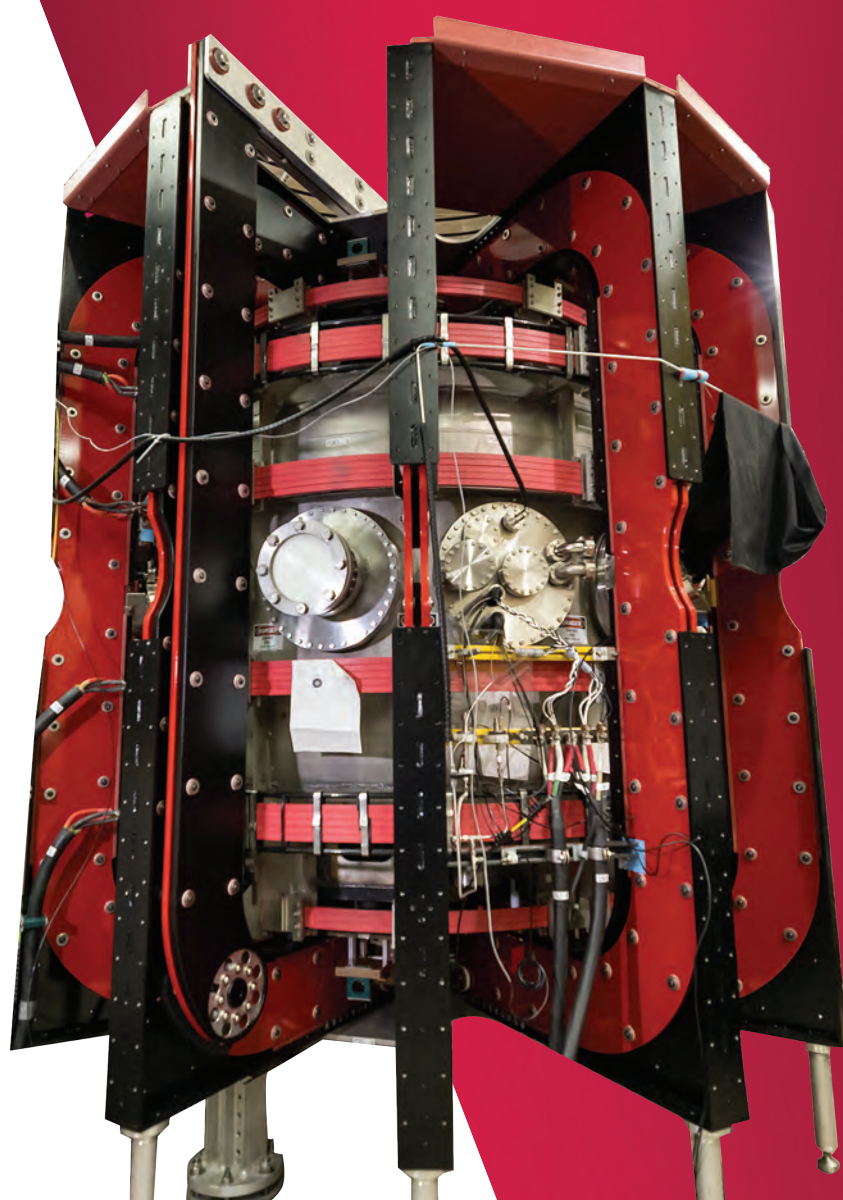
What's involved in getting a car to drive without a human behind its wheel? Watch this video of Civil and Environmental Engineering Professor **Xiaopeng Li** explaining how self-driving vehicles work (you can even see his own AV in action on campus)!

Unlikely origami applications unfolding here

After applying origami and kirigami techniques to 3D printing structural reinforcements for oil pipelines, PhD student **Weijun Shen** has turned his attention to biomedical solutions. He and Industrial Systems and Engineering Assistant Professor **Hantang Qin** are creating stent grafts, while combining more flexible tubular origami structures with electrohydrodynamic jet-printed metal sensors to produce soft robotic components. Controlled externally, they could be deployed in the body to monitor conditions such as acidity in the gastrointestinal tract, or to deliver a timed drug release.

Forging ahead in fusion

After several years of work, construction of our new Pegasus-III fusion experiment is finished and experiments have begun. Led by Nuclear Engineering and Engineering Physics Assistant Professor **Stephanie Diem**, researchers are using Pegasus-III to investigate several solenoid-free reactor startup techniques. Local helicity injection uses small plasma "lightsabers" to inject ribbons of super-heated plasma, where a magnetic field captures and confines them. In coaxial helicity injection, a voltage applied between two electrodes creates a plasma bubble, while radio-frequency wave injection uses specially tuned microwaves to transfer energy to the plasma. "We are in a unique space at UW-Madison where we can study all three of these methods in one device," Diem says. "Not only can we test each technique independently, but we can also investigate if one technique can enhance another. In addition, we can get our hands on the machine to design whatever experiments we want to test different theories—and this also provides a great hands-on learning opportunity for our students."

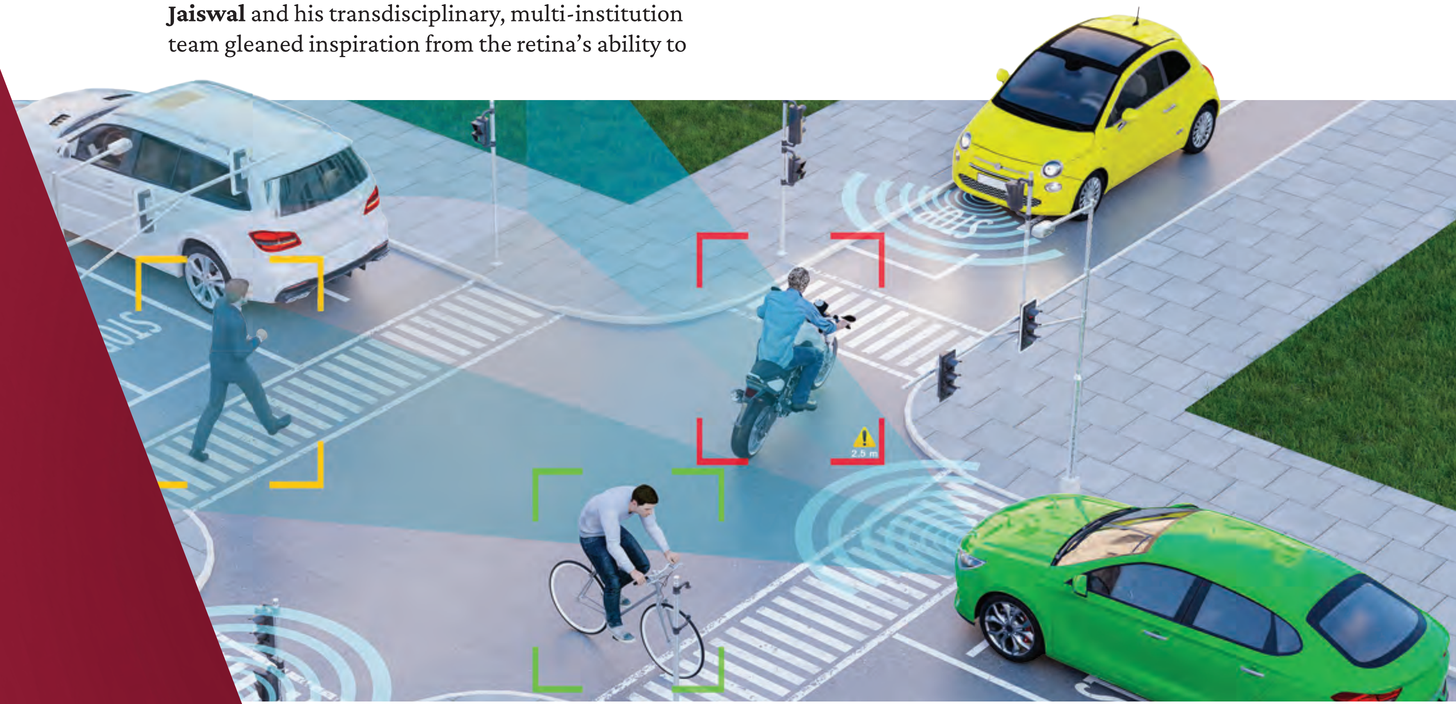


Team sets sights on safer AVs

Inspired by the retina, a new sensor could improve the safety and performance of self-driving cars, robotics and high-speed autonomous drones.

The retina is the layer of cells in our eyes that detects light and transmits signals to our brain. Specialized cells located beneath the light-detecting layer can process some information almost instantly. In fact, the retina may extract tens of different features simultaneously from the field of vision, allowing people to react quickly without thinking about it.

When designing their sensor, Electrical and Computer Engineering Assistant Professor **Akhilesh Jaiswal** and his transdisciplinary, multi-institution team gleaned inspiration from the retina's ability to quickly identify an approaching object and moving objects against a moving background. They used cutting-edge 3D chip-stacking techniques to design the sensor. The top chip uses dynamic pixels, which respond to light intensity changes; below is a chip that conducts preprocessing computations—like retinal cell layers in the eye—to allow an autonomous vehicle to react quickly. "We are ushering in an era where cameras have the capability to see, capture and analyze the world just as the human eye does, unveiling previously unseen details and spearheading unprecedented advancements in vision science," says a member of the research team.



EZacces$!

Website extensions expose passwords and more

Websites can be vulnerable to browser extensions that can extract information like passwords, credit card and social security numbers from HTML code.

Electrical and computer engineering PhD students **Rishabh Khandelwal** and **Asmit Nayak** and their advisor, ECE Associate Professor **Kassem Fawaz**, discovered that a huge number of websites they studied—about 15 percent of more than 7,000—store sensitive information as plain text in their HTML source code. And they learned they could find that data by creating and using a browser extension—an "add-on" that uses small bits of code to accomplish extra tasks like blocking ads. "Combining what we know about extensions and about websites, an extension can very easily access users' passwords," says Fawaz. "It's not something that actually *is* happening, but there is nothing preventing it."

He hopes his research will convince website managers to rethink the way they handle this sensitive information.

Innovating info about reactor heat

Nuclear Engineering and Engineering Physics Assistant Professor **Juliana Pacheco Duarte** is filling a big gap in reliable experimental data about critical heat flux, a transient heat transfer phenomenon in nuclear reactors. That dearth of data leads to uncertainty in the computational models used for reactor safety analysis.

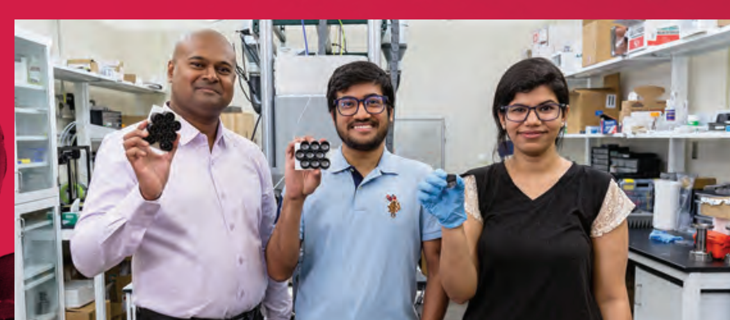
Duarte is using optical fibers to measure the temperature in a nuclear fuel rod simulator—with different cladding materials and under various transient scenarios—under prototypical light water reactor conditions. “I will be one of the first researchers performing these kinds of experiments at high pressure and at reactor conditions,” she says. “With this unique data, I will use machine learning to improve the models that are used for safety analysis of nuclear reactors.”

She’s also looking at how new accident-tolerant fuels and others affect transient critical heat flux and post-critical heat flux—knowledge that can inform the regulatory licensing process needed for upgrading existing nuclear plants to accident-tolerant fuels.

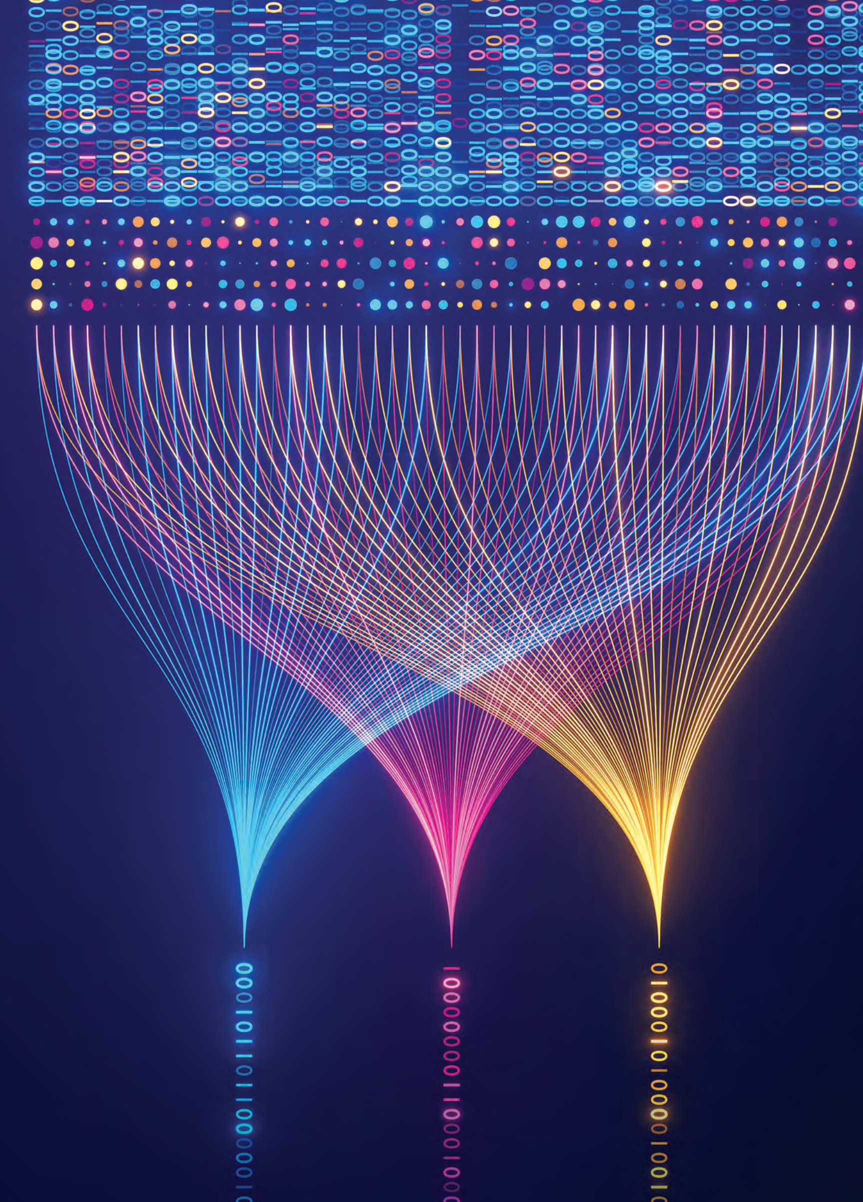
Helmet cushioning material leaps ahead

Pioneered by Mechanical Engineering Assistant Professor **Ramathasan Thevamaran** and his students, an ultra-shock-absorbing foam material already shows promise as a helmet liner that could mitigate or prevent concussions and other traumatic brain injuries. In fact, the new foam absorbs significantly more energy from impacts than the foam currently used in U.S. military combat helmet liners.

Now, by tweaking the internal architecture of their vertically aligned carbon nanotube foam, the researchers have made the foam even more lightweight, while at the same time improving its damping and energy-absorption capabilities.



The research team (from left): Assistant Professor Ramathasan Thevamaran, PhD student Abhishek Gupta, and postdoctoral research associate Komal Chawla.



Sifting and winnowing

From 8 million candidate materials to the final three, researchers pioneer new polymer discovery

From millions of candidates, Mechanical Engineering Associate Professor **Ying Li** and his collaborators used the power of machine learning predictions to rapidly discover several promising high-performance polymers called polymides.

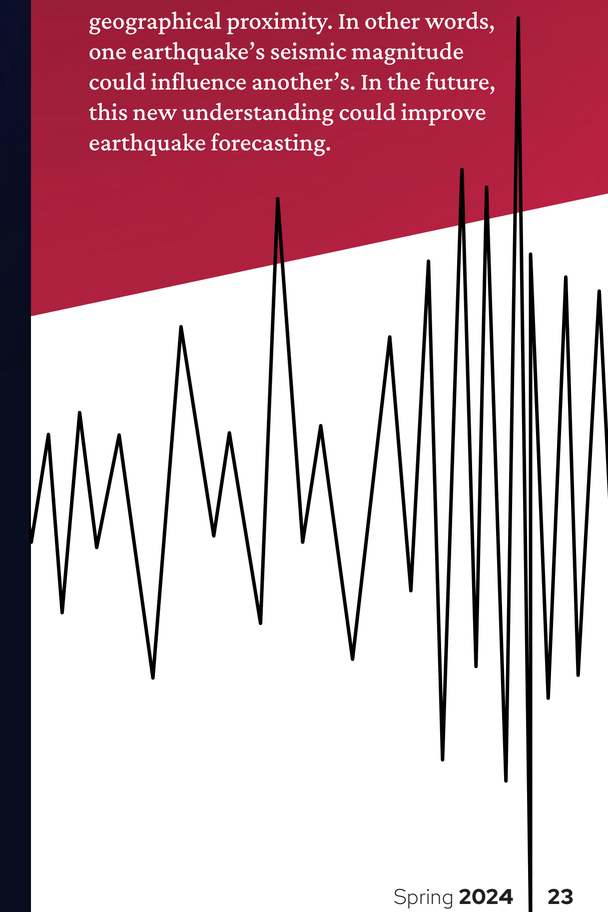
Although their strength, stiffness and heat-resistance make such polymers perfect for use in aerospace, automotive and electronics applications, only a limited number of polymides exist because they’re time-consuming and expensive to design. These polymides are made through a condensation reaction of dianhydride and diamine/diisocyanate molecules.

For their project, Li and his team used a computer to combine the building blocks, giving them all possible combinations in a huge database. They came up with 8 million hypothetical polymides—ultimately narrowing that field to just three. Then they built all-atom models, ran simulations to test them, made one of the new polymides, and performed experiments that showed it could withstand more than 1,000 degrees Fahrenheit before it started to degrade—a result that agreed with their predictions.

Submitted photo

With decades of data, earthquakes get their fair shake

Analyzing information about more than 400,000 earthquakes, Civil and Environmental Engineering Assistant Professor **Jesse Hampton** and postdoctoral researcher **Qiquan Xiong** discovered that clustering in earthquake magnitudes was more pronounced when earthquakes occurred within shorter time intervals and in closer geographical proximity. In other words, one earthquake’s seismic magnitude could influence another’s. In the future, this new understanding could improve earthquake forecasting.



Cracking the Da Vinci chronology

Centuries after his death, sophisticated technology will finally add order to the artist's hodgepodge works.

When Leonardo Da Vinci died in 1519, he left behind 7,000 pages of undated drawings, scientific observations and personal journals, more or less jumbled up in a box. Ever since, art historians have used all sorts of techniques to make a timeline of the various documents now held in museums and collections across the world.

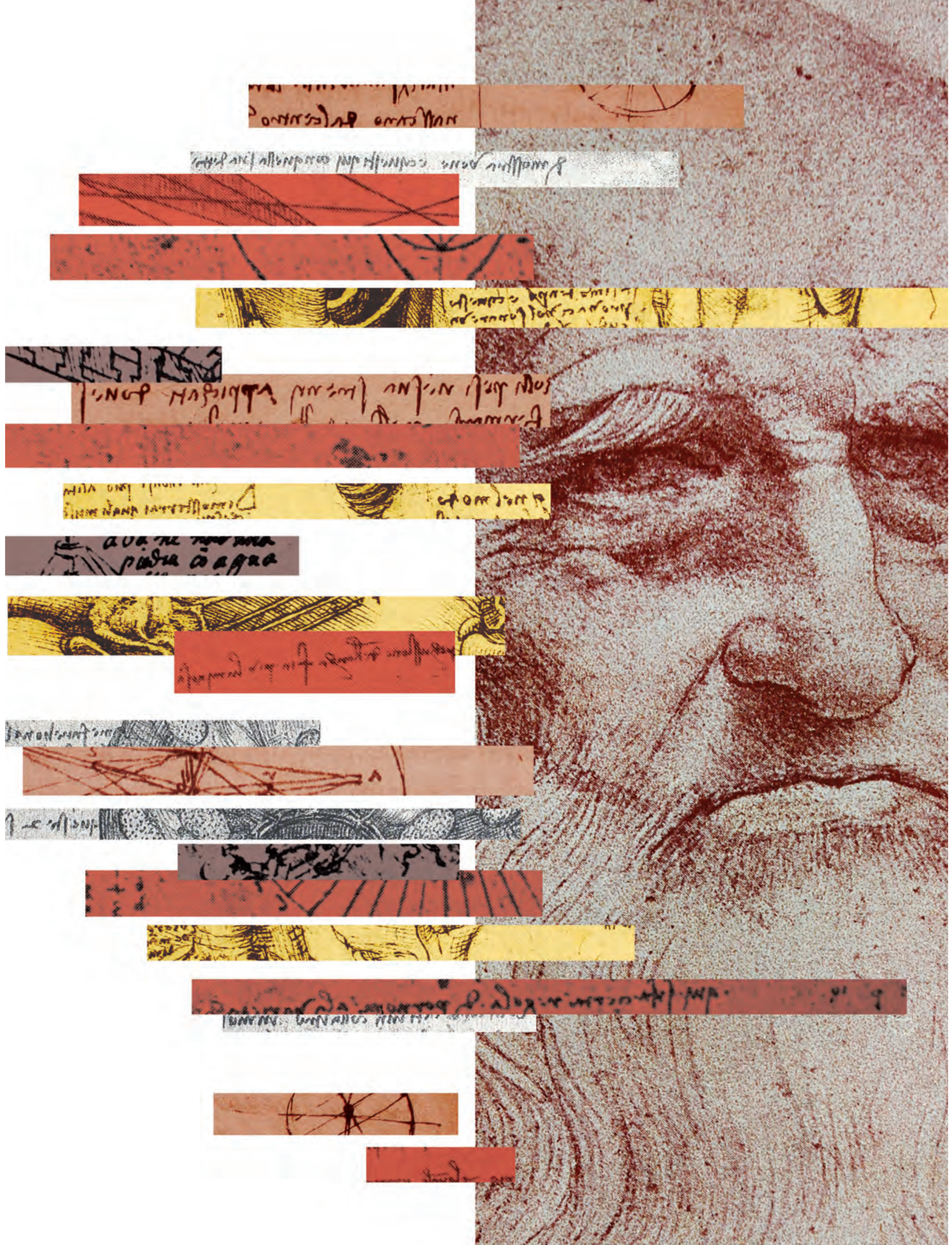
A technology developed by Electrical and Computer Engineering Professor **William Sethares** and PhD student **Elisa Ou** could help in that centuries-long effort.

With their camera system and sophisticated algorithms, they can find clues on the actual paper that allow them to match undated drawings and writings to others with established dates.

Here's why. In DaVinci's time, papermakers poured a slurry onto large mesh screens to produce large sheets of paper, which they then cut or folded and sold in bundles. Each of those screens was made of vertical chain wires and more delicate and numerous horizontal laid lines. Sometimes they included watermarks—unique miniature symbols made from fine wire—to identify their products. "If you can find two pieces of paper that have the same chain lines and watermarks, then they came from the same mesh molds, and that puts them in proximity in time," says Sethares. "That's because these molds only lasted about six months or a year."

Seeing the chain lines and watermarks is difficult, however—especially on delicate paper covered by ink, paint or writing. In the engineers' watermark imaging system, or "WImSy," researchers use a light plate to backlight an artwork, then take several photos, with light coming from different directions, to capture detailed images. They use algorithms to digitally remove the surface image to reveal chain lines, laid lines and watermarks, then align and compare those details to other works with known dates.

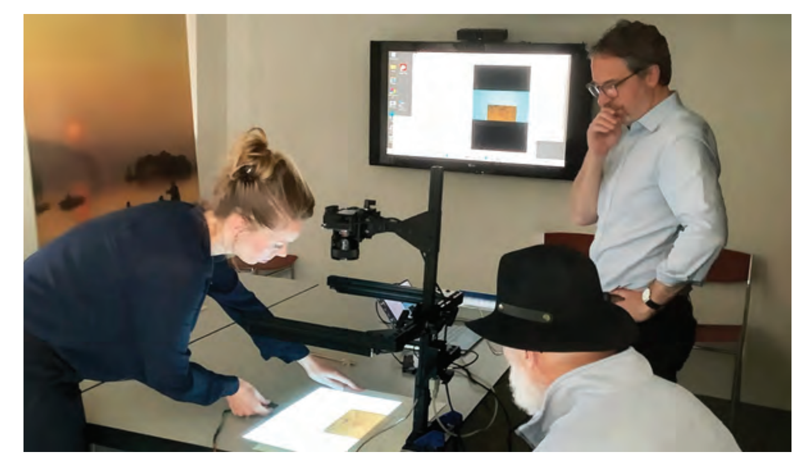
The team first tested the system on artworks at the Metropolitan Museum of Art in New York and at the Getty Museum in Los Angeles. In 2022, art historians used it to isolate watermarks to authenticate a newly discovered drawing by the German Renaissance artist Albrecht Durer. It's also part of a Da Vinci project called LEOcode, which involves researchers from UW-Madison, Cornell University and the New York University Institute of Fine Arts.



Some scholars of Rembrandt—another artist who rarely dated his artwork—are also embracing WImSy. Sethares has photographed the Dutch master's drawings at the Teylers Museum in Haarlem, in the Netherlands; additional stops for the system include the Boijmans museum in Rotterdam, the Rijksmuseum in Amsterdam, and potentially other institutions in Europe.

Eventually, Sethares says he would like to build a second WImSy system and would like to see a repository of papers photographed by the device that other researchers could access to date artworks and documents. Meanwhile, the team also plans to photograph papers or documents from the Dutch National Archives—among them, deeds of sale, wills and other paper documents. "The 'boring stuff' is almost always dated," says Sethares. "So if we can go through the archives and match those pieces of paper up with Rembrandt's, that will at least get us to within a couple of years."

Professor William Sethares examines a drawing made in preparation for Rembrandt's painting "Return of the Prodigal Son," which is not definitively dated. Watermarks and lines on the paper may allow art historians to match it to dated artworks from the same batch of paper. Submitted photo.



Marleen Ram, an art curator at the Teylers Museum in Haarlem, the Netherlands, places a drawing by Rembrandt under the watermark imaging system's camera along with Rick Johnson, a professor emeritus of electrical engineering at Cornell University (center), and Rob Fucci, an art historian at the University of Amsterdam (right). Credit: William Sethares.

Expert assessment

Individually, they're exceptional. Collectively, they bring an incredible level of leadership, expertise, innovation and enthusiasm to our campus. They're the 18 new faculty who joined us in the 2023-24 academic year. Some have industry or national laboratory experience. Several join us after roles at other academic institutions. Many have lived, worked and studied in multiple countries. Some hold multiple patents. Quite a few already have racked up prestigious honors and awards for their work. All of them are excited to be here, to teach, learn, connect and grow on our vibrant campus.

Check out our blog post for access to profiles of each new faculty member.

"It is a great privilege to be joining and growing in this unique community."

"When I applied for this position, they told me, 'Whatever you need you can find it here.' And it's true. That's a dream come true for a researcher."

"And I love the four seasons."

Charting a course for aquatic robots
Wei Wang
Assistant professor, mechanical engineering

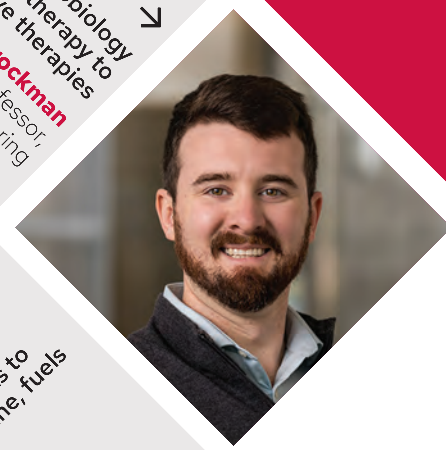
Helping communications networks work smarter
Feng Ye
Assistant professor, electrical and computer engineering

Making software systems to simplify high-performance computing
Tsung-Wei "TW" Huang
Assistant professor, electrical and computer engineering

Studying the connections between mind, motor and machine
Ranjana Mehta
Professor, industrial and systems engineering

Redefining what we use to generate and store energy
James Pikul
Leon and Elizabeth Janssen Associate Professor, mechanical engineering

Getting the power grid ready for a renewable future
Manish K. Singh
Assistant professor, electrical and computer engineering



Merging mechanobiology and immunotherapy to improve therapies
Joshua Brockman
Assistant professor, biomedical engineering

Using automation to accelerate materials discovery
Sebastian Kube
Assistant professor, materials science and engineering

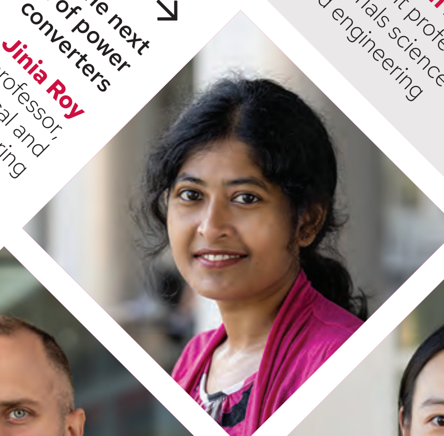
Pushing the limits of high-resolution deep imaging
Randy Bartels
Professor, biomedical engineering

Creating powerful tools to study quantum materials
Yuan Ping
Associate professor, materials science and engineering

Bridging the gap between fusion science and real-world energy technology
Adelle Wright
Assistant professor, nuclear engineering and engineering physics

Engineering plants to produce medicine, fuels and more
Quentin Dudley
Assistant professor, chemical and biological engineering

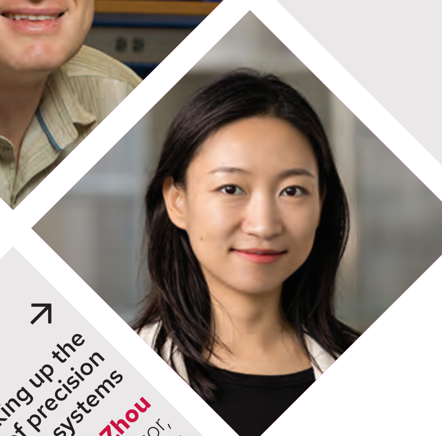
Pioneering techniques that move computer processing closer to the end user
Akhilesh Jaiswal,
Assistant professor, electrical and computer engineering



Designing the next generation of power converters
Jinia Roy
Assistant professor, electrical and computer engineering

Making machine learning safe and secure for everybody
Grigorios Chrysos
Assistant professor, electrical and computer engineering

Developing ground-penetrating radar to deliver in-depth detail
Haihan Sun
Assistant professor, electrical and computer engineering



Shaking up the design of precision mechatronics systems
Lei Zhou
Assistant professor, mechanical engineering

Creating microrobots to benefit human health
Yunus Alapan
Assistant professor, mechanical engineering

In our new data science certificate program, the numbers tell the story

"I love looking at data," says industrial engineering undergrad **Hailey Mendola**. "Being able to pinpoint and use those numbers to find new ways to do things and be able to manipulate data to figure out things easier, quicker, more efficiently."

Mendola's penchant for crunching numbers is leading her toward a career in manufacturing—ideally as a plant manager. In order to fulfill her career goals, however, Mendola realized she needed to build out her data science skillset, along with credentials to entice future employers. To help prepare students like Mendola for the evolving workforce, the college launched a new undergraduate certificate in engineering data analytics in fall 2023. It's a joint effort between industrial and systems engineering and electrical and computer engineering—but it's open to all engineering undergraduates.

Above: Bhumesh Kumar, right, a PhD student in electrical and computer engineering, guides students through a problem during a session of ECE 532: *Matrix Methods in Machine Learning*. Photo by: Tom Ziemer. *Left:* Hailey Mendola. Submitted photo.

"Data is everywhere," says **Amanda Smith**, an assistant teaching professor of industrial and systems engineering who's helped lead efforts to develop the certificate program. "Everything now is really based on data—collecting data, analyzing data, interpreting data and using data to make decisions. Regardless of industry, regardless of the specific job, having a basic understanding of how to do those four key things with data—you basically can't be a successful engineer without those skills. And what we're hearing, especially from a lot of the bigger-name employers that hire our students, is that they're really not even considering candidates who don't have a sound background in data science, data analytics."

To reach the required 15 credits, students choose courses in four categories—foundations of data analytics, applications of data analytics, data science, and machine learning—before taking a required capstone course, *Ethics of Data for Engineers*. **Kangwook Lee**, an assistant professor of electrical and computer engineering whose research includes improving fairness in machine learning, developed the new course.

While students learn programming in languages such as Python and Julia, database management skills, and the mathematical fundamentals underpinning modern analytical techniques, the program more holistically cultivates an engineering mindset to solve problems through data science.

Embark on a journey into the realm of robotics! Join us for Engineering EXPO's community day, April 20, 2024, from 9 a.m. to 2 p.m. This free event is organized completely by students and spans the entire UW-Madison engineering campus, inviting more than 4,000 middle school students to get involved in STEM. Since 1940, students participating in EXPO have showcased the field of engineering and science through more than 50 student organizations,

faculty and industry exhibits, as well as keynote speakers and design activities. Learn more at engineeringexpo.wisc.edu ... and join us as we inspire the next generation of innovators and celebrate the wonders of robotics and STEM!

Submitted photo.

In world challenge, rocket team places high

At the 2023 Intercollegiate Rocket Engineering Competition (AKA Spaceport America Cup) in New Mexico, our American Institute of Aeronautics and Astronautics (AIAA) student team placed 34th overall out of 158 total teams. It was UW-Madison's first entry in the cup—the world's largest intercollegiate rocket competition. The team successfully launched and recovered a rocket carrying a quantum magnetometer as a payload. "When the time finally came for the launch days, we quickly learned all of the ways Murphy's Law applies to rocketry," says competition team lead Kyle Adler, an engineering mechanics and aerospace engineering undergrad. "After preparing the rocket all morning, our first launch was scrubbed due to wind. Disappointed but determined to launch the second day, we woke up well before sunrise to give us the best chance. Another five hours of preparation and several broken switches later, we finally found ourselves loading the rocket onto the pad. ... We confirmed "go" for launch. Seconds later, we lost GPS tracking, and watched our rocket soar into the clouds. The successful recovery of our rocket was a perfect example of the importance of backup measures and planning for the worst—something none of us will soon forget."

A shoutout to the academically excellent recipients of our STAR scholarship. We now support 120 STAR scholars whose financial support allows them to focus on studying engineering rather than footing the bill for college. And, we have incredible alumni and friends whose pay-it-forward financial generosity is an investment in the future of every one of our scholarship recipients. That's pretty excellent, too!

A UW-Madison engineering education can lead to limitless opportunities. Our alumni drive innovation and economic prosperity at the local, state, national and international levels. In other words, when people learn they are Wisconsin engineering graduates, they know our alumni desire to—and can—make a difference.

Healthy choice

Through her work at Exact Sciences, **Travelle Ellis** is working to improve the lives of millions of vulnerable and underserved people in our country who don't have access to the resources they need to be healthy. In her current role, she focuses specifically on colorectal cancer screening—partnering with communities and caregivers to help them support at-risk populations. As an advocate at the local and national levels, she promotes health equity and makes the case for reducing health disparities. She's also a mentor and a champion for diversity within the medical profession.

Data driver

In every position he's held at Procter & Gamble, **Brian Gettelfinger** has used information, modeling, simulation and machine learning to help make decisions that affect everything from work process transformation to product research and development. His insights ensure P&G's products are not only innovative, desirable and helpful to consumers, but they're also discovered, designed, manufactured and delivered efficiently and sustainably. In short, he helps the company create products that achieve its business objectives and meet consumer needs.

Environmental advocate

Working with many other local, regional and national teams or agencies, **Anthony Heddelsten** addresses environmental emergencies and other big challenges that affect the lives of thousands of people in his district. Over the course of his career with the U.S. Army Corps of Engineers, he's led major projects that range from disaster response and managing floodwaters to hydropower generation and ecosystem restoration. As another illustration of his commitment to service, Anthony is mayor of the city of Riverdale, Iowa.

Motor scooter

As co-founder of C-Motive Technologies, **Justin Reed** is perfecting the electrostatic motor—a device invented by Benjamin Franklin nearly 300 years ago. Harnessing the power of static cling, the company's highly efficient motors include sustainable materials with a reliable supply chain and low environmental impact. Given the ubiquity of electric motors, Justin sees an opportunity to make a big impact in several sectors, particularly e-mobility and industrial applications.

Capital catalyst

As a venture capitalist with Kindred Capital VC, **Maria Palma** identifies and invests in promising early-stage companies. Through her mentorship and guidance, she has generated significant returns on those investments—and that wealth is shared with her founders. Alongside smart investments is Maria's drive to bring a more diverse group of entrepreneurs to the venture capital space. Throughout her career, she's helped startups worldwide to grow through training, business development support, and access to low-cost loans.

Nuclear energy

Rachel Slaybaugh has been a scientist at a national laboratory, a tenure-track professor at one of the country's top universities, a driver of transformational change in the nuclear energy sector, and a champion for global innovation and entrepreneurship in nuclear energy. She founded a think tank to make the progressive case for nuclear energy, and she led the Biden-Harris administration's transition efforts on nuclear energy. Today, as a partner at Data Collective Venture Capital, she guides investments in and supports climate technology companies.

Business planner

Julie Cameron has leveraged her chemical engineering education to bridge the worlds of research and business. She has led global sales, marketing and business development for product lines in areas as diverse as aerospace defense and long-term implantable medical components. She's equally adept at negotiating complex, balanced and lasting agreements as she is at mentoring people and fostering a positive corporate culture. She's currently CEO of two complementary companies, Excel Scientific, a manufacturer of specialized medical-grade film products; and Innovize, a custom development and manufacturing company with a focus on medical applications.

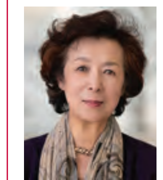
Sustainable source

Throughout his career with Honeywell UOP, **John Gugel** leveraged his training as a civil engineer to build energy infrastructure in countries around the globe. Under his leadership, the company provided technology and modular equipment in the United States for exporting liquid natural gas. He led the company's pivot to become a global leader of sustainable technology solutions, commercializing several breakthrough sustainable technology solutions in renewable fuels, advanced chemical recycling, energy storage, carbon capture and sequestration. Currently, he is CEO of Genomatica, a company that is using the power of synthetic biology to produce sustainable, low-carbon chemicals and materials to replace those that rely on fossil fuels or destructive land-use practices.

Chip architect

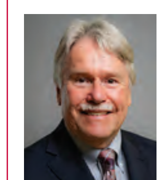
Many of the devices we use today rely on cloud computing, and thanks to **Kevin Lepak's** expertise, those data centers can process increasingly large amounts of information more quickly, using less energy. As one of only about a dozen corporate fellows with semiconductor company Advanced Micro Devices, Kevin is among the company's most elite and innovative engineers. He is developing the roadmap for the company's next generation of data-center processors. And, applying deep technology expertise, he plays a critical role in maintaining AMD's competitiveness and industry-leading efforts to reimagine chip architecture—thus enabling data centers worldwide to keep pace with emerging data-intensive technologies and applications.

Business leader



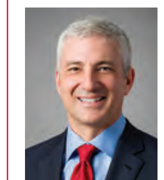
Lei Lei has served the Rutgers Business School community—and her profession—for more than three decades. As a faculty member, she founded the Rutgers Center for Supply Chain Management and was founding chair of the university's Department of Supply Chain Management. She also is a popular educator who has received numerous high-profile honors for her teaching excellence. Since 2011, Lei has been dean of the Rutgers Business School, which today has more than 230 faculty members and more than 10,000 students. During her 12 years as dean, she has been a visionary and inclusive leader, inspiring the faculty, staff and alumni to support her goals. As a result, the school has greatly expanded enrollment (by 48%!), and is highly ranked on lists that include the nation's top business schools, MBA programs, top-value undergraduate business schools, researcher excellence, and others.

Metal ally



With more than 50 U.S. patents to his credit and a host of prestigious honors for his innovation, **Iver Anderson** is a leading international authority on metallic alloy design and powder metallurgy processing and applications. His advances have global impact—for example, his lead-free solder alloys alleviate some environmental contamination associated with the mountains of electronics that pile up as we discard old devices. His work in powdered alloy atomization has been important to the high quality and characteristics of parts made through additive manufacturing, as well as in materials designed to withstand extreme environments. He is both senior metallurgist at Ames National Laboratory at Iowa State University and an adjunct professor in materials science and engineering—a role in which he is proud to have mentored and guided numerous students who now have become his colleagues and collaborators.

Farm foundation



Passionate about advancing the field of agriculture, **Eric Hansotia** is a global leader in the agricultural machinery business, driving sustainable development and delivery of equipment and technologies that are essential to feed our growing population. As chairman, president and CEO of AGCO Corporation, he champions a culture of innovation and collaborative excellence, partnering with farmers on smart and precision agriculture solutions that maximize yield and profits for everyone, while minimizing impacts on the environment. Under Eric's leadership, AGCO not only has increased revenue, but it also has added several technology businesses and grown its base engineering staff by sixty percent. Prior to his work with AGCO, he also spent nearly a decade with John Deere, where he also held several global leadership roles in areas that include harvesting and crop care.

Global energizer

Through her technical expertise; understanding of nuclear energy, environmental policy, electricity markets and energy economics; and passion for science-based advocacy, **Sama Bilbao y León** has provided global leadership in positioning nuclear energy for success. She has been a scientist, educator, ambassador, researcher and policy-driver. In her current role as director general of the World Nuclear Association, Sama is one of the leading voices in the global nuclear energy sector, with frequent opportunities to influence energy policies in individual countries and regions around the world.

A broken concrete sample during testing in the Jun and Sandy Lee Wisconsin Structures and Materials Testing Laboratory. The century-old samples withstood pressures of more than 8,000 pounds per square inch before failing.

Top: Steven Cramer, a civil and environmental engineering professor emeritus, carries a fractured concrete sample after testing it in a hydraulic press. Cramer oversaw testing of the samples, which were first poured in 1923, to conclude a 100-year study. *Bottom:* Civil and environmental engineering junior Ella Thomas loads a 100-year-old concrete sample into a hydraulic press for testing. The concrete is wrapped in sensors that measure stresses while the sample is under load. All photos: Alex Holloway.

View our 2010 video to learn how the 1910 concrete study turned out.

Century-long concrete test cements its place in college history

In the Jun and Sandy Lee Wisconsin Structures and Materials Testing Laboratory, Civil and Environmental Engineering Professor Emeritus **Steven Cramer** and undergraduate **Ella Thomas** cracked dozens of concrete cylinders that were first poured in 1923.

Perhaps counterintuitively, concrete strengthens as it ages, thanks to a process called curing, in which concrete continues to draw strength from moisture in the environment. How much concrete strengthens—or if it does at all—can depend on its composition and long-term environment.

Testing the 1923 cylinders with a hydraulic press, Cramer and Thomas found the 100-year-old concrete held up surprisingly well: Samples withstood more than 8,000 pounds of pressure per square inch.

Some of those samples have lived their lives in water, while others were stored in the Engineering Hall basement. Still others were left outside and exposed to wind and rain, baking heat and brutal cold. In 2010, when the researchers examined samples poured in 1910, the concrete stored in water grew stronger, while the cylinders exposed to air absorbed carbon dioxide and lost strength. “Today, we have ways of simulating weather, but back then, they didn’t exist, so they’d just put them outside,” says Cramer. “These poor cylinders have been subject to our severe winters and mild winters. There are times they’ve probably been close to a sidewalk and sprinkled with salt. It’s hard to generalize other than this: Despite what they’ve been through, they gained strength.”

While it’s not entirely uncommon to encounter 100-plus-year-old concrete today, what makes the UW-Madison research unique is that the samples were created specifically for a long-range study—complete with specifications. Such details about the mix, composition of the cement and aggregate aren’t always available.

The experiment began in 1910 under Professor Morton O. Withey, who also served as college dean. Initially designed to be a 10-year experiment, it extended for an additional 90 years under Professors Kurt F. Wendt and George W. Washa in the 1940s, then Cramer in 1981. (They also created samples in 1923 for another 100-year test and in 1937 for a 50-year test that concluded in 1987.)

Thomas joined the project after learning about it through her mechanics of materials class.

“It’s been really special to be a part of it,” she says. “It’s been cool to learn about the history that his project has—for UW-Madison and for everyone who has worked on it.”

That the samples made it to the finish line after 100 years is a credit to the college’s collaborative culture, says Cramer. “You can imagine two people who have a strong relationship,” he says. “But can you imagine those relationships building a chain among so many different people that lasts for 100 years? That’s pretty rich.”

Cramer plans to compile the results of the 1910 and 1923 studies for publication as a research paper. Though concrete mixing methods have changed and improved in the century since the study began, the tests may provide some insight into how older material behaves as it ages.

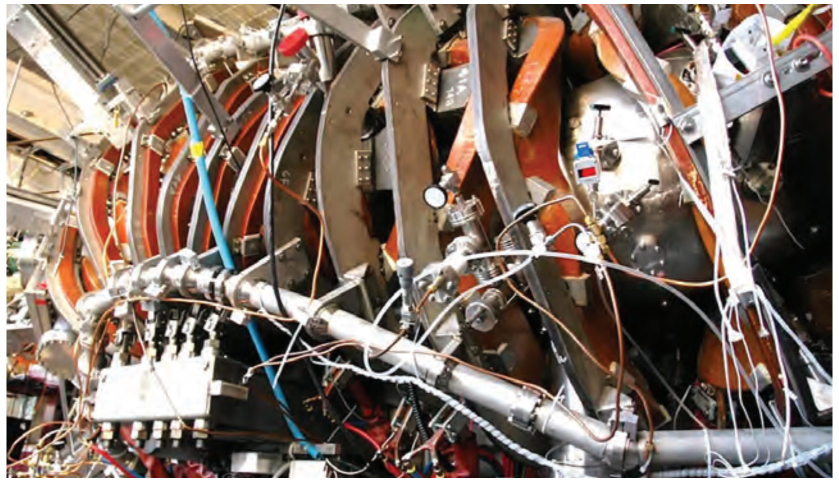
Fusion energy bears fruit

A 2023 TechCrunch article, *Wisconsin has quietly become a hotbed of fusion power startups*, notes: "The secret behind the state's recent success isn't so secret: University research programs that have been quietly cranking away for decades are now seeing the fruits of their labor emerge from the lab."

It's true: Realta Fusion and Type One Energy Group—both startup companies with UW-Madison roots—have received millions of dollars in university, private/venture capital and U.S. Department of Energy grants to support research and development of fusion energy technologies.

Type One Energy Group is building on the college's long-running HSX stellarator experiment, which also uses high-powered magnets to confine plasma. The company's leadership includes Electrical and Computer Engineering Professor Emeritus **David Anderson** and Harvey D. Spangler Professor in Nuclear Engineering and Engineering Physics **Chris Hegna**. NEEP Assistant Professor **Ben Lindley** and Thomas and Suzanne Werner Professor **Oliver Schmitz** are among Realta Fusion's co-founders; the company is developing fusion energy and heat for industrial applications via a compact but powerful magnetic mirror as an early step toward larger-scale fusion applications.

UW-Madison's fusion program began in the 1960s and includes researchers in multiple departments, including physics, engineering physics, and electrical and computer engineering. Combined, the departments have awarded hundreds of doctoral degrees to fusion researchers, including many preeminent scientists in the field.



Type One Energy Group is working to develop fusion energy that builds on the college's long-running HSX stellarator experiment, pictured, which uses high-powered magnets to confine plasma. Submitted photo.

With UW-Madison assist, groundbreaking project could accelerate nation's clean energy transition

A first-of-its-kind energy storage system in the United States could come online soon in Wisconsin's Columbia County, and engineering faculty and staff are playing a role in making it a reality. The project would be the first to demonstrate—at a commercial scale—a closed-loop, carbon dioxide-based energy storage system and could validate the technology for wide-scale deployment in the United States.

Led by energy provider Alliant Energy, the new battery system, known as the Columbia Energy Storage Project, represents a significant advancement toward a more sustainable, reliable and cost-effective energy future. In September 2023, the U.S. Department of Energy (DOE) Office of Clean Energy Demonstrations selected Alliant Energy for a grant of as much as $30 million to construct the 200-megawatt-hour energy storage system. Pending approval, construction could begin in 2025 with completion in 2026.

The project will use an innovative design by Energy Dome, a Milan, Italy, energy storage solutions provider, to deliver long-duration energy storage by compressing carbon dioxide gas into a liquid. When that energy is needed, the system converts the liquid carbon dioxide back to a gas, which powers a turbine to create electricity. This highly efficient, zero-emissions battery system can power approximately 20,000 Wisconsin homes for up to 10 hours on a single charge.

The idea to pursue the project grew out of conversations between UW-Madison faculty and Alliant Energy leaders who are members of the college-led Clean Energy Community Initiative, which brings together a network of industry, policy, research and community partners to co-create equitable and community-driven clean energy solutions throughout Wisconsin.

"Bringing a new technology of this scale to Wisconsin is very exciting and will create opportunities to build an economy around it here," says **Oliver Schmitz**, who directs the initiative and is the Thomas and Suzanne Werner Professor in nuclear engineering and engineering physics and college associate dean for research innovation. "This technology will provide crucial storage for solar and wind energy, enabling more renewable energy use."

Oliver Schmitz, Thomas and Suzanne Werner Professor in nuclear engineering and engineering physics and college associate dean for research innovation.

Energy Dome's CO_2 battery located in Sardinia, Italy. Photo courtesy of Energy Dome.

Education on the fast track: An accelerated master's degree

Engineers looking to advance their careers quickly are turning to the College of Engineering's accelerated master's degrees. These professional programs allow students to earn their master's degree in as little as one year, providing them with the advanced skills and knowledge to excel in their chosen field. "The program has helped me develop critical thinking skills, build confidence and constantly encourages me to think about how to make current technologies better," says **Lipika Garg**, a recent graduate of the electrical and computer engineering professional program.

The 11 accelerated engineering programs, which are course-based and span seven disciplines, allow students the flexibility to take classes that align with their career interests. "It offers a variety of options for tailoring your experience to fit your needs," says **Lexi Oxborough**, a mechanical engineering accelerated master's student. "I wanted to take more classes to support my work in industry and having a master's degree also opens more doors in the future."

Aron Saevarsson, a graduate of the industrial engineering systems engineering and analytics program, agrees. "This program made me a better person and a stronger candidate on the job market," he says.

Engineering undergraduate students are well positioned for the college's accelerated master's programs because they can apply undergraduate credits toward their master's degree, enabling them to complete their degree at an even faster pace—in some cases, as little as one year. "The accelerated master's has been a very fruitful and enriching experience," says **Alisha Handa**, an electrical and computer engineering graduate. "If you want a program to catapult you and position you for the industry as soon as possible, the accelerated master's is a great option."

Explore all engineering accelerated master's programs.

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON
1415 Engineering Drive, Madison, WI 53706

Badger Engineers are in demand

Hungry for engineering talent, employers flock to UW-Madison

Some-450 employers recruit on the College of Engineering campus across the academic year. In two career fairs, they spanned the gamut of the science and engineering world—The Boldt Company, Boston Scientific, GE Healthcare, Rockwell Automation, Cargill, Honeywell, Procter & Gamble, the U.S. Army Corps of Engineers, Sandia National Laboratories ... the list goes on.

More than 20 companies also visit campus for the college's employer partners fair.

"It's a great engineering program, and a lot of us know it—we have a lot of alumni at our company," says **Tim Hankens** (BSMS&E '19), a metallurgical engineer at MetalTek International, a Waukesha, Wisconsin-based manufacturer of metal components. "We know the program, we know what you learn, you come out with a good amount of experience."

Interested in a more formal partnership with the college that can help you to increase your company's visibility with our students? Contact **John Archambault** in Engineering Career Services, john.archambault@wisc.edu, to learn more!

Photos: Tom Ziemer.