With Agricultural Hall behind them, people gather on Henry Mall to observe a solar eclipse on Monday, April 8, 2024.

Photo by MICHAEL P. KING
FEATURES

16  Most Humans Can’t Multitask to Save Their Lives. But These Microbes Can.
CALS scientists have engineered bacteria to make two valuable products from plant fiber, which could improve biofuel economics and help slow climate change.
By CHRIS HUBBUCH

20  Science Through a Glass Darkly
The filters of modern news media create disparate, personalized perceptions of science. CALS researchers are looking for ways to craft messages that resonate with people of all viewpoints.
By CAROLINE SCHNEIDER MS’11

28  The Secrets of Cold Weather Soil Unearthed
To help ensure food security and protect the environment, a CALS-led team is working to understand how fluctuating winter conditions transform soil and influence water quality in agricultural areas.
By EMILY HALNON

DEPARTMENTS

2  Depth of Field

5  In Vivo  Major changes

6  Front List  New plant hardiness zones and your garden

7  Class Act  Natalie Sander used “horse sense” to revive a long-standing student organization

8  Natural Selections  Infertility factor, corn disease detection app, no-melt ice cream, cow-handling video game, more environmentally friendly cattle

34  Living Science  With remote sensing and computer modeling, Min Chen looks to make climate change prediction more accurate

36  Offshoots  Lenoria Addison BS’12 draws on her life sciences communication skills as an entertainment entrepreneur

38  High Yield  Kauffman fund beefs up meat science instruction

ON THE COVER  The science of effective science communication. See page 20.
Illustration by ELLA MARU STUDIO
From top: Photo by CHELSEA MAMOTT, illustration by ELLA MARU STUDIO, photo by MICHAEL P. KING
he world is changing rapidly. As it shifts, the challenges our stakeholders face — and what they require to tackle them — continue to evolve. So CALS is evolving too.

Through ongoing conversations with alumni and industry representatives, several of our academic departments have recognized a need for adjustments in how we prepare our graduates. These adjustments have now arrived in the form of new undergraduate majors and certificates, designed to improve how we develop and send problem-solvers out into the world.

The Department of Animal and Dairy Sciences recently launched a new major in dairy and food animal management. The new major comes in response to the needs of the dairy industry as well as the livestock, poultry, and meat processing industries. It encompasses a range of food animal species and meat science, but it’s also designed to provide stronger training in economics, business, management, and effective interpersonal skills, all of which are necessary for taking on modern challenges in animal agriculture. With the change, the department is also expanding flexibility and options for students to choose courses that match their interests.

The dairy and food animal management major will replace the current dairy science major, which focuses heavily on dairy cow biology, and is an excellent option for dairy-focused students. Students enrolled in the dairy science major have the option to complete their degree or switch to the new major.

The Department of Plant and Agroecosystem Sciences (PAS), home to the current agronomy and horticulture majors, is also implementing a new major. It’s called agroecology. This refashioned academic program takes aim at what may be the grandest challenge facing humanity. That challenge is achieving food, feed, fiber, and fuel security and sovereignty for an ever-growing and ever-diversifying population — all while setting up future generations to do the same.

Simple, right?

Maybe not, but agroecology majors will at least leave CALS ready to take this on. Through a suite of coursework and experiences focused on organisms, land, ecosystems, and people, students will grapple with questions and problems in a holistic way. They will rely on disciplinary academic expertise in PAS, entomology, plant pathology, soil science, and community and environmental sociology, but they will also search for multifaceted solutions involving multiple sectors of society. This transdisciplinary approach requires planning and training, which the agroecology major will provide.

These new CALS majors are accompanied by two new certificates. One will be offered by the Department of Soil and Environmental Sciences (the new name for the Department of Soil Science, a change that better reflects the department’s courses and programs). With the updated name comes a new undergraduate certificate focused on the science and environmental implications of soil. Its coursework mirrors the core courses of the soil science major and can be added to complement any existing major, even those outside of CALS, because knowledge of soil science is vital for a variety of academic and career paths. The department will be suspending admissions to the soil science undergraduate major, which has had low enrollment for several years, but its popular environmental sciences major will continue.

And last (but certainly tastiest), the Department of Food Science has launched a fermented foods and beverages certificate, open to all UW–Madison undergraduates. Through hands-on learning, students pursuing this certificate will develop skills and knowledge in the science, development, production, and marketing of everything from beer and wine to kimchi and sauerkraut to cheese and yogurt. They will also learn about non-food applications for fermentation, such as production of renewable materials and biofuels, and will be able to tailor the course selection to suit their career goals.

I can’t wait to see our students learning and engaging in exciting new ways through these evolved majors and certificates. I know you’re curious about it as well, so we’ll be sharing their experiences with you in a future issue of Grow.
Five Considerations for Plant Hardiness Zones (and Your Garden)

By ISAAC ZAMAN, REBA LUIKEN, and AL KOVALESKI

Plant hardiness zones are used to determine if a plant can thrive in a given climate — and your own backyard. The USDA Plant Hardiness Zone Map is a tool used to approximate growing zones and has been updated as our climate shifts, most recently in 2023. The map can be a helpful place to start, but there are many things to think about when determining what can grow in your garden.

1. A plant hardiness zone is a region of the United States that sustains an average extreme minimum cold temperature within a specific range each year. For example, the range for USDA zone 5a, which includes parts of southwestern, central, and northeastern Wisconsin, is −20°F to −15°F. The larger the zone number, the higher the average temperature range. But because the range is an average, it’s important to remember that the zone may experience even colder temperatures.

2. Our climate is getting warmer. If you compare the old map (published in 2012, using data from 1976 to 2005) to the new one (published in 2023, using data from 1991 to 2020), you’ll notice a trend of zones moving farther north. Even in areas that haven’t moved to an entirely new zone, the minimum cold temperature might be a few degrees warmer, and you might still see a shift in what plants you can grow in your garden.

3. The new map is more accurate. The USDA increased the amount of data incorporated into the map. Weather stations, research greenhouses, university buildings, and scientists in the field all contributed data points that increased the accuracy of zone delineations. Now we have a clearer picture than ever before of the changes we are seeing in our climate.

4. Microclimates are not reflected in the data. Even though it is more accurate, the new map is still only a guideline. If you’re a gardener, you may have noticed that plants do better in certain parts of your garden. Topography has profound effects on the temperatures that plants experience. Certain parts of the landscape may experience more or less cooling due to wind conditions or the locations of nearby buildings, hills, and bodies of water. For example, Allen Centennial Garden is close to Lake Mendota and has a protected perimeter of trees and buildings, so its microclimate allows some zone 6 plants to grow and survive despite being in zone 5.

5. Hardiness doesn’t guarantee survivability. Plants survive cold by building up cold tolerance to their environments. This means they rely on normal patterns of winter, with slowly cooling weather in the fall and slowly warming weather in the spring. So a plant considered to be hardy in your zone might be caught off guard by sudden or unseasonable changes in temperature, causing it to lose cold hardiness and be damaged or die when cold temperatures return, even if the cold temperatures aren’t below its hardiness zone threshold. Species that flower early in the spring, such as forsythias and flowering cherries, are especially prone to these false springs and late frost occurrences. Additional safeguards, such as plastic or cloth covers overnight, may be needed to protect these plants from sudden meteorological shifts.

Get in Your Zone
To see what plant hardiness zone you live in, visit plant hardiness.ars.usda.gov. Learn more about Allen Centennial Garden at allencentennialgarden.wisc.edu and the Plant Resilience Lab at plantresilience.cals.wisc.edu.

Isaac Zaman BS’22 is the horticulturalist for Allen Centennial Garden, and Reba Luiken is the garden’s director. Al Kovaleski is assistant professor in the Department of Plant and Agroecosystem Sciences and runs the Plant Resilience Lab.
Horse Sense

Natalie Sander used her equine industry knowledge and business acumen to revive a long-standing student organization.

By SUSAN LAMPERT SMITH BS ’82

When Natalie Sander BS’24 graduated in May with a degree in agricultural business management, she left behind an impressive legacy: a strong and successful Wisconsin Hoofer Riding Club, reinvigorated after the challenges of the COVID-19 pandemic.

Sander’s transition to higher education didn’t go as expected, a common theme among college-bound high school graduates of 2020. Her first two years on the UW campus were filled with virtual classes.

“It was definitely a weird start. I didn’t actually have the ‘college experience’ until my junior and senior years,” says Sander, who grew up riding horses in rural Mazomanie, Wisconsin. She joined the Wisconsin Union’s Hoofer Riding Club at the end of her sophomore year to meet fellow horse lovers.

But the club was not in a good place. Like most student organizations, it had suspended events during the pandemic and lost members. And it faced a bigger challenge, says Hoofer club advisor Pete Buscaino. Before the pandemic hit, the student-run club had sold its stable and horses, Hoofers still owned a lot of gear, and Sander began taking it to tack sales, where she connected with area stables. Soon, Buscaino says, Hoofers built a network of four local stables willing to host student lessons and events. He says Sander helped change the focus of the club, which had emphasized the English Hunting style of riding, by establishing relationships with stables that taught Western style and trail riding.

Three Gaits, an equine therapy stable just south of Madison in Stoughton, recently hosted a Hoofers Horsemanship 101 clinic that drew students and community members. Hoofers also brought ponies to the Memorial Union Terrace for UW’s Winter Carnival and Welcome Week, and they have organized trail rides.

Morgan horses are a compact, versatile breed, and one of the first to be developed in the United States. Sander enjoys their “big personalities and willingness to please.”

“She has a true passion for Morgans and a good eye for horses — and that is something you can't teach,” says Wingait owner Anita Pancsali. “You either have it or you don’t.”

Despite having sold its stable and horses, Hoofers still owned a lot of gear, and Sander began taking it to tack sales, where she connected with area stables. Soon, Buscaino says, Hoofers built a network of four local stables willing to host student lessons and events. He says Sander helped change the focus of the club, which had emphasized the English Hunting style of riding, by establishing relationships with stables that taught Western style and trail riding.

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Sander served as the club’s president during her senior year and won the Hoofer Leadership Award her junior year in recognition of her outstanding efforts to raise funds and grow membership. The riding club was voted Hoofer Club of the Year for the 2023–24 academic year.

“It was such a huge culture shift,” Buscaino says. “For the outing club, they just had to get back out on the trails, and for the sailing club, they just had to get back out in the boats. But the riding club needed a mentality shift and to envision a new way to operate. It wouldn’t have been possible without people like Natalie.”

Sander also won a Renk Agribusiness Scholarship, and for her senior capstone project, she worked on a business plan with a Fitchburg family farm that runs a horse boarding stable. Now, with the tools of her CALS education at her disposal, she hopes to find a job in the horse industry or possibly with a university extension service.

“I enjoyed my time in CALS,” Sander says. “I liked coming into a small school and into a small major. I know everyone in my classes and know all my professors. I really liked that.”
New genetics research involving fruit flies questions assumptions about obesity as the leading cause of fertility problems.

By ISABELLA MOUSSAVI

The association between obesity and infertility is a long-standing one. Some date the first written reference to this connection as early as 400 B.C., and much scientific and medical research supports it.

But scientists are still trying to determine the precise nature of the obesity-infertility correlation, and the limitations of current research can confound the process. For example, existing studies do not distinguish between the effects of a high-sugar diet and obesity, which makes it difficult to investigate the underlying cause behind decreased fertility.

However, a recent study focused on high-sugar diet, spearheaded by Rodrigo Dutra Nunes and Daniela Drummond-Barbosa in the Department of Genetics, opens the door for breakthrough advancements in fertility research. Published in the journal Development, their research includes a unique analysis of the effects of a high-sugar diet, obesity, and water intake on metabolism, oogenesis (production of egg cells) and fertility. They used the common fruit fly, or Drosophila melanogaster, as their model organism for the study.

“One of the novelties of this paper is that we didn’t only show that a high-sugar diet reduces the fertility of flies, but we also showed which steps of oogenesis are affected, and which process in each step is being affected,” says Dutra Nunes, a scientist in Drummond-Barbosa’s lab.

“We were able to dissociate the effects of obesity and high sugar and show that obesity is not what causes the reduction in fertility,” adds Drummond-Barbosa, a genetics professor and investigator at the Morgridge Institute for Research on the UW campus. “This highlights the importance of carefully separating the contributions of diet versus obesity in future studies not only in fruit flies but also in mammals.”

Drosophila are commonly used in biomedical research, and they are the main tool for Dutra Nunes’s fertility research. He notes that the high degree of similarity between the genes in Drosophila and the genes in humans can provide an excellent model for experiments that are too challenging or simply not feasible to conduct on people, such as genetic manipulation or diet alteration.

“Fruit flies offer major advantages as we progress towards identifying the cellular and molecular mechanisms underlying the effects of a high-sugar diet,” Drummond-Barbosa says. “The powerful genetic tools available, fast generation time, and large
sample sizes make it possible to combine cutting-edge research with high scientific rigor.

Dutra Nunes and Drummond-Barbosa compared reproductive changes in *Drosophila* on a high-sucrose diet to that of a control group without manipulation of the diet. In the experimental flies, fat storage quickly increased in one week, reaching much higher levels than in the control group.

An additional group of *Drosophila* were genetically altered to increase fat accumulation and model obesity on a normal diet. Fertility remained unchanged in these manipulated flies.

The decrease in egg production and hatching rates of female flies maintained on a high-sugar diet (in contrast to the normal fertility of genetically obese flies) led Dutra Nunes and Drummond-Barbosa to conclude that a high-sugar diet — and not obesity — is the primary cause of female infertility.

They also observed an increase in death among developing germ cells at two distinct stages of oogenesis in the flies fed a high-sugar diet. "If you have some of the steps of oogenesis surviving less, that means you'll have fewer eggs generated," Dutra Nunes says. “That is what's causing a decrease in fertility in flies.”

Apart from diet, Dutra Nunes also found that elevated water intake had a powerful metabolic effect counteracting high sugar consumption. "The dietary supplementation of water to obese flies on a high-sugar diet was able to reverse the negative effects on fertility without changing the level of obesity," he says.

Water supplementation also reversed the high glucose levels in the flies on a high-sugar diet. The apparent healing effects of hydration provide a foundation for future studies to explore the relationship between water consumption, high glucose levels, and fertility.

Next, Dutra Nunes intends to explore under-researched elements and their roles in reproductive processes. "We are now taking unbiased approaches, such as proteomics and metabolomics, to discover new points of connection between high glucose, water, and other effectors of a high-sugar diet and test their effects on fertility," he says. (Proteomics is the large-scale study of the structures and functions of proteins; metabolomics is the large-scale study of metabolites, which are small molecules found inside the cells, tissues, and fluids of living organisms.)

Dutra Nunes hopes his work with Drummond-Barbosa will inspire further research into possible therapeutic interventions in humans to reverse some of the effects of the Western diet that cause decreased fertility and other diseases.
This App Hits the Tar Spot

Armed with data from eight states, a CALS research team has created free mobile software that helps farmers fight a devastating corn disease.

By NICOLE MILLER MS’06

Tar spot, a disease of corn plants caused by the fungus *Phyllachora maydis*, has been causing problems in Mexico since the 1910s, but it stayed out of northern climes for more than a century. So it was surprising when tar spot was discovered in cornfields in Illinois and Indiana in 2015. The following year, it showed up in Wisconsin and a few other Midwestern states.

“Everybody thought it was a subtropical pathogen at the time,” recalls Damon Smith, professor and extension specialist in the Department of Plant Pathology. “People just sort of said, ‘Well, it’s cosmetic, it’s not going to be a problem.’ ”

Then the epidemic of 2018 happened. During that growing season, U.S. farmers lost approximately 5 million metric tons of corn to tar spot, an economic setback of around $680 million.

“We were just running all over the place, helping farmers try to make decisions plus gathering some data for research,” Smith says. “There was very little out there in terms of what we could do to manage it. We got caught without any solutions.”

In subsequent years, the disease continued to expand its territory. Smith assembled a multi-state team to study the new pathogen, and they secured funding in 2020 via the National Predictive Modeling Tool Initiative, a program of the USDA Agricultural Research Service, which supports the development of research-based tools to forecast U.S. crop diseases.

For their first step, they identified the weather conditions that promote tar spot development. Smith and then-graduate student Wade Webster PhD’22, along with collaborators in eight states, began scouting corn fields for the disease. Webster then gathered the team’s data, standardized it into a single format, and worked on the analytical aspects.

“We examined the correlations between tar spot development and over 100 environmental factors,” says Webster, who is now a faculty member at North Dakota State University. “With that, I was able to explore various statistical models to predict the risk of disease development.”

The team published their findings in *Scientific Reports* in October 2023. Even before that, as they were working on the manuscript, they took the project one step further, spurred by their dedication to the Wisconsin Idea — the long-held principle that the work of the university should benefit the citizens of the state and beyond.

“[We wanted to] help the farmers who are actually doing the work,” Webster says. “It’s all about getting the best tools into their hands, making their lives a bit easier.”

The result was an app called Tarspotter, built by staff in the Nutrient and Pest Management (NPM) program at UW–Madison and released in spring 2023.

“We take really complicated math, and we cook it in the background on the phone, and then we kick out nice displays and things for the user to look at. And it all runs in seconds,” says Smith, who has been working on plant disease prediction models for 20 years and is an affiliate at UW’s Data Science Institute.

The developers sought to make the app as smooth and accessible as possible — an effort that users have noticed and appreciated.

“The app is so well thought out. You click a few things, you put in
minimal information, and it works,” says Eric Birschbach MS’91, owner and operator of Ag Site Crop Consulting. “I work in a three-county area with different farming systems, and I can pull up all the fields I’ve got in there, and I can press one button, and it updates every field to tell me what the risk is in each of those fields, considering each microclimate — which is cool.”

Given the app’s success, Smith and his NPM collaborators decided to take yet another step. They cofounded Field Prophet, a startup company to ensure the longevity of Tarspotter and the other crop disease apps they’ve developed.

“Funding agencies can’t always support the long-term maintenance of tools like this,” says Smith. “So we said, ‘OK, let’s do this.’”

The Field Prophet app, which is free, has been downloaded more than 7,000 times, and last year it received around 300 hits per day during the growing season. It tells users whether they need to spray fungicide; and, when spraying is needed, the app helps them optimize the treatments to maximize the return on investment in the product. It’s a win-win-win because it’s better for the environment and farmers’ finances, and it helps prevent pesticide resistance in crops.

When it comes to optimal conditions for tar spot growth, what does all that data the research team collected tell the app to watch out for? Counterintuitively, the pathogen doesn’t need maximum heat and moisture to thrive. In fact, it prefers extended periods of mild temperatures — 30 days of around 70 degrees Fahrenheit. It likes a heavy rain followed by a long stretch of relatively dry conditions.

And it seems to always find a way. “Sometimes it comes early, sometimes it comes late. Most years, though, you can walk into any field at harvest time and see tar spot,” Birschbach says. “So, it’s great to have this tool so we can actually use some integrated pest management to try to make good decisions.”
There’s nothing quite like ice cream to cool you off on a hot summer day. It also puts you in a race to finish your scoop before it becomes a sticky puddle. But here comes Cameron (CJ) Wicks to save you from the mess.

Wicks, a Ph.D. student in the Department of Food Science, is working on a new technology that adds naturally occurring compounds to ice cream to prevent it from wreaking so much havoc.

“When you have normal ice cream, it will become a puddle of liquid in no time,” says Wicks. “However, we learned that adding polyphenols to ice cream can create a product that holds its shape for over four hours at room temperature. That’s pretty close to a no-melt ice cream.”

Polyphenols are compounds found naturally in foods such as green tea, blueberries, and cranberries and are known for offering health benefits. By incorporating these compounds into a standard ice cream recipe, Wicks was able to study how they interact with the ice cream’s milk fat and protein structures. She found that as she added more polyphenols to ice cream, its viscosity increased — meaning it became thicker.

While the ice in polyphenol-loaded ice cream does melt when left at ambient temperatures, the compounds help create a network between the cream’s fats and proteins that resists the flow of melted ice. In other words, polyphenols help the ice cream hold its shape and drip less in ambient temperatures.

After creating ice cream samples containing various levels of polyphenol extract, Wicks ran some meltdown tests. She placed ice cream on a wire mesh above a beaker and set each beaker on a scale that recorded the weight of any ice cream that dripped through the mesh as the sample melted. With this data, she measured the melting rate to assess how quickly each ice cream sample melted. Wicks also took photos of the ice cream as it melted over several hours.

These measurements and visuals — along with microscopic images of ice crystals, fats, and proteins in the samples — helped Wicks get a better understanding of what polyphenols do to ice cream. Prior research shows that the compounds can decrease the melting rate of ice cream, but not much work has been done to explain how it happens. Wicks was able to combine expertise from the labs of food science professors Brad Bolling BS’02, PhD’07 and Richard Hartel. Bolling’s team studies polyphenol chemistry, and Hartel’s group has the scoop on ice cream science.

“Ice cream already brings delight and happiness to many people around the world,” Wicks says. “So, to be able to make a new novelty — and with this new technology — was an amazing opportunity.”

Left: Cameron Wicks prepares ice cream samples for a demonstration of her polyphenol research in a Babcock Hall lab. The samples, from near to far, have green tea extract (2.5% polyphenols), cranberry extract (0.5% polyphenols), and a control sample with no added polyphenols.

Top: Wicks prepares a testing sample by packing a cup with ice cream containing blueberry freeze-dried powder. Photos by Michael P. King
‘Mooving Cows’

New science-based video game offers an improved training experience for dairy workers.

By NICOLE MILLER MS’06

The average weight of a fully grown Holstein cow is around 1,500 pounds, its average height nearly 5 feet at the shoulder. Guiding cattle that large from point A to point B while keeping the animals and people involved safe is no easy task. It requires effective training — the kind that’s now offered through a new educational video game codeveloped by a CALS animal scientist.

Called Mooving Cows, the free game gives dairy workers (and anyone else interested) the opportunity to practice cow handling skills virtually. The idea for the game emerged from feedback offered by Wisconsin dairy producers, explains Jennifer Van Os, assistant professor and extension specialist in the Department of Animal and Dairy Sciences. Over the years, Van Os, an animal welfare expert, says she has heard from numerous producers seeking better training options for milkers and other staff members on proper cow handling — ways to move cows through dairy facilities that help ensure worker safety while also minimizing cow stress and injury.

Compared to standard training videos and articles, the video game format allows for a more active and engaged learning experience. Players practice routine cow movement in a variety of simulated environments, including pastures, milking parlors, and freestall pens. They also learn how their actions affect cow behavior, stress, and milk production.

The game was developed with other collaborators, including Nigel Cook, a professor of medical sciences at the UW School of Veterinary Medicine. It’s based on decades of research and input from more than 60 people in the Wisconsin dairy community, including farm owners, milkers, consultants, and veterinarians.

The game can be played in English or Spanish, and it takes around 30 minutes to complete. People who successfully navigate all levels receive a certificate of completion. This certificate can be used as documentation for the Farmers Assuring Responsible Management (FARM) Animal Care Program, which requires everyone with animal handling roles on dairy farms to have annual continuing education on proper animal handling.

Funding for the development of Mooving Cows came from the UW Dairy Innovation Hub and the Research Forward initiative in the UW Office of the Vice Chancellor for Research and Graduate Education.

WHERE TO FIND MOOVING COWS

The game can be downloaded at no cost and without ads on both the Apple (iOS) and Google Play (Android) app stores. More details about the game and app store links are available at animalwelfare.cals.wisc.edu/mooving_cows.

NUMBER CRUNCHING

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13, 17, XIII, XIX: CICADA LIFE CYCLES AND BROODS

The life cycles of periodical cicadas require either 17 or 13 years to complete, depending on the species. Scientists sort these cicadas into broods (i.e., cohorts) based on when they emerge and label them with Roman numerals. Of the 15 broods that exist, 12 have 17-year life cycles and a more northern distribution while three have 13-year life cycles and a more southern distribution.

In certain locations, the 17-year broods and 13-year broods of periodical cicadas overlap; occasionally, they emerge in the same year. Spring 2024 was unique in that Brood XIII (17-year) and Brood XIX (13-year) both emerged, and their ranges overlapped in central Illinois. The last time this happened was in 1803, when Thomas Jefferson was president of the United States.

Learn more at cicadas.wisc.edu.

Photo by FLICKR.COM/JANETANDPHIL
Bovine Belch Busters

CALS scientists look for ways to reduce methane emissions from cattle with support from the Dairy Innovation Hub and the Green Cattle Initiative.

By JORI SKALITZKY BS’22

It’s easy to ruminate over methane when thinking about dairy and its production challenges.

Cattle are essential to Wisconsin’s $45.6 billion dairy community. But cattle have to eat — and when they eat, they produce the greenhouse gas methane during digestion.

This process is natural, but it’s not without problems. Individual cows emit 150 to 260 pounds of methane per year — primarily in the form of belches. Fortunately, there are ways to reduce the amount of methane that cattle burp up, and CALS scientists are using a grant from the Greener Cattle Initiative (GCI) to find them.

GCI is an international consortium of stakeholders that supports research on minimizing enteric methane production in dairy cattle. In September 2023, the initiative awarded a $3.3 million grant to Francisco Peñagaricano PhD’14, an assistant professor of animal and dairy sciences at CALS, for a project that takes a three-pronged approach to the challenge. His goals are to use genetics to selectively breed cattle that emit less methane, develop a milk-based test that can predict a cow’s methane emissions, and explore the rumen microbiome for possible dietary interventions.

“The Greener Cattle Initiative was launched identifying, developing, and validating effective enteric methane mitigation options … that meet farmers’ and broad socioeconomic needs,” says Juan Tricarico, director of GCI and senior vice president of environmental research and distinguished scientist at Dairy Management Inc. “This project is important for long-term mitigation because selectively breeding low methane-producing dairy cattle is permanent and cumulative, and it will probably also be cost-effective.”

Peñagaricano is working with three other faculty from the Department of Animal and Dairy Sciences: Hilario Mantovani, who specializes in rumen microbiology; Kent Weigel MS’92, PhD’92, who focuses on breeding and genetics; and Heather White, who studies nutritional physiology. All four are affiliated with the UW Dairy Innovation Hub.

Through multiple grants (including one to Peñagaricano), the Hub has helped CALS purchase two methane-measuring GreenFeed systems, bringing the university’s total to five. A GreenFeed device is a portable feeding bin that captures all the air exhaled by a cow while she is eating and delivers a reliable estimate of methane emissions for that individual cow. Peñagaricano cites the Hub support as a major factor in attracting the GCI grant.

A first step for the new GCI-funded project will be to develop a reference population of nearly 4,000 dairy cows. And the first research prong will be to look at the genetics of these animals, focusing on the natural methane-burping variability found in the group.
All cows produce methane, but not every cow is alike. Peñagaricano’s prior research shows that some cows release around 600 grams of methane per day, while others average around 300 grams. For the GCI study, the cows in the reference population will undergo genomic evaluations for various methane emission traits, such as the quantity or frequency of production. Once these traits are better understood, the team can pursue selective breeding for cows that produce less methane.

“Variability is crucial, [and] part of that variability is due to genetics,” says Peñagaricano. “We can use that variation to improve cows in the next few generations through genetic selection.”

The second prong of the project explores milk testing. Generally, dairy farmers send monthly milk samples to a lab to monitor quality and to get an idea of protein and fat levels in the milk. Peñagaricano’s team envisions farmers also receiving a prediction of methane emissions from the herd. The new test would use milk spectrometry, which involves scanning milk samples with infrared light to identify specific chemical compounds. The goal is to develop a low-cost, noninvasive tool that farmers could potentially use at the national level.

“Let’s say the federal government or milk buyers say [farmers] need to minimize methane emissions, but first the farmers need to have an idea of which cows are emitting more, and which are emitting less,” says Peñagaricano. “And if they know which ones are emitting more, they can target those cows with interventions, such as specific diets, to minimize that.”

The third prong of the project focuses on the rumen, the digestive organ in cows that contains methane-producing bacteria. Not much is understood about the relationship between the rumen microbiome and methane production or how cow diet or genetics impact the process. Using emissions data from the GreenFeed systems, the team will identify the 10% highest methane-producing and the 10% lowest methane-producing cows in the reference population and sample their rumen microbiomes. The sampled microbiota will be evaluated for differences before testing the impact of microbial or dietary interventions.

“Being a part of a project this big is really challenging but, at the same time, really amazing,” says Mantovani, a Hub-funded faculty member who will lead the rumen microbiome studies. “It is an opportunity to have access to a very large number of animals and to do research that could have a real impact in changing management practices and developing new tools.”

Over the course of three years, Peñagaricano, Mantovani, and others in a team from multiple institutions and states will tackle the expansive project and deliver solutions with both short- and long-term benefits for farmers, the broader dairy community, and the environment.
Most Humans Can’t Multitask to Save Their Lives.

But These Microbes Can.
We often look to the smallest life-forms for help solving the biggest problems: Microbes can make foods and beverages, cure diseases, treat waste, and even clean up pollution. Yeast and bacteria can also convert plant sugars into biofuels and chemicals traditionally derived from fossil fuels, which are a key component of most plans to slow climate change.

Now, researchers at CALS and the Great Lakes Bioenergy Research Center (GLBRC) have engineered bacteria that can produce two products — at the same time — from underutilized plant fiber. And unlike humans, these multitasking microbes can do both things equally well.

“To my knowledge, it’s one of the first times you can make two valuable products simultaneously in one microbe,” says Tim Donohue, GLBRC director and a professor of bacteriology at CALS.

The discovery, detailed in an article in the December 2023 issue of the journal Applied and Environmental Microbiology, could help make those biofuels more sustainable and commercially viable by tapping into multiple chemical markets.

“In principle, the strategy lowers the net greenhouse gas emissions and improves the economics,” Donohue says. “The amount of energy and greenhouse gas that you need to make two products in one pot is going to be less than running two pots to make one product in each pot.”

Every Molecule Counts
The quest to replace fossil fuels with sustainable alternatives hinges on extracting the most value possible from renewable biomass. As with petrochemicals, every molecule counts: Low-volume, high-value products help keep the fuel more affordable.

One of the biggest barriers is a part of the plant cell wall called lignin, which binds together the walls’ main molecular components — carbohydrates called cellulose and hemicellulose — to make plants sturdy.

Lignin is the world’s second largest source of renewable carbon, but its complex and irregular structure make it notoriously difficult to break apart into useful components. There’s even a saying in the paper industry: You can make anything from lignin, except money.

That’s why scientists with GLBRC have studied a microbe called Novosphingobium aromaticivorans (or simply Novo for short). Discovered in sediment contaminated with petroleum products, Novo can survive by feeding on ringed carbon and hydrogen molecules such as toluene, naphthalene, and xylene, which are also found in lignin.

While other bacteria can digest some of the aromatics in lignin, Novo eats nearly all, funneling them into smaller compounds through a series of chemical reactions it uses to capture energy.

Some of those intermediates can be substituted for petroleum-based chemicals used in common plastic products, such as soda bottles. It’s just a matter of...
rewiring the microbe to stop the digestive assembly line at the desired chemical.

Fortunately, Novo also happens to be amenable to genetic modification. In 2019, a team of GLBRC researchers engineered a strain of Novo that produces a chemical known as PDC (2-pyrene-4,6-dicarboxylic acid), which is used to make products such as nylon and polyurethane.

More recently, a team in Donohue’s lab discovered other modifications that allow Novo to make a different plastic precursor, muconic acid (cis,cis-muconic acid, or ccMA) from a mix of aromatic compounds in poplar tree lignin that had been chemically treated.

But they didn’t stop there.

“We’re not going to solve our carbon emissions problem by only producing two products,” says Ben Hall MS’21, PhD’23, a recent doctoral graduate in genetics and coauthor of the paper.

Donohue’s team used genomic modeling to come up with a list of potential products that could be made from biomass aromatics. To make it on the list, the products needed to be valuable and able to be produced in large quantities with fewer than five genetic changes. Near the top of the list was zeaxanthin, one of a group of organic pigments known as carotenoids.

Carotenoids — which give distinctive hues to carrots, pumpkins, salmon, and even flamingos (via the birds’ steady diet of algae and shrimp) — are used as animal feed, nutritional supplements, pharmaceuticals, and cosmetics. They have a cumulative market value worth tens of billions of dollars per year.

Researchers already knew that Novo had the genes to produce another carotenoid with little market value. Based on
the bacteria’s genome sequence, they suspected zeaxanthin is a stepping stone to that less valuable carotenoid in the process that cells use to make complex molecules. They just needed to alter the right genes to stop the digestive assembly line at the more valuable product.

By deleting or adding selected genes, the research team engineered Novo strains that produced zeaxanthin as well as other valuable carotenoids, such as beta-carotene, lycopene, and astaxanthin, when grown on an aromatic compound commonly found in lignin.

Next, the team showed that the engineered Novo bacteria could produce the same carotenoids from a liquor made from ground and treated sorghum stems, a solution that contains a mixture of aromatics that many industrial bacteria can’t digest.

**One Pot, Two Products**

Hall then wondered what would happen if he combined the genetic changes needed to make PDC and a carotenoid in the same microbe. The resulting strains produced both PDC and the target carotenoid with no discernable loss to either yield. Even better, the bacteria accumulate carotenoids within their cells, which must be separated from the solution that contains the PDC, which they excrete.

“We’re already separating the cells from the media,” Hall says. “Now we would have a product coming out of both.”

The next steps include testing whether engineered strains can co-produce carotenoids and ccMA, which Donohue thinks is possible, and to engineer strains to improve yields in industrial conditions.

While there are lucrative markets for each of these products, Donohue and Hall say the real value of the discovery is the ability to add multiple functions to this biological platform.

“To me, it’s both the strategy and the products,” Donohue says. “Now that we’ve done this, I think it opens the door to see if we can create other microbial chassis that make two products.”

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“The amount of energy and greenhouse gas that you need to make two products in one pot is going to be less than running two pots to make one product in each pot.”

— Tim Donohue

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**Far left:** Ben Hall, who recently earned his genetics Ph.D. at CALS, completed research at the Great Lakes Bioenergy Research Center showing it’s possible to modify the Novosphingobium aromaticivorans bacterium to simultaneously produce two valuable chemicals from an underutilized part of plant cells called lignin.

**Left:** Bacteria grown on a solution of sorghum lignin secrete products such as PDC into the surrounding media, which must be separated from cells (right) containing carotenoids to yield two valuable products.
In the 1980s, the steps involved in a high school research paper assignment looked much different than today. Given a hot-button health topic of the time — perhaps the link between smoking and cancer or the emergence of HIV/AIDS — a student might peruse the stacks of a local library, question a doctor in the neighborhood, or lug an encyclopedia off a shelf at home. But today’s students, and most people in general, get their science information in quite different places: a story about artificial intelligence on their favorite news website or a video describing nanotechnology on TikTok.

These modern news sources apply filters to the scientific findings that decades ago would have only been gleaned from a book or heard directly from an expert. Today, science is viewed and analyzed through the lenses of personal beliefs, social standing, political views, and identity. And in the evolving terrain of media, news consumers gravitate toward sources expressing the beliefs and values that most closely match their own, and they get the bulk of their information from those outlets.

How do a person’s identity and values influence their choices of news sources? How do these personal traits affect their understanding of the scientific information their preferred sources provide? How can people who communicate about science cater to the various values and views of the public?

The field of science communication is asking all of these questions, and more. At CALS, researchers in the Department of Life Sciences Communication (LSC) aim to understand not only how the public learns about science but also how to form strategies to provide information that both teaches and resonates with an increasingly divided society.

“LSC is at the forefront of these efforts to understand the connection between science and the many groups in society,” says professor and department chair Dominique Brossard. “We’re looking for effective ways to both serve and learn from a public that comes from diverse backgrounds with many different inherent values and views.”
“This area of science has an almost pure basic science appeal,” Xenos explains. “So much of space is about discovery and answering questions about our universe. We rarely see political viewpoints applied to space exploration like we do in other areas of science.”

The question of why so many different people consume space news is just one of many that Xenos wants to answer. He also intends to explore the resilience of its nonpolitical position. Could space news be politicized? If so, how could that happen? While his work is just getting underway, early data suggests that space is a surprisingly resilient topic.

By understanding why space is nonpolitical — perhaps its fundamental nature, its historical context, the sense of national pride it instills — Xenos hopes researchers find lessons that might apply to other decidedly political areas.

“Space can tell us about the broader dynamics of politics intersecting with science,” he says. “We can better understand all types of politicized science topics by better understanding this topic that usually sees little political disagreement.”

On the other end of the spectrum of politicized science topics lies misinformation. Misinformation is incorrect or misleading information; and with the explosion of online news and social media, the term is often used in political circles. The COVID-19 pandemic increased the amount of misinformation lurking online as well as the need many people feel to correct or “cure” it.

In 2022, a U.S. Food and Drug Administration commissioner called misinformation “our leading cause of death” in the pandemic. For science communication researcher Dietram Scheufele and others in LSC, however, this statement raises some red flags.

“Our tendency in science is to look at the public as having something wrong with them or having pathologies that must be fixed,” says Scheufele, a professor and expert in political communication, science communication, and science policy. “We often think, ‘If they just had the right information, the same information we do, they would think like we think.’ That just isn’t true. Some of the most highly informed people are the ones who are polarized.”

For many years, several “deficit” models have been popular research topics in the field of science communication. First came knowledge deficit: If they knew more, they’d think like us, the scientists. Next came trust deficit: If they trusted us more, they’d agree with us. And now, as the spread of false and misleading information increases, the idea of the misinformation deficit has arisen.
“We’re again saying that if we can just get people the right facts, they will make better decisions. But none of these models are correct,” explains Scheufele, who is also the Taylor-Bascom Chair in Science Communication. “Two people can look at the same information, whether it’s right or wrong, and come to different conclusions. The same science means different things to different people.”

So if it’s not a matter of “curing” misinformation or other deficits, how can science determine policy? Scheufele says it can’t. While scientists might think the data are clear and should point in one direction, the process of making policy is complicated. A lot more goes into policy than just scientific fact.

For example, science can tell us that wearing seat belts and banning cigarettes will save lives and money. Yet we, as a society, have decided we will mandate seat belts but not force smokers to quit. Every policy decision is based not only on scientific evidence but also on values held by the public and lawmakers, economic opportunity costs, and other factors.

“In the policy realm — and other places — there are many actors that have equally important voices. They may not be experts on the scientific evidence, but they have other input,” Scheufele says. “And that’s where science can get into trouble. Science can answer many questions, and it should speak its answers confidently. But it won’t lead to one specific policy outcome.”
The Question:
How does social media change perceptions of science?

As people consume science and other news from more and more sources, social media plays an increasing role in informing their decisions. Many politicians and scientists engage with news consumers through social media. But political and scientific information can also come from less obvious sources, such as lifestyle influencers who produce aspirational content — content that conveys a consumer’s ideas of success or ideal way of living.

“A lot of social media influencers aren’t talking explicitly about science or politics, but they do address these topics,” says Sedona Chinn, an assistant professor in LSC who studies how individuals make sense of science claims. “A cooking influencer might tell followers they want to use non-GMO blueberries, or parenting accounts may talk about vaccinations for kids.”

In the eyes of their followers, two factors make these influencers reliable sources of information. First, aspirational content producers position themselves as experts. These influencers may not be experts on science, but if followers view them as experts in one area, they take the influencers’ general opinions more seriously. Second, influencers are relatable. They want to be viewed as someone akin to their followers, the neighbor you want to sit down with for a conversation or a meal.

These two factors lend credibility to influencers but not necessarily expertise. So it’s perhaps not surprising that studies by Chinn and her colleagues have found that aspirational social media use is associated with adherence to more inaccurate beliefs. In the science realm in particular, their research shows that those who consume more aspirational social media hold more unevidenced medical and wellness beliefs.

Many aspirational influencers also position themselves as at odds with traditional institutional experts, as alternatives to the academic or medical establishments. Along with that stance, these content producers encourage followers to “do your own research” instead of listening to established experts.

“In the pandemic especially, they started pushing the idea of doing your own research,” explains Chinn. “But how people perceive expertise is a difficult question, especially when they’re trying to navigate uncertainty, like we see in scientific topics.”

In some cases, Chinn and her colleagues have found that the act of doing your own research and trusting those who lack expertise can cause people to distrust institutional experts — or even view experts as being in direct opposition to their group. That viewpoint, along with the idea that followers should only trust their own instincts, causes hostility and contention.

“Someone may come to believe that the institutions are trying to control them or intentionally mislead them,” Chinn says. “Those people will then not just ignore the experts but actively go against their advice. This reinforces the broader social divisions we’re seeing in our society now.”

Chinn hopes that understanding this dynamic more fully and finding the right messages for people who tend to trust influencers over experts could shrink the divides.
The Question: How can communities and science communication help each other?

To understand what messages different groups prefer based on their values and views — as well as what information is even helpful to them — many researchers are going to the source. They are working directly with community groups to hear what is most important to them. Kaiping Chen and her colleagues are collaborating with underserved groups around Madison to understand their environmental concerns and the problems they face in their neighborhoods.

“In the past 10 years, I’ve been working with local governments and community groups to empower those who are underrepresented in the policy-making process,” says Chen, an assistant professor with expertise in how digital media and technologies affect political and public discourse. “Many of these groups are under-resourced while also being hurt more severely or more often by environmental consequences.”

In the summer of 2022, Chen and other UW researchers began to work with local Black and Latinx groups to organize in-person forums where community members can dialogue with local officials. At the events, participants talked about the environmental issues they see most in their neighborhoods and how they would like to work with officials to address those problems.

These forums created important networks and relationships while also allowing researchers to listen to participants and their concerns instead of bringing preconceived notions to the table. Another outcome was a website that allowed hundreds more community members who were unable to attend the forums to share their environmental justice stories. Users could pinpoint locations on a social map feature and annotate air quality, urban heat, and tree issues.

To consolidate community input gathered during the forums and information from the website, Chen and her team are developing a digital map application. The app uses data science methods to analyze the input and then visualize community opinions.

“We call this a community knowledge map,” Chen says. “These community members are the experts on conditions in their neighborhoods. They know where the hot spots are or where more trees are needed. We can use this information for our work, and they can then use the data to advocate for policy changes in their areas.”
This two-way communication and collaborative work is crucial to Chen’s project. In similar ways, other LSC faculty are teaming up with communities in Milwaukee to better understand what and how they think about science. “We want to know what emotional, intuitive connections different types of audiences have to science,” says Todd Newman, an assistant professor who focuses on the role of strategic communication in the context of science. “When you say science, or when you think about science, what comes to mind?”

Newman and Xenos are now collaborating with Black residents in Milwaukee. Black communities have substantial distrust of medical institutions due to historical mistreatment as well as modern everyday prejudices. Many Americans relate to science through medicine and health care topics, so if they have bad experiences with health care providers, their feelings about science might be negative too. “We’re trying to understand the extent to which Black Americans’ lived experiences create a set of perceptions and understanding about science and scientific research,” Xenos explains. “We want to better understand the mistrust to try to find communication strategies that maximize engagement in Black communities.”

Lived experience is the knowledge gained from direct, firsthand involvement. Research-backed data about how such experiences shape opinions about science are not common. But the information is critical. Newman and Xenos have begun gathering data through focus groups that allow intentional dialogue with community groups. They will continue that collaborative work in Milwaukee and later expand statewide and beyond with in-person work and surveys.

This project will give researchers insight into their own questions about the impact of lived experiences on perceptions of science. It will also lead them to what science topics matter most to Black Americans, in their neighborhoods and their lives, independent of what scientists or science communication researchers may want to know. “We have to reimagine our approach so we can collaborate and co-create with communities,” Newman says. “Shared and lived experiences are important factors in communities’ engagement with science. We need to build these more inclusive approaches to science communication.”

“The Answer: Tailored messages are key to reaching people.”

As science continues to change rapidly, politicians and people from diverse communities are looking for ways to navigate the uncertainty of scientific discovery and fold science knowledge into policymaking. Information for making decisions comes from endless news channels, social media accounts, online newspapers, and other sources. With all that potentially useful news, however, comes divisiveness, misinformation, and marginalization.

Science communication researchers in CALS, along with colleagues across the university and around the world, are working to lessen the divides and better reach those who need to make decisions for their countries, their neighborhoods, their families, and themselves. How can scientific messages be shared in a way that people will both care about them and benefit from them? For many researchers, the answer involves finding the right messages, catered to the beliefs and views of specific audiences, that make the information both consumable and relevant.

“We have to think about how to frame messages in ways that resonate rather than contradict people’s value systems,” says Scheufele. “Science as a community needs to actually pay attention to what people care about and be responsive to public input. We need to speak with the person, not to ourselves.”

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A CALS-led team is working to reveal how widely fluctuating winter conditions impact soil and water quality in agricultural areas. Their findings could improve environmental protection while ensuring food security.

BY EMILY HALNAN

These small plots at the UW Arlington Agricultural Research Station in Arlington, Wis. — shown here as viewed from a drone in winter (left) and summer (right) — are part of a multiyear study examining the effects of weather and land management on soil freezing and thawing, water movement, and nutrient transport and runoff in Midwestern agricultural areas.

Photos by LAXMI PRASAD and JEFF NELSON
When hydrology engineer Anita Thompson was growing up in Minnesota, she knew what to expect from winter. The temperatures would drop below freezing around November or December, snow would fall throughout the season, and it would melt in the spring.

But she can’t say the same thing about Midwest winters a few decades later. Snowmelt is much less predictable, and temperatures can often swing from below freezing to well above and back again in a matter of days.

With such increasing variation in weather comes much uncertainty. This includes uncertainty about how excess nutrients from agricultural fields move between the soil and water sources throughout the winter. The unknowns complicate efforts to protect and improve water quality and soil health. That’s why Thompson is leading a multi-institutional research project to better understand what it all means for farming hubs around the Midwest.

“We’ve got periods of freezing and thawing throughout the winter that are increasingly difficult to predict,” says Thompson, professor and chair in the Department of Biological Systems Engineering. “This research will help us better understand how varying winter conditions impact soil freeze-thaw processes and soil and nutrient movement throughout watersheds in the region.”

This is an especially relevant issue in Wisconsin, and across the Midwest, because many farmers use fertilizers for their crops, and some apply manure. While manure contains many vital nutrients that help plants grow, such as phosphorous and nitrogen, those nutrients can pollute water sources if they don’t get absorbed by the soil. This compromises water quality in streams, rivers, lakes, and groundwater and contributes to harmful algal blooms and waterborne diseases.

“If we want to protect water quality in our region, we need to better understand seasonal variation and, specifically, winter season processes,” Thompson says. “The land management practices that are effective during the warmer growing season might not have the same results during colder weather and may contribute to the decline of soil and watershed health across the Midwest.”

Thompson is collaborating with several other researchers to probe how factors such as air and soil temperature, precipitation, and snow cover affect the transport of nutrients during the winter compared to the warmer growing season. The research team is also evaluating how land management practices influence soil dynamics (the motion and behavior of soil over time) and water quality, all with the aim of assessing which practices are more effective during warm or cold conditions.

The study’s implications are incredibly broad.

“Understanding changes in soil nutrient dynamics and transport in surface runoff and subsurface flow is important for environmental protection, sustainability of water resources, and food security,” Thompson says.
The research team launched their project in 2021 with support from the National Institute of Food and Agriculture at the U.S. Department of Agriculture (USDA). They’re an interdisciplinary group — composed of soil scientists, hydrologists, and watershed modeling specialists — hailing from CALS at UW–Madison, Ohio State University, and the Agricultural Research Service at the USDA.

The team’s geographic distribution helps them take a regional approach as they dig into cold weather soil dynamics across a range of weather gradients. They’ll assess data from Wisconsin, Minnesota, and Ohio that will encompass a wide variety of conditions and span many years.

The team is also operating at multiple scales, which means they will draw from research across labs, agricultural plots, and full-scale fields as well as sophisticated watershed modeling. This approach allows researchers to examine real-world conditions and data alongside highly controlled experiments where they can adjust variables to strategically probe their research questions.

“We can take what we’re learning in the field under actual conditions and then use that to inform our lab research,” Thompson says. “It sets up a circular research process across different scales that will offer us valuable insights into what’s actually happening in these watersheds.”

THE NOT-SO-SIMPLE FREEZING POINT OF SOIL

The temperature at which soil freezes plays a significant role in how nutrients move through watersheds. But quantifying the exact freezing point of soil has been a challenge — and a misconception — in the scientific community for years.

“We generally think that water freezes at zero degrees Celsius,” says Laxmi Prasad PhD’21, a postdoctoral researcher in the Department of Biological Systems Engineering who’s been involved in the project since its inception. “But that freezing point only applies to pure water; and, due to the solutes, minerals, and pressure in the soil, the freezing point of water in the soil is actually lower.”

Many research studies and hydrological models have incorporated a freezing point of zero degrees Celsius for soil. So, they’ve also incorrectly assumed that an ambient temperature of zero degrees Celsius means no rainfall or snowmelt is infiltrating the soil and, thus, no nutrients are on the move. But that is not what’s actually happening in the ground.

The lab is an ideal venue to investigate how cold temperatures affect key processes within the soil matrix because researchers can create highly controlled and easily replicated conditions. Prasad has developed lab experiments to quantify the actual freezing point of soil while accounting for different variables: the amount of moisture content in the soil, the volume of snow cover, and the various types of soil found around the region.

Prasad is also conducting experiments to examine how freezing and thawing impacts soil characteristics, such as hydraulic properties (how water moves through the soil) and the amount of nutrient transport from soil to water sources. The freezing process also affects the stability of soil because, when moisture in the soil freezes, it can expand and compromise the soil’s structure.

“If we can better understand the soil freezing point, we can improve understanding of how water and nutrients are moving through the soil during winters,” Prasad explains. “We can use this information to develop better models for different climatic scenarios and have a more accurate understanding of how they’re affecting water quality and soil health.”

Prasad has made a lot of progress in the lab and has confirmed that soil freezes at a lower temperature than zero degrees Celsius. He has also discovered distinct connections...
between moisture content and temperature gradients. He’s excited about how his findings can be applied to this research project and beyond.

“The insights we gain from this project are not only going to improve our understanding of soil dynamics and water health,” Prasad says. “They’re also going to help inform climate models, carbon emission modeling, and other environmental research projects.”

THE BRIDGE BETWEEN LAB AND FIELD

It’s one thing to make a discovery in the lab. It’s quite another to understand how soil dynamics and management practices are playing out in the real world under a wide variety of conditions.

When a farmer applies liquid manure to a cornfield, the air temperature could be 27 degrees or 60 degrees Fahrenheit, it could be raining or sleeting, and the ground could be dry or covered in 7 inches of snow. To understand how the phosphorous and nitrogen in that manure will move through the landscape, researchers need ways to gauge the process when there are more variations and less predictable conditions.

To do this — and to bridge the gap between the lab and what’s actually happening in the watersheds — the research team is using small plots at UW’s Arlington Agricultural Research Station. This manageable scale helps them add complexity and variability to their experiments while still allowing for some degree of control and isolation. With this setup, they can also home in on the most significant factors that control hydrological and nutrient processes as well as the most influential field conditions and treatments.

The plots are part of a multiyear study examining the effects of weather and management on soil freezing and thawing, water movement, and nutrient transport and runoff. They’re looking at a range of standard agricultural treatments on the plots, including conventional tillage versus no tillage and cover crops (both with and without liquid manure fertilization) versus no cover crops with liquid manure fertilization.

CALS soil scientist Francisco Arriaga PhD’00 is leading the effort to compare the effects of these different agricultural treatments on nutrient and water transport over a range of temperatures, precipitation, and ground cover. He’s been involved in earlier iterations of this research, and he’s found that reality often does not match expectations. For example, research shows that when liquid manure is applied over snow, it can change the energy dynamics of the melting process, even after succeeding snowfall, causing the snow to melt faster — and more phosphorous to move into water sources.

“We’ve seen that what’s actually happening in these plots varies from conventional wisdom about what’s happening in the fields,” says Arriaga, an associate professor and extension specialist in the Department of Soil Science. “We’ve found that some management practices that are meant to benefit soil health might not always be the best choice for water quality.”

The research group is also partnering with Discovery Farms, a UW–Madison Division of Extension program that collaborates closely with farmers to collect data across the
Toward More Powerful Computer Models

When biological systems engineer Margaret Kalcic compares field data to her current computer modeling tools, she sees many inconsistencies between reality and model predictions. One of these inconsistencies is the flawed assumption Prasad has been looking to eradicate — that if the air temperature is freezing, there's no water moving through the soil and, therefore, no pollutants traveling to water sources.

“But when we look at the field data, we see water is still draining through the soil, and, in some instances, even increasing when the air temperature is freezing,” explains Kalcic, an associate professor of biological systems engineering. “And drainage carries nutrients that pollute water resources.”

Kalcic specializes in watershed modeling, and she's working to improve the computer models so they can better predict how different weather conditions and management practices will influence nutrient movement, soil dynamics, and water quality. This will be an especially helpful tool as climate change continues to shift weather patterns across the region and increases the need for understanding how climatic variability connects to water quality.

“We need to have tools that can predict water quality and help regions understand the effectiveness of different practices in agricultural lands,” Kalcic says.

The path toward such a tool includes incorporating research findings from labs, plots, and fields into the computer models to enhance their predictive power. Kalcic and her collaborators have already improved the model by integrating an algorithm that better reflects the freezing point of soil and integrates Prasad’s findings about soil freezing and thawing temperatures from the lab experiments.

“The lab results are informing promising improvements to the model so that we can better capture the infiltration of water into the soil, and the movement of nutrients, during winter conditions,” Kalcic explains.

The team will compare their modeling results to data from the Discovery Farms and agricultural research sites to gauge how well they’re forecasting the flow of water and the movement of nutrients, especially during the critical winter months.

The hope is that the combined strength of all four sources of data — labs, plots, fields, and models — can inform more effective agricultural practices that strike the right balance between crop health and environmental protection.

Thompson knows the steady and reliable Midwestern winters of her youth are not likely to return, which underscores the importance of the work she is doing today.

“We want to supply the crops we need for a growing population and ensure food security,” Thompson says. “And we also need to be good stewards of the land and manage agricultural areas in a way that’s protecting water quality and the environment.”
‘More Complicated Than Launching a Rocket’

Min Chen combines remote sensing and computer modeling to make climate change prediction more accurate.

Interview by NICOLE MILLER MS’06

When Min Chen first checked out Google Earth, the tech giant’s highly detailed digital globe, he was totally blown away. And the moment he learned its images were created through remote sensing, he decided to attend graduate school to learn more about the evolving technology. For his master’s program, Chen landed in a remote sensing lab — but one that focuses on the fundamental theories of remote sensing rather than its practical applications. It turned out to be a happy accident. Chen enjoyed the theory-level research. He went on to pursue a Ph.D. at Purdue University and postdocs at Harvard and the Carnegie Institution for Science at Stanford, adding skills and experience in terrestrial ecosystem modeling and advanced remote sensing techniques. He also worked at Pacific Northwest National Laboratory (PNNL), where he helped improve the models used in assessment reports by the United Nations Intergovernmental Panel on Climate Change. Chen later received a grant from NASA to further explore remote sensing theory, one of very few theoretical research grants provided by the agency. Chen launched the NASA-funded project after joining the Department of Forest and Wildlife Ecology in 2021. He was recruited as part of a campus-wide cluster-hiring initiative focused on emerging polar regions, and his research program encompasses that academic field and more. Chen’s big-picture goal is to improve understanding of Earth system dynamics using satellite remote sensing data and Earth system models. In turn, he hopes this will enhance predictions of how the globe is changing, including the volume of methane emissions in the Arctic, wildfire risks, vegetation growth, and the effectiveness of climate change mitigation strategies.

Your lab is called the “Global Change Research Laboratory.” How did you pick that name?

Well, I’m concerned about climate change, and I do research about how the Earth system evolves in the background of climate change. More specifically, I study land and atmospheric interactions and human-Earth system interactions. That’s a huge topic, and I’m generally interested in every aspect of that. So, the term “climate change” is too narrow. “Global change,” however, includes the climate, terrestrial ecosystems, and human behavior.

I use an integrative approach, including satellite remote sensing and Earth system modeling. We get our remote sensing data from government satellites or publicly available satellites. We use computers and high-performance computing for our modeling work. In terms of the human dimension, we use so-called integrated assessment modeling, which is an approach that couples human and Earth systems.
It’s exciting that you were recruited as part of the campus cluster hire focused on polar regions. What does your polar research look like?

The polar region is unique in the global system because the Arctic is subject to the fastest climate change, and the terrestrial ecosystems there are experiencing probably the most dramatic changes as well. And it’s a big source of global methane emissions.

We published a paper about this in the March 2024 issue of Nature Climate Change, where we quantify the polar Arctic methane emissions from the wetlands there. Methane, of course, is the second most important greenhouse gas after carbon dioxide. So, we use machine learning algorithms and the best available data, and I think we’ve produced the most reliable estimates of the wetland methane emissions in that area.

I don’t do field research, but I did get a chance to visit the Arctic and see what the ecosystem looks like. Where I visited, they dug a tunnel into the permafrost, and you can see the ice in the soil.

What can you tell us about some of the non-Arctic projects you’re working on?

There are many. For example, we are working on wildfire predictions because there are so many wildfires happening every day. Remember the wildfire smoke that blew down from Canada last year? The aerosols in wildfire smoke are very harmful to sensitive groups. I coughed a lot during that time.

We’re trying to make better predictions of wildfires so people can better understand which factors contribute to the wildfires happening and determine their severity. This provides insights for the people who manage fires to help them see how we can prevent or reduce the damage. I’m proud of using advanced machine learning algorithms to work on this, and we achieved a model with high accuracy.

Carbon comes up a lot when people are talking about big-picture changes to our planet. Does your work look at carbon?

Yes, I’m interested in carbon because carbon dioxide and methane are the top two greenhouse gases we have today. In terms of understanding climate change impact, we must have good computation of the carbon budget in different sectors in the whole Earth system — a global carbon budget.

The biosphere plays a big role in the global carbon budget because photosynthesis is the biggest consumer of atmospheric CO2. At the same time, the biosphere also releases a huge amount of CO2 and methane back into the atmosphere.

To make these carbon budget estimations, we have to rely on satellite remote sensing combined with a terrestrial ecosystem model. Satellite remote sensing can tell you how much vegetation is there, the health of the vegetation, or characteristics of the soil, such as soil moisture. But satellite remote sensing cannot directly observe how much carbon has been absorbed or released by vegetation. For example, the photosynthetic capacity of trees and the photosynthetic capacity of corn are completely different. Satellites cannot directly tell you that.

So we have to estimate the carbon budget with a model. But models themselves have huge uncertainty. We are using satellite remote sensing data to reduce the model uncertainty, to help us improve the models.

At the same time, there are issues with satellite remote sensing itself because the way satellites observe the Earth’s surface creates some artifacts. These artifacts come from the sun and the satellite observation angles. Especially for optical satellite remote sensing, it is very sensitive to the shadows cast by the sun at different angles.

Vegetation structure also brings artifacts into our observation. Take forest, for example — the trees have a lot of gaps. But a cornfield is uniform across the top, just flat. So we probably see more shadows in the forest but less shadows in the cornfield. That’s what makes satellite remote sensing so complicated.

Part of my work is trying to understand those artifacts so we can take them into account when using satellite data in our models, so we can get the best estimates from the models. We published significant findings on this in the November 2023 issue of Nature Ecology & Evolution.

What is your motivation for doing this kind of work?

Part of it is curiosity. Climate change is a big issue, and there are so many unknowns about the climate system. I think it’s more complicated than launching a rocket. We can do the rocket launching pretty well, but we cannot predict climate change well. So, we need people with different expertise to work on different aspects of the climate system and bring this knowledge together to have an integrated view.

I also hope we can have more reliable projections of how our living environment will change in the future, so we’ll have better information to understand things and help mitigate climate change. I want to help make our planet — our home — more sustainable, particularly with the challenge of climate change.
Career Pivot: The ‘Key’ to Success

Lenoria Addison draws on her life sciences communication skills as an entrepreneur in the entertainment industry.

By NICOLE SWEENEY ETTER

Not long after graduation, Lenoria Addison BS’12 paid a visit to a friend in Los Angeles. With just two suitcases and a backpack in tow, it wasn’t her plan to move to L.A. But, only a week later, she landed a job and began to build a wide-ranging career that has spanned both the tech world and the entertainment industry.

Now Addison is an entrepreneur, producer, marketer, and executive for KeyTV, a creator-focused streaming television network that she launched with actor Keke Palmer. Since launching in 2022, the network has attracted more than a million YouTube subscribers and has garnered headlines from Entertainment Weekly, Variety, Teen Vogue, and other outlets.

There’s a lot of “hurry up and wait” that comes with bringing a new creative vision to life, Addison notes. But the experience she gained at UW was good preparation.

“I think getting a degree in a science- or math-related field really teaches you how to be resilient, become a creative problem-solver, and deal with difficulty,” she says. “Those are transferable skills when it comes to entrepreneurship, business, and anything related to the arts.”

Addison’s career path is far from what she envisioned when she first came to UW as a pre-med student. She was inspired to pursue medicine after seeing the toll that chronic illness took on her own family, including the loving great-aunt and great-uncle who raised her in Milwaukee. She was just 16, preparing to take the ACT exam, when her adopted mother died suddenly of a pulmonary embolism. It was a poignant reminder not to postpone her dreams.

“I knew very young that I had two options: Let my circumstances consume me, or be fearless and dream and believe that I could have a bigger, brighter, greater life,” she says. “And that’s what I’m working so hard towards today — to inspire others like me that they can do the same.”

Her life sciences communication major was meant to be a step on the path to medical school, but then she took a class with Allen Dines, a former UW staffer focused on university start-up ventures. It opened Addison’s eyes to new possibilities.

“I was super inspired,” she says. “Working with Allen Dines and learning more about the entrepreneurial route definitely got me very excited that you can usher in ideas that could also change lives, help influence and impact the larger economy, the larger world, and in the same way that you can do through anything related to medicine or life sciences.”

Addison’s first job in Los Angeles was at a recruiting firm that hired software engineers for startups, such as Snapchat and Tinder, which were just getting off the ground at the time. But she was itching to launch a project of her own. With the help of a software engineer friend, she created a fashion app that people could use to share and discover new places to shop.

“I was bootstrapping it and learning a lot,” she says. “I taught myself how to do UI and UX [user interface and user experience], so I was really figuring out how to design the mobile...
I’m proud of taking risks, not being afraid to try new things, to pivot if something isn’t working for me.”

– Lenoria Addison

experience and going through the user journey. I think all of my science background helped because, really, it’s breaking down a big problem and trying to find creative solutions to get an answer.”

She grew the app to 3,000 users but decided to end the project after she couldn’t find funding to take it to the next level. Along the way, she also developed something else valuable: a network of influencers who were creating online content. From there, Addison pivoted to the entertainment industry and joined Awesomeness TV as a talent partnerships manager and producer.

“Brian Robbins, Awesomeness TV’s founder, realized that most kids and youth were spending a lot of time on YouTube, and so we wanted to make content to serve that audience,” she says. “That was a really fun experience because it was an innovative company meeting at the edge of new tech and new media, and I loved it.”

Addison also went on to launch creator content and talent partnership departments at global ad agencies R/GA and Deutsch, where she worked with brands such as Samsung, Taco Bell, eBay Fashion, Sonic, Snapchat, FX Networks, and more.

At Awesomeness TV, Addison met Palmer. Eventually, the two dreamed up a new idea: to build a digital platform for the next generation with a focus on creators of color, creatives, and entrepreneurs — without the gatekeeping that can be a barrier in traditional media and entertainment companies. This idea became Key TV, and it was a natural next step for Addison’s career.

“Lenoria is a singular talent and a force of energy, compassion, and persistence,” says Chelsea Sanders, a Key TV executive. “Working alongside her so closely with Key TV for the past two years has taught me personally what it means to have a truly entrepreneurial spirit that supports others and how to explore different possibilities and paths to success.”

While Addison loves her work at Key TV, she remains full of ideas, and she never knows when a new venture or curiosity will strike.

“I’m most proud of betting on myself,” she says. “I’m proud of taking risks, not being afraid to try new things, to pivot if something isn’t working for me. Gone are the days of thinking about your career or your life in this very linear way. Instead, it’s about being open to all the experiences and passions that you might have and really designing your world to be just that.”

ACCOLADES

‘EMERGING LEADER’
The Wisconsin Farmer’s Union (WFU) has presented Dylan Bruce MS’22 with its Emerging Leader award, given each year to an individual “who has ignited energy and engagement in WFU.” An agroecology graduate, Bruce cofounded Circadian Organics with his spouse and fellow CALS alum Skye Bruce PhD’23. Together, they manage four acres of vegetable and flower seeds and recently launched Driftless Seed Supply, a retail seed brand, in collaboration with regional producers.

DISTINGUISHED SERVICE IN FOOD SAFETY

Kathleen Glass PhD ’02 has been named the winner of Food Safety Magazine’s Distinguished Service Award for 2024. The award was presented at this year’s Food Safety Summit on May 6–9 in Rosemont, Illinois. Glass is associate director and distinguished scientist at the Food Research Institute at CALS.

GENETICS RANKED #1
UW was ranked the best place to study genetics in the United States by College Factual, which provides data-driven rankings of academic programs to assist families with the college selection process. The UW genetics program, housed at CALS, was chosen from among 65 institutions for the number one spot.
Kauffman Fund Aims to Beef Up the Meat Science Learning Experience
By MYRISSA ZOFF

First unveiled in fall 2020, the Meat Science and Animal Biologics Discovery (MSABD) building is a state-of-the-art facility for research, teaching, and outreach. It contains a USDA-inspected plant for meat production, an animal biologics preparation room, a high-security biosafety lab, and a retail store called Bucky’s Varsity Meats. (See “The Future Holds No Limits for Meat Science at CALS,” Grow, spring 2021.) The building is also home to the MSABD program in the Department of Animal and Dairy Sciences, which offers exceptional training opportunities for students, staff, and industry professionals.

The MSABD program is now looking for ways to help more students benefit from the building’s high-tech environment and maximize their exposure to modern meat processing, food safety, and career opportunities. The Kauffman Experiential Learning Fund is a primary driver behind this goal.

For more than 30 years, Robert Kauffman MS’58, PhD’61 was a professor of meat and animal science in CALS, where he was an outstanding teacher and inspiring mentor. He was perhaps best known for taking students on field trips to meat businesses in Madison, Green Bay, Milwaukee, and Chicago, which allowed them to speak with industry professionals and observe industry practices. Kauffman’s main motivation was to show his students the application of their textbook and lecture knowledge. His students used this experiential learning and his inspiration to develop leadership roles in the business and science of the meat and livestock industries.

“It wasn’t so much what Dr. Kauffman taught people but how he taught people to think,” says Al Gunderson BS’77, MS’79, who studied with Kauffman as an undergraduate and graduate student. He says Kauffman’s out-of-the-box thinking and unique take on animal science classes created a long-lasting impact on his students and prepared them for their careers.

Gunderson recently retired as vice president of Vita Plus, a Madison-based animal feed and technology company. He remembers when Kauffman took his class to the Oscar Mayer facility in Madison to see the full picture of the meat processing industry. The experience ignited Gunderson’s passion for agricultural business.

“[Kauffman] particularly enjoyed providing unusual kinds of learning experiences,” says Dan Schaefer BS’73, MS’75, an emeritus professor of animal nutrition who studied with Kauffman. “He always thought that the learning outside of the classroom was just as important — if not more important — than simply lecturing to students.”

Kauffman passed away in October 2022. To acknowledge and sustain his distinctive teaching style, the Kauffman Experiential Learning Fund was created to support undergraduates with science or economics interests in gaining hands-on experiences in meat science, meat animal production, animal biologics, food safety, and business — both in the MSABD building and beyond. The fund will support students through internships, special projects of practical importance, and extracurricular mentorships to aid students in building knowledge and networks for their future careers.

“A goal of this fund is to introduce students to the different sides of meat science,” says Steve Ricke PhD’89, director of the MSABD program and professor of animal and dairy sciences. “They will learn what it means to manage a project and find out what works for them in this field, beyond the classroom and beyond the laboratory. Introducing students to the concepts of meat science, and then giving them experiences in terms of the real world, is what sets them up for success.”
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ICE CREAM THAT WON’T MELT?
This ice cream research demonstration was conducted in a lab at Babcock Hall by Cameron (CJ) Wicks, a doctoral student in the Department of Food Science who is studying how micronutrients called polyphenols help slow the melting process. The ice cream samples, from near to far, are a control sample with no added polyphenols, a sample with cranberry extract (0.5% polyphenols), and a sample with green tea extract (2.5% or more polyphenols). This photograph was taken about one hour after the frozen samples were placed at room temperature. Read about this delectable project on page 12.

Photo by MICHAEL P. KING