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University of Wisconsin–Madison



Can Farms Capture Enough Carbon to Fight Climate Change?

PAGE 20



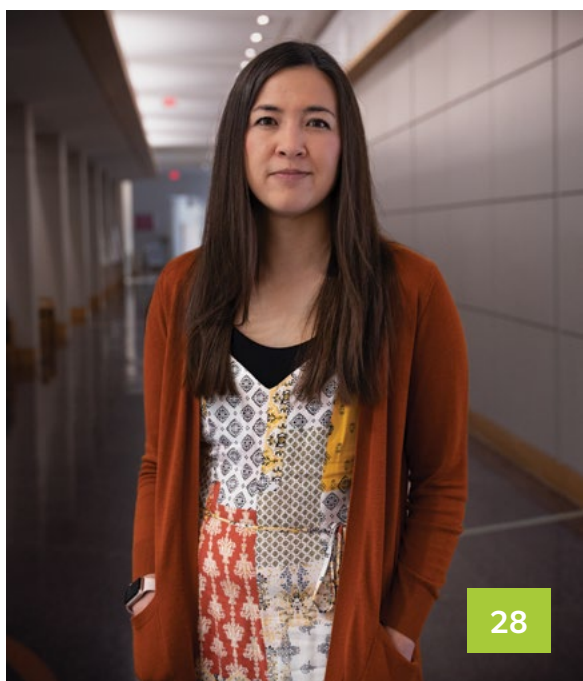
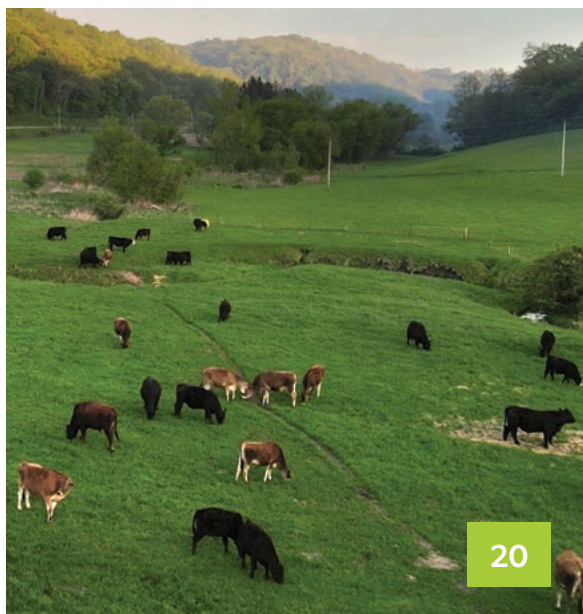
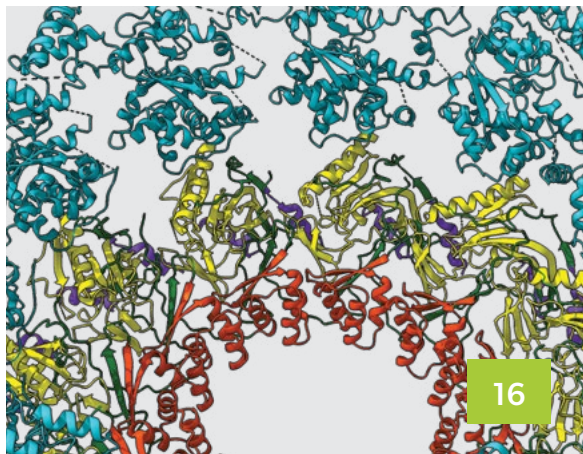
REPRESENTATION IN SCIENCE
PLANT-BASED ICE CREAM
VIRAL COPY MACHINE
WEATHER TRACKING VIA MESONET



From left: Yusuf Bin-Rella, co-founder of TradeRoots Culinary Collective and a UW–Madison chef; Ryan Dostal, a Department of Horticulture outreach specialist; and Reba Luiken, director of Allen Centennial Garden, harvest collard greens in the African Diaspora section of the kitchen garden at Allen Centennial Garden. Visible in background is Luiken's husband, Jarek.

Photo by MICHAEL P. KING





Wisconsin's
Magazine for the
Agricultural and
Life Sciences

grow

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ON THE COVER Some studies suggest that grazed pasture, like where these cattle are resting, and native perennial grasslands work best to sequester carbon. But further research is needed. Read more on page 20.

Photo by ISTOCK.COM/MARIOGUTI

Images, from top, by THE MORGRIDGE INSTITUTE, JACOB GRACE, PAUL ESCALANTE



Photo by MICHAEL P. KING

DEAN GLENDA GILLASPY

CALS Beyond Campus

Summer is in full, fabulous bloom on the UW campus. The beauty of this place could tempt us to keep our focus here and only here, but that simply isn't in the nature of CALS. In every season, our faculty, staff, and students are engaged in impactful activities that look beyond our 936 acres, and their efforts drive one of the college's core missions: outreach.

Outreach takes on many shapes. Sometimes it's a formal extension activity, such as assisting farmers and processors or interacting with the public during field days at our agricultural research stations. Other times, our staff, faculty, and students bring their passions to K-12 schools. One excellent long-term project in this vein is the Wisconsin Fast Plants program, initiated 35 years ago by **Paul H. Williams** PhD'62, now a professor emeritus of plant pathology. Fast Plants have been used in thou-

sands of classrooms worldwide to help students learn about plants and their genetics.

In this same spirit, some of our students design their own outreach programs, which provide meaningful professional development and a service to the community. Recently, a group of plant pathology graduate students who lead an educational program called What's Eating My Plants? (WEMP) won a college-wide diversity award for their work. The group's efforts have been wide ranging, including supporting Milwaukee's agriculturally focused Vincent High School, which I had the chance to visit in May. These activities are important to advancing our mission to serve the state, nation, and world.

This is the purpose of a land-grant institution such as UW, which stands out for its unique, campus-wide focus on the Wisconsin Idea. All UW–Madison students, faculty, and staff, at CALS and beyond, are exposed to this critical concept.

I recently had the good fortune to participate in the Wisconsin Idea seminar, a weeklong trip around the state with about 40 other folks from across campus. At each stop, we learned about geology, history, and the area's past and current residents (while taking in some gorgeous scenery). We also were exposed to the challenges and problems faced in each locale. The idea is to forge connections between UW's academic pursuits and practical solutions for problems throughout the state. I had quality time to reflect on my new state and the impact of CALS within its borders — what it is now, and what it could be. I am already taking advantage of my new knowledge (including my newfound ability to pronounce "Manitowoc" correctly)!

So where is CALS going next with outreach programs? I am happy to announce that we are launching a new initiative with a statewide network of Wisconsin high schools, scheduled to begin in late 2023. The plan is for our faculty, staff, and students to visit schools and offer educational activities that will help high school students learn about plant genetics. In doing so, we continue the proud tradition started by Professor Williams, now furthered by WEMP.

I am interested in hearing what you think of CALS, and how we are positioned to make a difference, moving forward. Please feel free to contact me at glenda.gillaspy@wisc.edu.

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Six Brain-Freezing Facts About Nondairy Frozen Desserts

By SCOTT RANKIN

Ice cream has long been a popular, almost sacred, part of global diets. Influenced by consumer appetites, ice cream comes in a host of flavors, colors, and even compositions, from low-fat versions to options with fortified protein. One of the more controversial variations involves replacing traditional dairy ingredients with nondairy or plant-based alternatives.

Nondairy frozen desserts are becoming more popular in the U.S., now occupying around 10% of the broader frozen dessert market. As demand grows, many traditional dairy companies are offering nondairy or plant-based alternatives. Here are some important things to know about these products.

1. Nondairy frozen desserts are ancient. They have been with us for probably as long as people have been making frozen desserts — at least several thousand years. Common plant-based products have been commercially available for many decades, including those made with soy, rice, or other nondairy plant derivatives.

2. People choose nondairy versions of ice cream for many reasons. Some do so because of dairy allergies, lactose intolerance, caloric density, or religious observances. Others have concerns about sustainability, environmental impacts, or animal welfare. Whatever the rationale, these choices all contribute to a growing pool of product options in the plant-based frozen dessert market.

3. Plant-based and nondairy frozen desserts are extensions of a tried-and-true formula. Although the structure and function are quite complex, a reasonably acceptable frozen dessert, in its simplest form, comprises three ingredients: water, sucrose, and a moisture-retaining stabilizer, such as guar gum. From these ingredients, a manufacturer can build additional layers of complexity and function to enhance flavor, increase shelf life, or incorporate

nutrient-rich ingredients, including plant-based options.

4. Although nondairy frozen desserts can be made in ways that many consumers find favorable, they are generally less well-liked than traditional, dairy-based ice cream.

Typical criticisms of plant-based frozen desserts include off flavors, atypical colors, or textural shortcomings. At UW's Frozen Dessert Center, a group of CALS food science experts helps innovative companies address these and other issues as they develop both traditional and novel products.

5. For now, nondairy frozen desserts cannot legally be called "ice cream" — but that could change. To be made and sold in the U.S., ice cream must conform to standards of identity set within the U.S. Code of Federal Regulations. The standards help assure that products are manufactured safely and contain minimum levels of key dairy ingredients. However, parts of these standards are becoming less enforced or rigidly applied. For example, the Food and Drug Administration recently declared that plant-based beverages may legally utilize the term "milk." It's probable that other plant-based or



nondairy products will soon start to use traditional dairy names, including yogurt, butter, and maybe even ice cream.

6. Both dairy and nondairy frozen desserts are here to stay. No matter the product — music, fashion, cars — consumers tend to prefer a wide variety of options to suit their needs and interests. Food is no exception. The frozen dessert sector will continue to display this same diversity of choices, including offerings of both traditional and nondairy ice cream.

Scott Rankin is an extension specialist in dairy food manufacturing and professor and chair in the Department of Food Science, which houses the Frozen Dessert Center. More about the center at go.wisc.edu/frozen-desserts.

Illustration by JORDYN VOWELS



Photo by MICHAEL P. KING

SARAH ALMUTAWA

The Rhodes to a Career in Research

Sarah Almutawa's work on a new genome editing technique paves her way to the finals for a prestigious international honor and a bright future as a scientist.

By DOUG ERICKSON

As a middle school student in her native Saudi Arabia, **Sarah Almutawa** BS'23 found herself — somewhat unexpectedly — competing in the International Chemistry Olympiad.

She had not yet taken a single chemistry course, but her parents believed in her. They'd already witnessed her science aptitude and always encouraged her to try new things, however challenging or unfamiliar.

"My parents used to throw me into these kinds of opportunities all the time," says Almutawa, who finished in the top five nationally for females in one Olympiad. "Now I throw *myself* into them."

It's an approach that has worked well for Almutawa, who graduated from UW–Madison in May with a degree in biology and certificates in global health and Biocore, the university's biology core curriculum honors program. Last fall, Almutawa was a finalist for a prestigious Rhodes Scholarship — a testament to the years she has spent seizing opportunities.

In high school, Almutawa scored high on pre-college exams and was awarded a scholarship from King Abdullah University of Science and Technology that fully funded her education at UW. It's an honor given to a select group of gifted Saudi Arabian students — and it's a gift she intends to repay.

"I've always had the desire to give back to the Saudi people and the Saudi government for all the support they've given me," Almutawa says. "I would love to take the knowledge I've learned here and use it to encourage Saudi children, especially young girls, to go into the sciences."

Almutawa's Rhodes application highlighted her work in the lab of **Junsu Kang**, an assistant professor in the Department of Cell and Regenerative Biology at the UW School of Medicine and Public Health. Kang's lab focuses on heart and fin regeneration in zebrafish, which share a large percentage of genes with humans. Unlike adult humans, however, zebrafish can regenerate their damaged heart tissues.

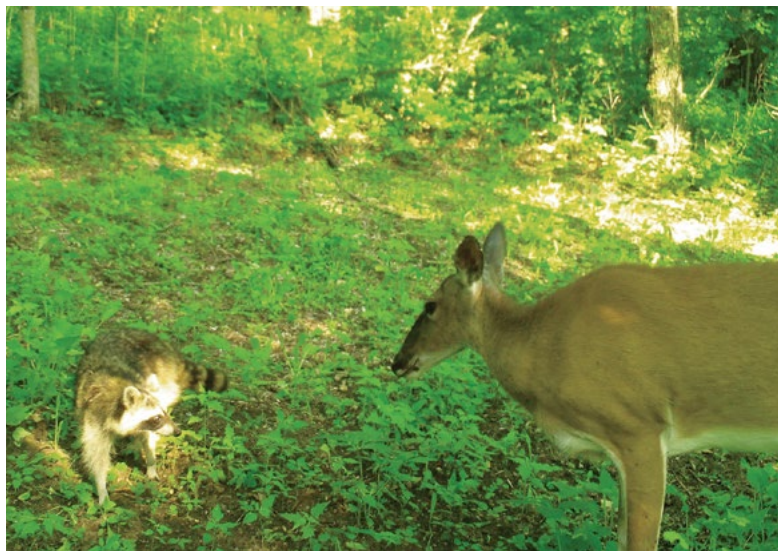
"Perhaps they have a set of proteins that help turn on these genes — it could be as simple as that," Almutawa says. "If we could identify these proteins, we could hopefully translate that into therapies that address cardiovascular disease in humans and help heart attack patients recover."

Almutawa's independent research project used the genome editing tool CRISPR to study tissue regeneration in zebrafish. She worked with Kang to develop a new approach to what is known as knock-in genome editing — a strategy to add DNA into the genome. Although the technique is challenging, the new approach will improve its efficiency and potency, says Kang, who calls Almutawa an exceptionally gifted student and researcher.

"She makes sure she knows every step that goes into an experiment and why it is significant," he says. "That is why I anticipate that she will become a great researcher."

Looking back at her childhood, Almutawa says she can see the signs of a future STEM career. Her favorite videos starred Bill Nye the Science Guy, and she couldn't wait to read the next issue of *National Geographic*.

"I think science was always my destiny," says Almutawa, whose mother, one of her role models, holds a master's degree in biology. "I was just a very curious kid."



Less Elbow Room for Wildlife

In a study using camera traps, a CALS research team finds that animals encounter each other more often when they live closer to humans.

By CHRIS BARNCARD

Human presence and influence on landscapes change the way other animals interact by bringing them close together more frequently than happens in wilder places.

That's the finding of a recent study by CALS researchers, who used photos from more than 2,000 camera traps in the Wisconsin Department of Natural Resources Snapshot Wisconsin program to determine the proximity in space and time of animals of various species. The time between appearances of different species on cameras was significantly shorter in areas closer to human disturbance, meaning animals are likely to interact more often when people are near.

The findings, published in the *Proceedings of the National Academy of Sciences*, support the compression hypothesis — the idea that encroaching human activity condenses the space and time animals share, leaving them closer and more likely to encounter each other. Another school of thought, the expansion hypothesis, predicts fewer interactions as some types of animals (like predators) are

disproportionately displaced by people.

"Compression works like a house party," says **Neil Gilbert** PhD'22, lead author of the study, which he conducted while completing his doctorate in forest and wildlife ecology. "The more people you crowd into a party, the less elbow room you're going to have and the more likely someone is going to step on your toes."

While not every species is troubled by human activity — squirrels and deer in particular flourish near people — one thing is clear: Animals that want to avoid human contact must make do with less elbow room.

"We have converted more than 40% of the Earth's land surface to anthropogenic uses, urbanized landscapes, agricultural landscapes," says **Ben Zuckerberg**, study coauthor and professor of forest and wildlife ecology. "We can think of that as a pretty major form of habitat loss for many species."

How that loss affects animal behavior and relationships can be hard to study. Tagging individual animals or small



groups with tracking devices provides too narrow a view to study community-level interactions. But Snapshot Wisconsin, a community science initiative that recruits volunteers to place camera traps on private and public land, has thousands of sites around the state, producing millions of photos that amount to near-continuous monitoring of animals moving through a wide range of landscapes.

"Snapshot Wisconsin supports the DNR's decision-making by answering important questions about species like elk and deer," says **Jennifer Stenglein** MS'13, PhD'14, a Snapshot Wisconsin research scientist and study coauthor. "But it also can push the envelope on theoretical studies when someone like Neil gets creative with this big data set."



Multispecies interactions caught on camera traps, like the encounters shown here, are few and far between, so CALS researchers analyzed the time between species appearances on Snapshot Wisconsin cameras to study the frequency of their interactions near human activity.

Photos courtesy of WISCONSIN DNR/SPAPSHOT WISCONSIN

+ FURTHER READING

[Grow first covered the research applications of Snapshot Wisconsin in “Candid Camera” \(Summer 2017\).](#)



Gilbert pulled almost 800,000 photos of animals from the Snapshot Wisconsin archive, assigning each of the 2,000-plus camera locations a rating for the level of human disturbance within 5 kilometers — plots like those in national forest at the low end and urban development or intense agriculture at the high end — based on NASA satellite imagery.

The researchers also grouped 18 observed species into 74 pairs and sorted them by the likelihood that an encounter turns violent, from low-antagonism pairs like skunks and rabbits to high-antagonism pairs like deer and coyotes. Then they measured the time between appearances at individual camera sites by an animal from each member of a pair.

“Time separation is our proxy for an

encounter,” Gilbert says. “If a camera picks up a squirrel, and then a minute later picks up a coyote, it’s more likely that those two animals are going to interact than if it was a squirrel and then three weeks later a coyote.”

Pairs in the study averaged 6.1 days between camera detections in low-disturbance landscapes and 4.1 days between detections in high-disturbance landscapes. High-antagonism pairs averaged the most time between detections and low-antagonism pairs the least, but the trend held for both groups — the nearer they were to human disturbances, the less time there was between the likely interactions.

“This is a big question in ecology: How does human disturbance affect wildlife?

We’re clearly seeing it can change their interactions,” Zuckerberg says. “The next questions are about the ramifications. Does it lead to changes in disease transmission? Does it alter predation? Affect things like deer–vehicle collisions?”

The researchers hope their work helps people understand the broad impact they have beyond changes in the size of animal populations and habitats.

“Even if it’s just in terms of the animals in your backyard, your surroundings, your neighborhood, I hope this encourages thinking about our impacts as humans on these invisible dimensions of biodiversity,” Zuckerberg says.

This research was supported by grants from NASA (NNX14AC36G) and to Snapshot Wisconsin by the U.S. Fish and Wildlife Service.



One Step Ahead of Wisconsin's Weather

A new statewide network of environmental monitoring stations, part of the Wisconsin Rural Partnership, will help farmers and others better understand and prepare for what's becoming more difficult to predict.

By JORI SKALITZKY BS'23

Wisconsin weather has grown increasingly unpredictable and extreme since the 1950s. The rapid shift poses difficult challenges for farmers, researchers, and the public. But with the help of a statewide network of weather stations, known as a mesonet, Wisconsinites will be better equipped to face the uncertainties of a changing climate.

"Mesonets can guide everyday decision-making for the protection of crops, property, and people's lives while also supporting research, extension, and education," says **Chris Kucharik**, professor and chair in the Department of Agronomy. Kucharik is leading a major project to expand Wisconsin's mesonet with assistance from **Mike Peters BS'95**, director of UW's Agricultural Research Stations.

Unlike many other agricultural states, Wisconsin's current network of environmental monitoring stations is minimal. Almost half of



A weather station, silhouetted against the sunrise, in a field at UW–Madison's Arlington Agricultural Research Station.

Photo by MICHAEL P. KING

the 14 weather and soil monitoring stations are at UW research stations, with the others concentrated in Kewaunee and the Door Counties on private fruit orchards. Data from these stations is currently hosted by Michigan State University's mesonet. Going forward, these stations will move to a designated Wisconsin-based mesonet called Wisconet, and the total number of stations will increase to 90 to better monitor all regions of the state.

This effort is supported by a \$2.3 million grant from the Wisconsin Rural Partnership, a U.S. Department of Agriculture–funded UW initiative, as well as \$1 million from the Wisconsin Alumni Research Foundation. The network's expansion is a critical step in providing the highest quality data and information for those who need it.

Each station contains equipment to measure atmospheric and soil conditions. Instruments above ground measure wind speed and direction, humidity, air temperature, solar radiation, and liquid precipitation. Below ground, soil temperature and moisture levels are measured at specified depths.

For now, data from Wisconsin's stations is accessed through Michigan State University's Enviro-weather website. But this summer, the data will migrate to a Wisconsin-focused site, **wisconet.wisc.edu**. Kucharik and his team are working to build a simple, open-access site where users can view and download station data in real-time and find practical guidance for using the data to make real-world decisions.

"Our growers rely on weather data to make important decisions on their farms on a daily basis. It affects when crops are planted, irrigated, and harvested," says **Tamas Houlihan**, executive director of the Wisconsin Potato and Vegetable Growers Association (WPVGA). "So we're very excited about utilizing this expanded mesonet in the near future."

In February, Kucharik, who is also a faculty member in UW's Nelson Institute for Environmental Studies, presented the mesonet plan at a WPVGA grower education conference. **Andy Diercks** BS'93,

a Wisconsin farmer and frequent collaborator with CALS and the UW–Madison Division of Extension, was in the audience. He liked what he heard.

"Many of our agronomic decisions are based on weather we've experienced or weather we expect to arrive within the next few hours or days," says Diercks. "It's our goal to keep water, nutrients, and crop protectants where plants can use them. But we can't succeed if we don't fully understand the current conditions in the air and soil and what to expect in the near future."

Diercks cites an unforeseen heavy rain washing away a recent fertilizer application as an event for which the mesonet could help farmers better prepare. And more than just farmers stand to benefit from the network.

"The National Weather Service regards these networks as valuable because they're able to verify and lead to a better understanding of extreme events," says Kucharik, who earned his Ph.D. at UW in atmospheric sciences. "A research-grade network of weather stations evenly spread across the state provides the NWS that many more data points."

While call-in reports from backyard weather stations are valuable, a mesonet can provide a more consistent and complete picture. Data from the stations could also aid researchers, transportation departments, environmental managers, construction managers, and anyone whose work is influenced by weather and soil conditions.

School grounds are potential homes for environmental monitoring stations, as well, which would create opportunities to support K-12 education.

"It's another way of getting more students connected to something that affects their everyday lives," says Kucharik. "You can connect that science to all sorts of other fields in agriculture, forestry, and wildlife ecology."

Installation of Wisconsin's new mesonet stations will start this summer and is expected to be completed in fall 2026.

■ NUMBER CRUNCHING

HOW BIG IS THE MESOSCALE?

The term mesonet stems from "mesoscale network." These networks contain automated environmental monitoring stations that gather data on meteorological events, such as thunderstorms and snow squalls, on the mesoscale (from 1 mile to around 150 miles in size). Meso-net stations are clustered closer and report more frequently than larger-scale National Weather Service stations.

Illustration by MARY QUINN



The Food Label Effect

A team of economists set out to discover whether clear identification of genetically engineered food products can shape consumer behavior.

By SILKE SCHMIDT

Use the term “genetically engineered food,” chances are you’ll spark a debate. Some praise its societal benefits — lower greenhouse gas emissions and reduced food prices. Others believe that genetically engineered (GE) food is unhealthy, despite scientific consensus on its safety. But how do these beliefs play out when food labels allow consumers to readily identify GE food in the grocery store?

Economist **Andrew Stevens** and his colleagues set out to answer that question by comparing packaged food sales in Vermont to those in Oregon and Washington. Vermont was the first and only state to implement mandatory GE food labeling in the U.S. — but only during the month of July 2016. A month after the policy went into effect, a federal law repealed the Act 120 state law.

Despite the short duration of what economists call a “natural experiment,” Vermont provided a unique opportunity to study if and how food labels affect consumer behavior, as measured by grocery store sales.

“The strength of our study is that we analyzed real purchases made by real people under real-life conditions,” says Stevens, an assistant professor of agricultural and applied economics. “Previous studies of this topic mostly relied on experiments or survey data.”

The drawback of designed experiments, such as simulated auctions to study bidding behavior, is a much smaller sample size. Surveys usually evaluate hypothetical behaviors with “what would you do if...” questions.

To estimate the policy’s impact, the researchers had to make two decisions: which products to analyze and which “control state” to use as a policy-free reference point for grocery store sales during the time period of interest.



As the GE food item, the team chose soups from an undisclosed manufacturer that rolled out nationwide GE labels months before Act 120 went into effect. The company’s national press releases highlighted the transparency of its early, proactive decision as a potential selling point. This provided confidence that the same product information was available at the same time in Vermont, Oregon, and Washington.

To see if Act 120 affected sales of other labeled products, the researchers selected two types of food with a long history of labeled attributes: certified organic (GE-free) and non-GMO (genetically modified organisms). Both groups included a wide range of products from baby food and soups to frozen meals and snacks.

As a control state for Vermont, New Hampshire might seem like an obvious choice. However, its close proximity would create spillover effects. For example, the two states share the same wholesalers, New Hampshire residents may shop in Vermont grocery stores, and many local news outlets reported on Act 120 in both states.

Oregon and Washington, however, have similar political landscapes, comparable interest levels in GE food, and shared northern geography, making them appropriate control states without spillover effects. Sales trends for organic and non-GMO products were similar in the three states before July 2016, and earlier ballot initiatives in Oregon and Washington showed that many residents also supported mandatory GE food labeling.

The researchers analyzed scanned food purchases at around 200 major regional and national chain grocery stores throughout 260 weeks of sales. Since the scanner data did not indicate the presence of new mandatory GE labels, restricting the GE soup analysis to the transparent manufacturer was



Photo by MICHAEL P. KING

important. The analysis compared sales during July 2016 — the Act 120 implementation period — with appropriate pre- and post-periods and accounted for other factors that influence sales, such as price, local consumer preferences, and time of year. Due to the variable length of pre- and post-periods, the

number of data points ranged from 318,000 (for GE soups) to 23 million (for organic foods).

By including data from the two control states, the researchers were able to attribute changes in Vermont sales to the implementation of Act 120. They found that the state law caused a decrease in GE soup sales of 5.9% and an increase in sales of non-GMO and organic products by 2.5% and 1.7%, respectively. After Act 120 was repealed and GE food labels were no longer mandated, sales of non-GMO and organic products returned to their original levels while GE soup sales increased by 6% from August 2016 to the end of 2017.

These results suggest that consumers have stronger short-term than long-term reactions to new food policies, especially when the policies are featured by local news outlets. Over time, processing the newly available information seems to improve consumer attitudes toward GE food.

An important broader lesson is that labels can be powerful. The term “salience” describes the ability of labels to increase the prominence and consumer awareness of certain product features. In this case, the attention garnered by Act 120 increased the salience of GE food labels in Vermont above and beyond the label information itself, which was equally available in Oregon and Washington. Other examples of salient labels include front-of-package labels that stand out visually and large shelf labels that highlight multiple locally sourced products.

The study provides further evidence that information salience influences consumer decisions in real-life settings. This may help guide future food policies, says Stevens. “Our results show that labels do much more than provide information by drawing attention to specific product attributes, and this can actually shape consumer preferences over time.”

This study was published in the journal *Food Policy* in July 2022.

FINDINGS

DAIRY LINK IN CHINA ADVANCES CALS MISSION

In a new book entitled *Wisconsin in the World* (Information Age Publishing, 2023), dozens of authors from UW–Madison highlight the success of the university’s international programs. Using case studies, the book illustrates how, when aligned with university values, these programs contribute to long-term stability, even in the face of a global pandemic and economic crises.

A chapter coauthored by CALS Global Director **Jennifer Kushner** BS’91 and **Brett Schieve**, CALS assistant dean for international and experiential learning, showcases this success in the context of the college. Through the example of the Dairy Farming Institute in China, they describe how research, teaching, and outreach and extension generate a dynamic feedback loop that develops new research ideas, generates solutions to local problems, and provides important training opportunities for students.

SURVEY: UW PLANT BREEDING PROGRAM IS #1

The UW Plant Breeding and Plant Genetics (PBPG) program at CALS is one of the largest and most impactful of its kind in the nation. A survey conducted by the National Association of Plant Breeders, which included 53 U.S. institutions that offer doctoral degrees in plant breeding, identified PBPG as the nation’s top graduate training program in terms of its placement of new Ph.D. grads in public or private employment. Founded in 1968, the program features 28 faculty from eight departments who teach around 45 to 50 graduate students in any given year. PBPG alumni — 380 Ph.D. graduates and 142 with master’s degrees — are found across all facets of the plant breeding world, nationally and internationally.

EXPLORE ONLINE
More CALS highlights at
news.cals.wisc.edu.

One Civet Coffee, Please — Hold the Poop

A partnership between CALS bacteriologists and a professor in Thailand yields a more animal-friendly delicacy drink.

By SUSAN LAMPERT SMITH BS'82

Thailand produces some of the most expensive coffee in the world, as much as \$100 a cup or \$600 per pound in some countries. The premium price stems from its unique origins: Between harvest and roasting, its beans pass through the guts of wild, catlike mammals called civets. But thanks to an international collaboration between Thai and CALS researchers, there's a new bioengineered version of civet coffee that takes the civet out of the process.

First, some history. When the Dutch were making a fortune in the spice trade in the 1700s, plantation owners imported coffee from the Middle East to grow in Southeast Asia. Workers were forbidden from consuming the expensive crop, but they noticed that when wild civets ate the ripe coffee cherries, they excreted the seeds (or beans) intact. The workers collected, cleaned, and roasted the scat-captured beans and used them to brew a mellow coffee. Due to digestive processes in the civet's gut, this coffee is lower

in acid and has a chocolatey caramel flavor, with hints of musk.

Jon Roll BS'88, PhD'96, a member of the teaching faculty in the Department of Bacteriology, met his first civet on a motorcycle tour of northern Thailand. He's been traveling there since 2003 to help set up CALS students in summer undergraduate research internships at Thai universities. He also teaches a UW course, Microbio 304, at Mae Fah Luang University, in the postcard-pretty mountains of Chiang Rai.

Roll visited a civet coffee company where women in the colorful costumes of the hill tribes, their teeth dyed black with betel juice, sifted through civet feces to glean digested beans. He also toured a civet farm, where the two-pound animals were kept in wire cages that have prompted animal rights activists to call for a boycott of civet coffee.

"The coffee is clearly being changed by going through the civet's gut, but what is going on in the process?" Roll wondered at the time. And he thought he might find the answer by working with Thai researcher **Jomkwan Meerak**, of Chiang



Mai University, whom he met when he was placing student interns. They decided to compare the microbiome of civets that were eating coffee cherries to those that weren't.

Roll introduced Meerak to bacteriology professor **Garret Suen**, whose lab has studied the microbiomes of animals ranging from dairy cattle to ground squirrels. Back in Thailand, Meerak's lab obtained the civet feces samples and extracted DNA, and Roll brought the DNA to Madison for microbiome analysis through an advanced genomic research method called next generation sequencing.

It turned out that certain species of lactic acid bacteria and yeast were driving the process. One member of Suen's lab was Thai student **Chutikarn Chitboonthavisuk** MS'18, now a doctoral candidate working in the lab of biochemistry professor **Vatsan Raman**. Bacteriology professor **Daniel Amador-Noguez** and his lab team also got involved in the civet research, identifying metabolites from the process.

Meerak and graduate student **Teerawat Ngamnock** have used the discovery to establish a civet-friendly coffee company, called BIRTH 2022, that uses an innovative process with probiotic starters of lactic acid bacteria and yeast isolated from the civets to ferment organic coffee beans. This produces a cold-brewed espresso with special flavors and higher levels of bioactive substances that may be anti-inflammatory immune boosters. The special brew's name: Beyond Coffee.



“THE COFFEE IS CLEARLY BEING CHANGED BY GOING THROUGH THE CIVET’S GUT, BUT WHAT IS GOING ON IN THE PROCESS?”

— Jon Roll



Far left: Professor Jomkhwan Meerak discusses the details of civet coffee with a civet farm owner (center) while two Chiang Mai University graduate students (left) and Aisha Inuwa BS'16, a CALS microbiology major at the time (right), listen in.

Top right: An Asian palm civet, native to South and Southeast Asia. The coffee beans these civets eat and defecate are used to brew coffee with a distinctive (and expensive) flavor.

Photo by WIKIMEDIA COMMONS/PONDEYO, CC BY-SA 4.0

Bottom right: Counterclockwise from top, a basket of coffee beans that were dried after being consumed and excreted by civets, a bowl of roasted "post-civet" beans, and a cup of brewed civet coffee.

Photos by JON ROLL (2)



■ FOLLOW-UP

NEW SOIL SCAN AIDS FARMERS AND THE ENVIRONMENT

When farmers make decisions about managing their crops, it's extremely valuable to know how much water their soils can hold. With this information, they can properly gauge the levels of irrigation and nutrients they should apply — and when.

"But the current industry standard method used to measure this soil [characteristic], known as the soil water retention curve, or SWRC, is labor-intensive and slow," explains **Jingyi Huang**, assistant professor of soil science. "Because of that, farmers often make a best guess based on experience."

Fortunately, there's a better option in the works.

Grow first introduced Huang and his imaging techniques in "The Soil Doctor Is In" (Spring 2020). Now, he and a team of researchers in the Department of Soil Science have developed a new approach for accurate and rapid estimation of SWRC using spectroscopy technologies. They have patented their invention through the Wisconsin Alumni Research Foundation.

"Our invention enables farmers to scan their soils and get information related to water and nutrient management in one minute and make an immediate decision," Huang says. "When people use this approach, they can get the same crop yield while reducing the costs of irrigation, fertilizer, and fuel. They also reduce the environmental footprint of agricultural production, such as groundwater contamination."

The approach utilizes a field spectrometer — called a vis-NIRS — to scan a soil sample that yields an estimate of the soil's water-holding capacity. Farmers can access the results via a smartphone app.

Huang's co-inventors include **Alfred Hartemink**, professor and chair in the soil science department, and **Zampela Pittaki-Chrysodonta**, who worked as a postdoctoral researcher in Huang's lab. The group is in discussions with spectroscopy companies interested in licensing the technology.

—Nicole Miller MS'06

Jingyi Huang Photo by MICHAEL P. KING

VIRAL COPY MACHINE REVEALED

A UW research team uses cryo-EM to render a stunningly detailed 3D blueprint of a complex genome replication apparatus found inside RNA viruses.

By BRIAN MATTMILLER

RNA viruses, such as the coronavirus that causes COVID-19,

jump into a life-and-death race the moment they infect a cell.

These viruses have only minutes to establish their replication machinery inside the host cell before the genetic instructions contained in their vulnerable RNA genomes — which are even more fragile than DNA — are destroyed by cellular housekeeping. If they win the race, the viruses can multiply rapidly, going from just a few copies of their RNA genome to a half-million copies incorporated into new infectious particles in less than 12 hours. If they lose, they die.

A UW research team has shed new light on these crucial early stages of virus infection and control. The group, housed at the Morgridge Institute for Research and led by a CALS scientist, has developed new ways to release viral RNA replication complexes from cells and visualize them in sophisticated ways through cryo-electron microscopy (cryo-EM).

Cryo-EM combines highly advanced imaging with extensive computational analysis to allow scientists to visualize flash-frozen molecules in their native state at molecular to atomic resolution (see “A Cold, Hard Look at Macromolecules,” *Grow*, Spring 2021). The technology provides revolutionary insights into biological structure, which can be a powerful foundation for developing therapeutics to thwart disease.

Most microbe and host genes function in large protein complexes that operate as molecular machines. The structures of these critical assemblies, however, have largely been unknown, greatly limiting understanding and control of the relevant processes. In 2017, using cryo-EM tomography and an advanced model virus, a research team led by professor Paul Ahlquist provided the first full imaging of a viral RNA replication complex and its striking organization.

The team found the parental viral genomic RNA “chromosome” tightly coiled inside a protective sac in the cell membrane. This vesicle includes a narrow channel leading to the cytoplasm, the dense mixture of diverse proteins and other molecules that fills the inside of a cell. Atop this channel, facing the cytoplasm, they discovered the site of the viral RNA replication machinery — the dynamic, multifunctional engine of genome copying. They also found that this machinery is organized in a previously unknown 12-fold, symmetric ringed complex that they named the “crown.”

Earlier this year, in a paper published in the *Proceedings of the National Academy of Sciences*, the team presented a further leap by revealing the intricate structure of this molecular crown, including enzyme domains that serve multiple functions, at atomic to near-atomic resolution. These dramatically higher resolution results show how the many distinct parts of this replicative engine are arranged. They also provide an essential basis for working out its assembly and dynamic operation, as well as ways to interfere with both — all of which could lead to better ways to fight viral infection.

“The first visualizations of the crown machinery by our lab in 2017 were like identifying the existence and general outline of a building,” says Hong Zhan, assistant scientist at the Morgridge Institute and first author on the study. “The new 2023 resolution is like showing fine details, such as the electrical wiring

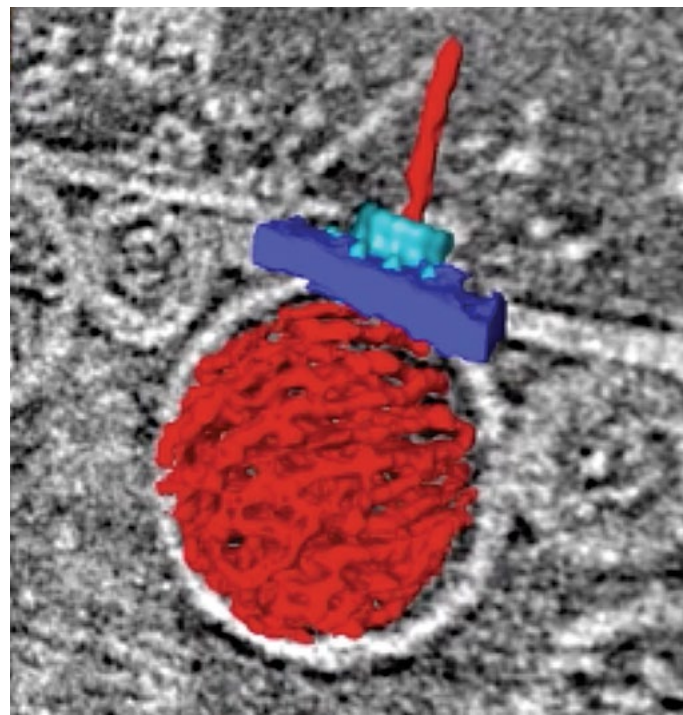
and the interior mechanisms of the door locks.”

“In virology, the complexes people have focused on to date mainly are the infectious particles that move between cells, which are relatively easy to purify and study because they release themselves from cells,” says Ahlquist, who is professor of plant pathology, molecular virology, and oncology and director of the Morgridge Institute’s John and Jeanne Rowe Center for Virology. “However, most viral replication processes occur in the complex environment within cells. This is a new chapter, where we’ve been able to reach inside cells to capture and image, in great detail, even more intricate viral machinery that carries out the central events of viral replication.”

The study found that the crown is made of two stacked rings, each containing 12 copies of an

A 3D rendering of a virus RNA replication spherule from the 2017 study by Ahlquist’s team. The mitochondrial outer membrane is depicted in dark blue, the spherule membrane is white, the interior spherule RNA density is red, and the spherule crown aperture is light blue.

Image courtesy of THE MORGRIDGE INSTITUTE



MEET THE RESEARCH TEAM

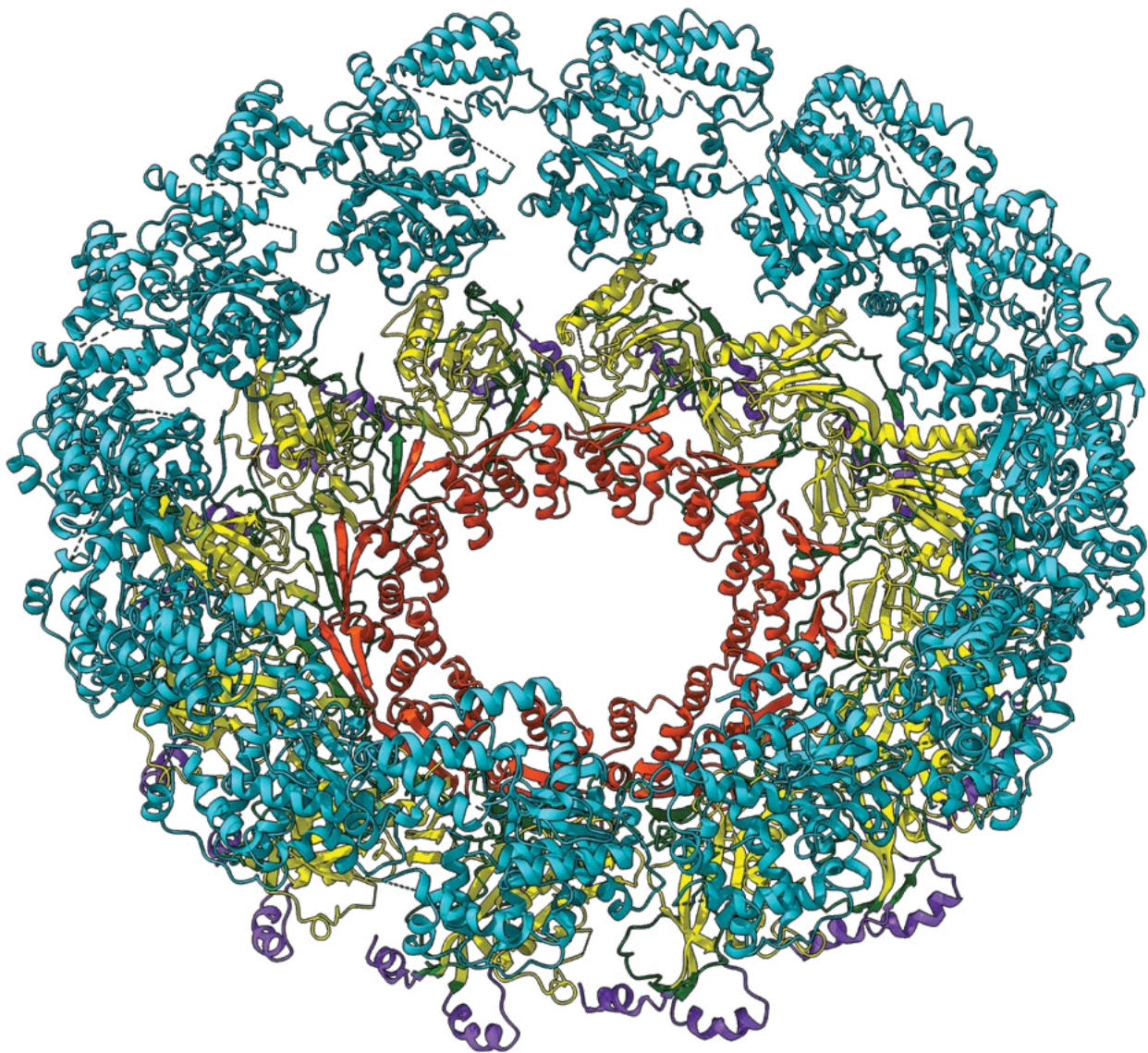
At CALS and the Morgridge Institute

- **Paul Ahlquist**, professor of plant pathology, molecular virology, and oncology; director of the John and Jeanne Rowe Center for Virology
- **Tim Grant**, assistant professor of biochemistry and Morgridge investigator

At the Morgridge Institute

- **Hong Zhan**, assistant scientist
- **Nuruddin Unchwaniwala**, former assistant scientist (now a researcher at Assembly Biosciences)
- **Johan den Boon**, associate scientist
- **Janice Pennington**, former electron microscopy specialist (now retired)

- **Andrea Rebolledo-Viveros** BS’16, former specialist (now a graduate student, Tufts University)
- **Mark Horswill**, senior research specialist
- **Roma Broadberry**, graduate student, biophysics
- **Jonathan Myers**, former assistant research specialist



enormous viral RNA replication protein whose multiple domains provide all functions required to synthesize new copies of the viral genomic RNA.

“However,” says team member Johan den Boon, “the proteins in the upper and lower rings are in dramatically different conformations, with their constituent domains in different positions relative to each other.”

+ VISUALIZE ONLINE
View a video illustrating the molecular assembly of the “crown” core of the RNA virus genome replication complex at go.wisc.edu/grow-viral-copy-machine.

One implication is that the same protein domains operate in distinct ways in the upper and lower rings. Several other features underscore that the crown is not a static structure but a sophisticated, active machine that progresses and cycles through a series of movements to carry out its successive activities. Based on this structure and further targeted experiments, the Morgridge team is clarifying the crown’s functions and conformational gymnastics.

Another valuable finding from these studies is that the lower ring is an assembly precursor, meaning it forms prior to the actual steps of RNA replication. This “proto-crown” then recruits the viral genomic RNA template and other components to initiate synthesis of new RNAs, and it serves as a base to assemble the mature, double-ring replication complex.

Growing evidence suggests that the crown not only synthesizes new copies of the viral RNA genome but also helps deliver these new genomes into downstream processes of gene expression and assembly of new infectious viral particles. Based on these findings, the crown appears to perform major functions for organizing many critical phases throughout infection.

“Just slowing down the assembly and function of RNA replication complexes is enough to kill these viruses,” Ahlquist says. “These new results provide a strong basis for finding new ways to do that.”

A ribbon diagram of the atomic resolution structure of the crown core of the RNA virus genome replication complex. This ringed assembly contains 12 adjacent copies of a single large viral RNA replication protein. Using cryo-EM tomography, cryo-EM single particle analysis, and other approaches, a UW research team revealed the intricate structure of this molecular crown, including enzyme domains (distinguished by the color coding) that serve multiple functions.

Image courtesy of
THE MORGRIDGE INSTITUTE

Ahlquist and other team members praise the UW–Madison Cryo-EM Research Center (CEMRC) and its leadership as crucial to their progress. The CEMRC was launched in 2020 with funding from a \$22.7 million grant from the National Institutes of Health and an initial \$15 million-plus investment from several campus units: the Department of Biochemistry and College of Agricultural and Life Sciences, the Morgridge Institute for Research, the Office of the Vice Chancellor for Research and Graduate Education, the School of Medicine and Public Health, and the Departments of Biomolecular Chemistry and Neuroscience. These units continue to partner on the center's efforts to make the valuable technology accessible to scores of scientists across campus, the nation, and beyond. Led by biochemistry professor Elizabeth Wright, CEMRC provides advanced capabilities in essentially all forms of cryo-EM imaging.

Emerging results from the Morgridge group and other researchers indicate that the principles revealed by these studies are evolutionarily ancient. New evidence also shows that similar crown-like complexes are central to the replication of most, if

A PUBLIC-PRIVATE PARTNERSHIP

The Morgridge Institute for Research is a private, nonprofit organization dedicated to improving human health through interdisciplinary biomedical research. It is housed in UW's Discovery Building, along with the public Wisconsin Institute for Discovery and the first-floor community space called the Town Center, managed by the Wisconsin Alumni Research Foundation. The Morgridge Institute uses mechanisms unique to a private entity to help recruit top scientific talent and build powerful research collaborations. Many faculty from CALS and across the UW campus serve as Morgridge investigators and affiliates and leverage the institute's resources to advance their research.

not all, RNA viruses in this large class. This includes SARS-CoV-2 (the coronavirus that causes COVID-19) and many other pathogens.

According to Ahlquist, what his team and others have discovered might serve as the basis for developing more powerful, broad-spectrum antiviral strategies. These strategies could inhibit infection by not just one but whole groups of viruses. [g](#)

Paul Ahlquist in his lab.


Photo courtesy of THE MORGRIDGE INSTITUTE





Can Farms Pull Carbon from Sky to Soil?

By Hal Conick

An aerial photograph of a vibrant green landscape. A winding stream, identified as a trout stream, flows through the center of the frame. The surrounding land is a mix of lush green grass and patches of brown earth, likely from grazing. In the background, rolling hills covered in dense green forest rise up. A dirt road runs along the right side of the image. In the lower right corner, a small group of people is standing near the stream. The overall scene is a beautiful representation of a rural, agricultural landscape.

A CALS agronomy group is partnering with farmers on a 10-year study to find out if improved agricultural practices can really sequester carbon and help fight climate change.

An aerial photo of grazing land and a trout stream on the Cates Family Farm in Spring Green, Wis. Photo by RANDY MANNING



In fall 2022, right after Midwestern farmers had gathered the last crops of the season, a team of CALS agronomy researchers hurried into the fields to collect samples of the soil.

They had just received a grant for the **Soil Organic Carbon network (SOCnet)**, a new decade-long study that could change the way farming affects the earth. To kick-start the project, the research group needed to take baseline samples post-harvest but *before* farmers began managing the soil for the next batch. Only a rapid response would do.

Associate scientist Gregg Sanford collects a deep soil core near Columbus, Wis., while Mark Walsh, an agricultural research equipment operator, looks on from the tractor. Photo by ADAM VON HADEN

The CALS team was led by Gregg Sanford MS'07, PhD'12, a senior research scientist in the lab of professor Randy Jackson, a grassland ecologist in the Department of Agronomy. With a tractor-mounted Giddings hydraulic soil probe, a gooseneck trailer, and a Ram 5500 truck, they set off from UW's Arlington Agricultural Research Station. At each farm site, researchers used the Giddings to probe deep into the soil, taking samples that, when analyzed, would tell them how much organic carbon it stores.

With baseline samples secured, they drove back to campus, the first step on a long journey toward answering a vital question: Can certain farming practices efficiently pull carbon from the atmosphere and into soil? If the answer is yes, it would bring them one step closer to understanding how farming practices can help quell climate change.

Better Living with Plants

When Sanford was a young boy, long before he ever thought about soil carbon, he was spellbound by plants and agriculture. Each summer, he traveled to his grandparents' dairy farm on the Kickapoo River in Southwest Wisconsin, where he often wandered its hilly terrain — and loved every minute of it.

As Sanford grew, so too did his interest and education in plant life. But he wanted more than knowledge, often wondering how the applied

science of plants and agricultural systems could improve the world. He knew that, when poorly managed, agricultural systems could have devastating consequences — the Dust Bowl, the dead zone in the Gulf of Mexico, even the Madison lakes turning green with algae blooms from excess phosphorus. But when managed well, Sanford knew that agriculture could feed growing populations, provide clean water, and potentially help stabilize the climate.

While working on his Ph.D. at CALS between 2008 and 2012, Sanford read scientific studies that made a fascinating connection: Farming practices might be able to draw carbon from the atmosphere into plant biomass, which would then become soil carbon. Done correctly, this process, called carbon sequestration, could reduce carbon in the atmosphere, thereby slowing the effects of climate change and providing important nutrients for farmland soil. This would be vastly different than many common farming practices, such as tillage (the turning of soil to prep for seeding or weed and pest control), which tend to release carbon dioxide into the atmosphere.

At this point, these were simply ideas on a page. But Sanford felt compelled by the theory that farming could assist in the fight against climate change. This idea of carbon sequestration, that plants can pull atmospheric carbon into the soil through photosynthesis and store it there, grew in popularity among researchers until it hit the mainstream.

Five years ago, Sanford noticed that many organizations were promising to pay farmers who use practices that sequester carbon in their soil. It's supposed to work like carbon credits, he says. "If our agricultural systems could pull carbon into the soil, you could theoretically pay a farmer for the amount

of carbon they sequester as an offset," Sanford says. "If you're Google, for example, and you want to go carbon neutral, you might have some areas of your business where it's not possible to cut down your carbon footprint. But perhaps you can offset your carbon footprint by paying a farmer for however many tons-per-acre that can be sequestered in soil."

While the concept was fascinating, Sanford knew the research about carbon sequestration had gaps, which means it also had gaps in practice. He had made this painful discovery in graduate school.

While doing research for his Ph.D., Sanford dug into the Wisconsin Integrated Cropping Systems Trial (WICST), which was launched nearly 35 years ago by CALS agronomy professor Josh Posner, whom Sanford studied under before his death in 2012. This trial — established to see how organic farming practices compared to nonorganic practices for growing food — collected baseline soil samples, including how much carbon each sample contained.

After seeing the array of systems and soils sampled, Sanford felt excited. This could be it, he thought. If he sampled these same areas 20 years later, he could find what systems best build carbon over time. But when he dug deeper, Sanford was disappointed by what he found.

"I analyzed the data and was totally shocked to find out that most of the

How Does Carbon Sequestration Work in Crops?

Through photosynthesis, crops use water and the energy from sunlight to transform carbon dioxide into their food, seemingly creating biomass from thin air. This activity removes carbon dioxide from the atmosphere and creates the oxygen many living things, including humans, need to breathe. As a result of this chemical process, carbon is captured and can be stored in the soil in which the crops grow. Having less carbon in the atmosphere can help mitigate climate change.

These large plots of corn, soybeans, wheat, and pasture are part of the Wisconsin Integrated Cropping Systems Trial, or WICST. Photo by GREGG SANFORD



systems had been losing carbon for 20 years,” Sanford says. “The results were contrary to what I expected.”

There was a clear signal that grazed pasture and native perennial grasslands — biodiverse plant communities that green up early in the spring, stay green late into the fall, and cling to soil through the winter — worked best to sequester carbon. But several questions remained about how these findings might apply to carbon sequestration in the region more broadly.

To this day, little is known about what practices work best to sequester carbon, Sanford says, due in part to the large role soil type and climate play in the equation. What works on one farm or field might not work on another. Inconsistent and historically inadequate scientific methods have also muddled the waters. Companies paying for carbon sequestration today may be putting ineffective practices to work. In this case, minimal carbon is being offset, if any.

This annoyed Sanford. What he once saw as applied agriculture that could change the world was turning into greenwashing. He began thinking of a way to make it right.

A Three-Tiered Idea

Sanford racked his brain to figure out a way to verify his observations from WICST and meaningfully assess the carbon sequestration potential of agricultural practices in the Upper Midwest. Properly gauging changes in soil carbon takes a long time — not only does carbon change slowly, but soils are diverse in character and content, making consistent measurement difficult. But, he thought, perhaps there’s a way to control the process.

“If we built out a network to do long-term monitoring and got farmers to buy in and work with us, we could find the best methods and get really accurate estimates,” he says. “That idea kept bubbling and bubbling.”

Sanford believed he and a team from Jackson’s lab could manage a long-term monitoring process across many landscape types, soil varieties, and management styles. By taking time to study the rich, prairie-derived soils throughout the Midwest’s corn belt — amplified by the 34 years of long-term WICST data and partnerships with other long-term, university-led experiments — researchers could better understand what practices work best to sequester carbon. This is the impetus behind SOCnet.

“We decided to evaluate carbon at these different experimental sites in the area where we have complete control of what’s happening,” Sanford says. He was ecstatic — this project would truly measure the impact of farming practices on soil carbon based on long-term observations, perhaps for the first time in the region.

SOCnet uses baseline, or “time zero,” carbon measurements and long-term monitoring to understand how management affects soil carbon over time. Many soil carbon studies take samples from different parts of a landscape at one time point and compare the carbon levels under different management (e.g., cover crops vs. no cover crops). Cover crops, such as rye and winter wheat, aren’t meant for harvest — instead, they improve soil, smother weeds, and deter pests. The assumption is made that soil carbon levels in “business as usual” no-cover-crop management have remained stable over time, and the difference between the two is therefore the result of carbon sequestration.

But this is an imperfect comparison, Sanford says, because, as work at WICST has clearly demonstrated, many of the assumptions do not bear out. With baseline measurements and long-term tracking, researchers repeatedly sample from the same piece of land, soon after the management



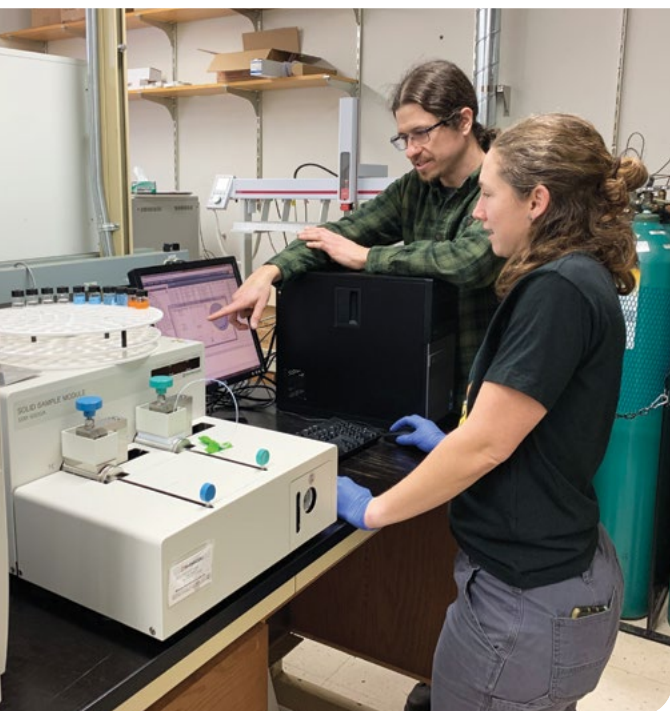
Top left: Soil core samples, taken during SOCnet’s first foray into Midwestern farm fields in fall 2022, await further processing and analysis in the lab. Photo by ADAM VON HADEN

Top right: Assistant scientist Adam von Haden and graduate student Mia Keady analyze soil samples for both inorganic and organic carbon in the lab. Photo by GREGG SANFORD

Bottom left: A side-by-side comparison of soil particles, left, and gravel after a SOCnet sample was sieved in the lab.

Photo by GRETA HIPPENSTEEL

Bottom right: Research specialist Greta Hippensteel BS’15 divides a SOCnet soil core for further analysis. Photo by ADAM VON HADEN



style has changed. “That’s a huge piece, tracking these systems over time,” he says.

SOCnet has three tiers. The first tier brings together ongoing long-term research by CALS scientists, including UW’s WICST, with multiyear experiments by Iowa State University (Marsden Long-Term Rotation Study) and the University of Minnesota (Long-Term Agricultural Research Network).

“Because these studies are on research sites, we can ask and answer questions more manipulatively than we can on farms,” Sanford says. “And, within each one of those associated states, we have a network of on-farm sites where we’re co-creating experiments with the farmers and collecting carbon data.”

That network of on-farm sites constitutes tier two. These are the sites where SOCnet teams rushed to sample with the hydraulic soil probe immediately following the 2022 harvest.

As soon as SOCnet received funding — a nearly \$250,000 grant from the grassroots Sustainable Agriculture Research and Education program — Sanford and his team began visiting potential tier-two farms. Farmers agreed to make changes in management (e.g., add cover crops, reduce tillage, etc.) in a section of their land, allowing researchers to sample from those locations. Every three years, researchers will return to see how much soil carbon has been gained or lost.

SOCnet’s third tier includes a larger network of farmers, those who won’t be making any changes. Instead, farmers in these locations have simply chosen a preferred system and will allow researchers to sample and track their soil over time. Taken together, the three tiers will give researchers a multifaceted view of what practices best build soil carbon on Midwestern soils that were built over millennia by the tallgrass prairie.

“If all goes well, this will be a 10-year project,” Sanford says. “Long-term research might not be the most exciting thing for a funding agency, eager landowners, or private investors hoping to see carbon accumulate quickly. But our point is to get the most accurate data possible on whether carbon is truly accumulating, and the only way to do that is by tracking it over time.”

A Slow, Deep Process

Most soil researchers take cylindrical samples around 30 centimeters long (roughly 12 inches). But Sanford wanted SOCnet to go deeper.

At each farm, the hydraulic probe samples down at least a meter for each sample — at least three times deeper than most other studies, Sanford says. While the top of the soil is the easiest to sample from, and where most of the “action” occurs, prior UW research has found that much of the carbon is gained and lost in a lower layer.

“We realized that the information, especially on the deeper soils, is limited,” says Adam von Haden, an assistant scientist in the Department of Agronomy and a SOCnet collaborator.

Von Haden mapped the areas they’d be sampling and accompanied the probe across the Midwest with Sanford. Now, von Haden runs the processing of the soil samples, a time-consuming affair. The first step is sieving the soil down to particles that are 2 millimeters in diameter or less, the cutoff for what is considered soil versus a larger particle, such as gravel.

“Some of these soils are very challenging,” von Haden says. “The deeper soils tend to have higher clay content and less organic matter, which makes it a little stickier, and it’s a real pain to get through the sieve.”

Under the guidance of Greta Hippensteel BS’15, a research specialist in the lab, the SOCnet team recruited several UW undergraduate students to

muscle through the sieving process. The sieving takes months because it must be done entirely by hand each time samples are taken.

After the soil is sieved, the samples are dried for analysis. Researchers take a small sample of dry soil, grind it up, and load it into an elemental analyzer. The analyzer combusts the sample and measures how much carbon dioxide it releases. Rather than working by hand, researchers can load dozens of soil samples at a time, allowing the analyzer to run all day.

SOCnet researchers will also examine the soil's texture, acidity, and what kind of organic matter it contains, von Haden says. There's a theory that soil containing more mineral-associated organic matter will likely hold nutrients, such as nitrogen and carbon, for longer. SOCnet researchers intend to study this further.

Von Haden says the probe will visit twice as many sites in 2023 as it did the previous year as SOCnet takes its first samples of tier-three farms. Under von Haden's management, all the data will be compiled into a database and then compared over time.

"I believe it's a unique study, having this aspect where we're working with farmers across three states and actually doing the research on their farms," von Haden says. "I can't think of another study like that offhand."

Farmers as Partners

Farmers are true collaborators in SOCnet. Researchers rely on them to manage their land in specific ways, report back on activity and changes, and grant access for soil sampling. Von Haden says that a big part of the SOCnet team's job is to educate farmers on what data they're finding. The team will readily share data and insights to inform farmers about agricultural practices that sequester carbon.

That education component is why Eric Heins, owner of Minnesota family farm Hoosier Ridge Ranch, decided to become part of SOCnet. "The carbon piece piqued my interest," Heins says. But he wanted to learn more.

In the past, Heins had reached out to carbon markets about sequestration methods, but none were interested in working with small farms. To him, most seemed like fly-by-night operations — he never quite trusted them. "I think that those who are signing up right now are going to get the short end of the stick as more people jump into that market," Heins says.

In 2015, Heins and his family bought Hoosier Ridge Ranch and converted tillable land into rotational grazing land, which moves livestock through different areas of the property, and started their own grass-fed beef herd. Their plan now is to grow cover crops over everything. But for SOCnet, researchers asked Heins to keep a few acres of land free of cover crops so they can compare its soil carbon to other areas of their land with cover crops.

"If we can prove that these practices where you're not disturbing the soil — cover cropping, no-till planting, and minimal tillage — help sequester more carbon, that really gives proof to the world to say, 'Everybody should be doing this,'" Heins says.

Jason Gruenfelder, owner of Greenfield Farm in Southwest Wisconsin, is also part of SOCnet's second tier. His 400-acre farm, which he runs with his wife and five children, has everything in permanent pasture — land used for growing grasses or herbaceous fodder for five years or more — with dairy cattle grazing rotationally.

For SOCnet, Greenfield Farm will grow a double crop with sorghum silage harvested in the fall and winter wheat or rye grown across the year as a cover crop. Gruenfelder will allow cattle to graze in this area more



An aerial photo, taken with a drone, of cattle grazing on pasture at the Cates Family Farm in Spring Green, Wis.

Photo by JACOB GRACE



“

By getting data in the hands of the farmers . . . they can then critically filter and sort the wheat from the chaff regarding carbon sequestration.” – Gregg Sanford

frequently than usual, which is a method use to prep soil for planting without tillage. “We’re going to really get a lot of hoof action on it here this spring when it gets a little mucky, but not tear it up completely,” Gruenenfelder says. For his part, Gruenenfelder says he’ll record what days cattle graze as well as whether he does any other forms of tillage or spraying in those areas.

While Sanford is glad to have more control over management practices through tier one, he believes that collaboration with farmers in tiers two and three is the most important part of SOCnet. Farmers will give researchers a deeper level of understanding, just as the hard-won data of SOCnet will empower farmers to know what works best to sequester carbon in soil.

“Farmers are bombarded with information and data, including a lot of kind of snake oil sales, for lack of a better term,” Sanford says. “It’s hard for anybody to sort through what’s true and what isn’t true. By getting data in the hands of the farmers and helping them understand what the data means, they can then critically filter and sort the wheat from the chaff regarding carbon sequestration.”

‘Agriculture Really Can Be an Answer’


Heins hopes that SOCnet shows that certain farming practices can indeed pull carbon into the soil — and with efficiency. “Agriculture really can be an answer,” he says. Heins also believes that carbon markets, and thus the farmers who work with them, will only be truly successful after accurate measurements are taken. “They’re going to be able to prove that they did it rather than just saying it on paper.”

In 2022, members of Congress showed their enthusiasm for this idea when they introduced legislation to fund research to better understand and implement carbon sequestration practices.

For von Haden, the end results of SOCnet will be fascinating, no matter the findings. Few if any studies have tracked changes for as long and as deep into the soil. “The data will be extremely informative for both the farmers and for the broader science community,” he says. “The only issue is that we have to wait 10 years to get the results.”

The wait will be worth it, Sanford believes, because it will clear up misconceptions and inform farmers of the best practices in sequestering carbon. This will reduce the chances of greenwashing, improve clarity in how farming can thwart climate change, and improve soil quality for agriculture. And it will demonstrate that the applied science of plants and agriculture can change the world.

“We have really carbon-rich soils and this huge carbon resource,” Sanford says. “If we’re working with bad data, we will continue to degrade it. Or we can use the right data to protect it and make it better.” **g**



Representative SCIENCE

Judith Simcox and her colleagues look to diversify the pool of researchers — and the questions they're asking — to get answers that address health care disparities.

By **Caroline Schneider** MS'11
Photos **Paul Escalante**

Judith Simcox can trace the course of her research career all the way back to high school. Her class was given an assignment to explore a question about the world around them. Most students posed somewhat conventional queries: Why is the sky blue? or Why are animals going extinct? But Simcox's question was far more particular: Why do people with Down syndrome have elevated rates of type 1 diabetes?

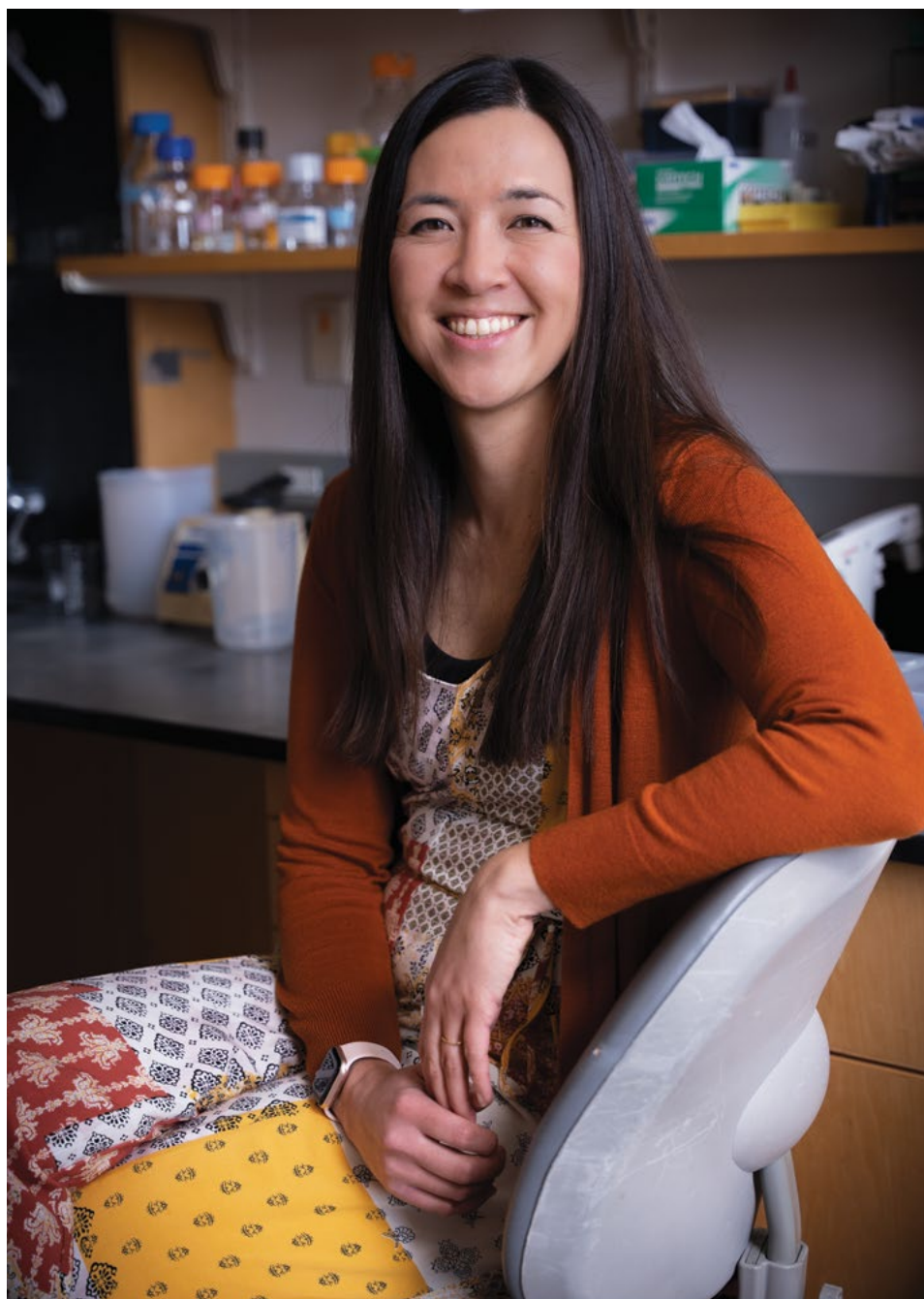
It was a highly personal inquiry for Simcox, one that stemmed from her family's own circumstances. Her mom, a nurse, worked with the Special Olympics team where her younger sister, Jan, was a member. Jan was born with Down syndrome and developed type 1 diabetes in elementary school. At the time, Simcox simply found this to be unfair. She later discovered that, of the 12 people with Down syndrome on her sister's team, four of them also had type 1 diabetes.

Those numbers stuck with her, and she jumped at the chance in high school to find out more about the connection between the diagnoses. Simcox learned that 4% of people with Down syndrome are diagnosed with type 1 diabetes. That's compared to just 0.5% of people in the general population.

"It was a major difference," recalls Simcox, who is now an assistant professor of biochemistry. "But I also found out that no one knew why they have these high rates. It was the first time I had asked a science question that didn't have an answer."

Her curiosity about metabolic disease in diverse populations also began with personal experience growing up in a rural town next to the Crow Reservation in Montana, where her friends and family live. All of her aunts and uncles struggled with complications from type 2 diabetes or cardiovascular disease. Simcox carried her interest to Carroll College, a small liberal arts school in Helena, where she intended to follow in her mother's footsteps and study nursing. But her plans changed.

For one of her classes, she was required to attend a science seminar. Simcox chose a talk about evolution and



Judith Simcox, assistant professor of biochemistry, in her lab in the DeLuca Biochemistry Laboratories building.

ecosystems by a professor named Gerald Shields. Afterward, she peppered him with questions.

"I basically cornered him for 20 minutes," she says with a laugh. "Luckily, he said, 'You should come and answer all your questions in my lab.' I ended up working with him for four years, and he opened up the world of science to me in so many ways."

Again, Simcox's questions had spawned new ideas and possibilities. They would lead her through college as well as a Ph.D. program and postdoctoral training at the University of Utah. It was there that she dove into metabolism research, studying diabetes and cardiovascular disease, and began to address the questions she first raised as a high school student. She continues finding answers at UW–Madison. Since joining the Department of Biochemistry in 2019, she has built an impressive team of five graduate students, three postdoctoral fellows, and two faculty collaborators.

The main interests of Simcox's lab are metabolism, lipids, and biomarkers. Biomarkers, or biological markers, are substances or processes in the body that can be objectively measured and used to predict the occurrence of disease. Simcox and her colleagues aim to discover how different markers perform for different populations throughout the world, including Black populations, Native American populations, people with type 1 diabetes, and people with disabilities. The most commonly used markers to determine diabetes risk are lipids, energy-giving fat molecules that circulate in the blood, such as LDL and HDL cholesterol and triglycerides.

"The negative thing about these markers is that they were developed in an all-white population of Western European descent," explains Simcox, who is also an affiliate in the Department of Nutritional Sciences. "We have known since the '90s that these markers don't predict cardiovascular disease in diverse populations, specifically in Black populations. This means they're not getting the same standard of care."

This problem led Simcox to ask another round of ambitious questions: Why hadn't this disparity been addressed yet? How could better markers of disease in all populations be identified? She and her team look for previously unidentified markers by identifying and separating lipids in plasma using techniques such as mass spectrometry and liquid chromatography. And, through a fruitful collaboration with two local organizations — Midlife in the United States (MIDUS) and the Survey of the Health of Wisconsin — they have acquired human samples for testing.

Chris Coe, a professor emeritus in the UW Department of Psychology, oversaw the Biomarker Core for MIDUS before retiring in 2021. He approached Simcox because he had heard about her expertise in lipids and metabolism.

"We had generated lipid profiles for over 2,000 middle-aged and older Americans," explains Coe. "Judi provided us with expert guidance on how best to analyze the hundreds of lipids that had been quantified. She has a deep knowledge about this growing field that has so much relevance for human health."

In addition to helping the MIDUS team, Simcox and her lab tested samples for their own experiments. They were able to measure around 480 lipids in the human plasma samples, some of them known and some unknown — and most not considered biomarkers of disease. Further analysis of the lipids found that those associated with cardiovascular disease in Black populations were also relevant in the white population. These results are promising. It seems likely that more comprehensive biomarkers of cardiovascular health could be identified for a greater proportion of the general population.

The lipids that Simcox and her lab are identifying fall into various categories. Some are oxylipins, lipids with oxygen groups that are built from omega-3 and omega-6 fatty acids in the diet, that can act as signaling molecules. These lipids call for immune responses in the body — namely, increased white blood cell and macrophage counts and vein constriction.

But the main questions with these lipids are whether they serve as biomarkers for cardiovascular disease and, if so, what

is their relationship with the disease? Because it's difficult to control human behavior to alter lipid profiles, and because self-reports from study subjects can vary in quality, Simcox's team is turning to mouse models to answer those questions. These studies give them the ability to control the parameters of diet and activity, study a mammal with anatomies and processes similar to humans, and construct a more detailed picture of the roles of lipids in the body.

"We want to know where these lipids are produced, how the production is regulated, how they get transported, where they're going, and what they're doing once they get there — just the basic questions of life," says Simcox with a smile.

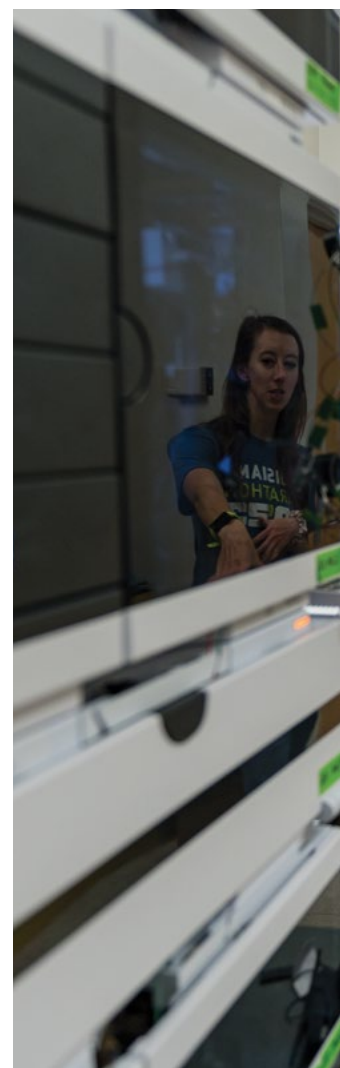
Working to answer many of these questions about lipids is Jess Davidson, a graduate student in the Integrated Program in Biochemistry and a member of Simcox's lab. She focuses on biomarkers for heart disease in people with type 1 diabetes. People with type 1 diabetes often have normal (rather than high) baseline levels of LDL and triglycerides, making those biomolecules poor markers of cardiovascular disease in that population. This is why Davidson is looking at individual lipids in the plasma, including those contained within LDL. It's possible that one of those will be a better predictor of cardiovascular disease than LDL and triglycerides.

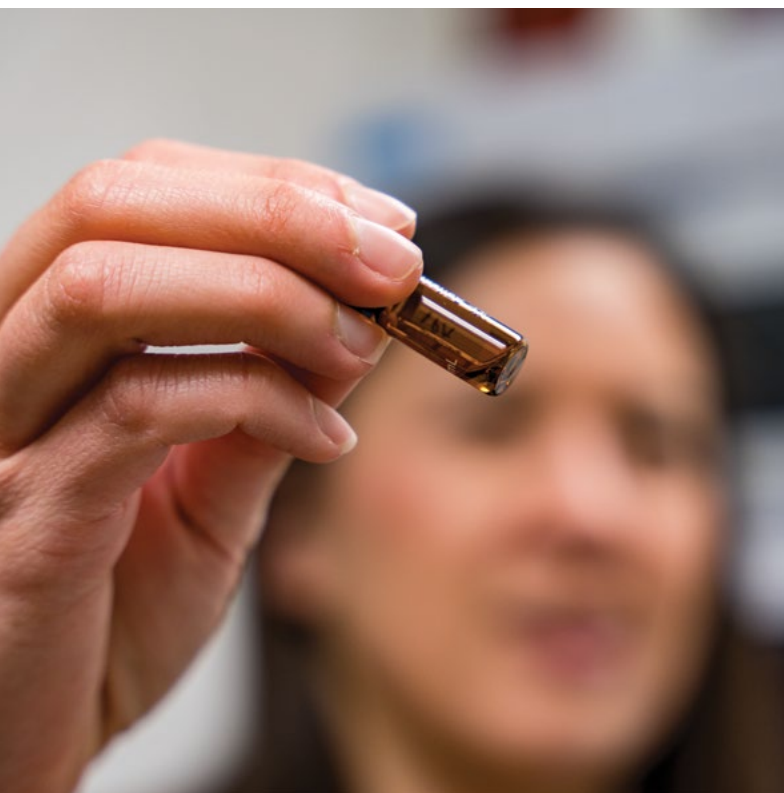
For this project, Davidson analyzes human blood samples from the Wisconsin Diabetes Registry Study. Participants enroll at the time of their initial diagnosis, and some have been with the study for more than 30 years.

"We have banked plasma samples for each person over the years and all of the clinical information that's been collected," says Davidson. "We bring them in for another appointment, and I'm able to interact with those patients, talk with them, and then go to the lab to ask really good scientific questions that can impact how their disease is monitored or treated."

Right Judith Simcox holds a vial filled with a lipid extraction from human plasma.

Below Jess Davidson, right, a first-generation college student and a graduate student in the Integrated Program in Biochemistry, talks with Judith Simcox in Simcox's lab in the DeLuca Biochemistry Laboratories building. In the foreground is a liquid chromatography mass spectrometer, which measures thousands of lipid species from human plasma or cells.





Davidson is a first-generation college student. She completed an undergraduate degree in biomedical engineering at Johns Hopkins University and worked as a research technician for several years. Davidson intended to go into a combined MD/Ph.D. program but realized that, while she enjoyed interacting with patients, treating them wasn't her skill set. Her true passion, she discovered, is people-focused research.

When looking for a graduate program, Davidson was still considering how to marry her interest in bench science with her desire to help patients. When she talked to Simcox, she realized not only was this possible, but she could find a graduate mentor who would be supportive of her plans.

"Judi told me that there would be a way to do it. I'd have to seek it out, but there are ways I could collaborate around the hospital, talk with patients, and collect survey data," Davidson says. "She's helped me bring this aspect to my work and find opportunities that fit my interests."

It's no surprise that Simcox invests so much in the students and scientists she works with given her own experience with mentors. Her first of many pivotal mentor relationships was with Gerald Shields, the professor she barraged with questions back in college. When he asked her to join his lab, she was concerned that doing research rather than waitressing would make it harder to pay her way through school. Shields told her about a fellowship that could help. But when they discovered the fellowship funding was no longer available, he and his wife donated the money to pay Simcox for her work. She later asked Shields why he did this, and he told her that when she became a professor, she'd know that some risks are always worth taking.

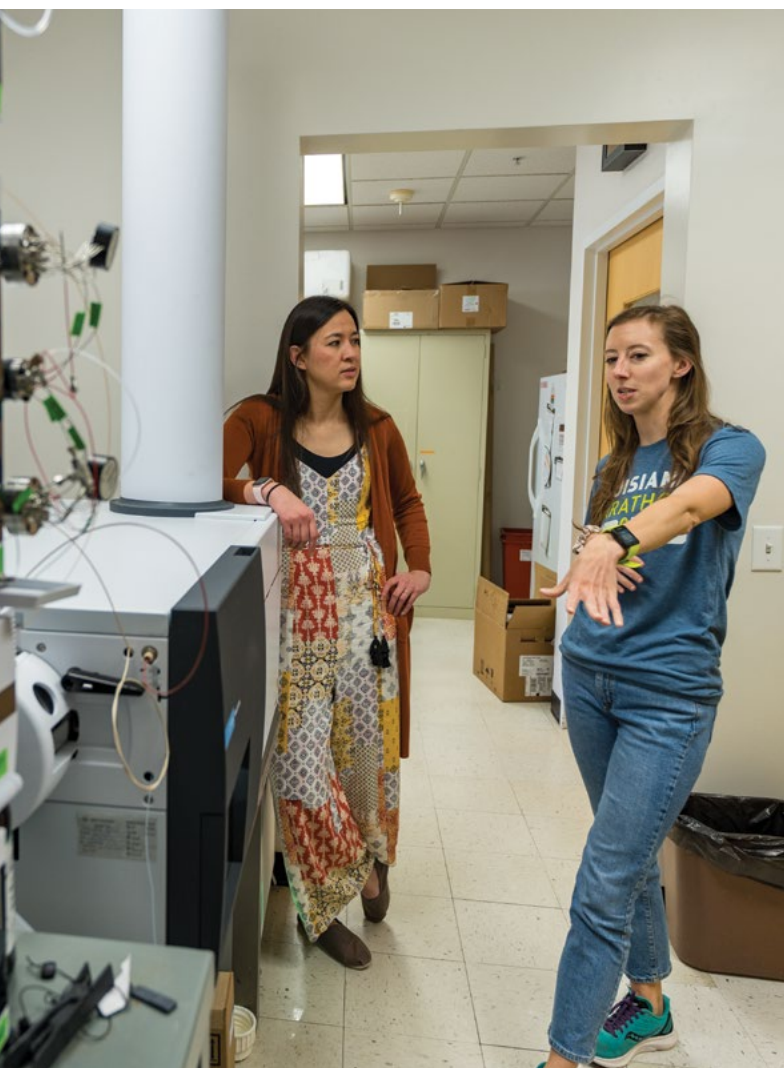
"He taught me about potential and the importance of mentorship," says Simcox. "I think of him every time I take a new student into my lab."

In graduate school in Utah, another mentor, medicine and biochemistry professor Donald McClain, taught Simcox to recognize and embody her values. "I learned with Don to live a value-driven life and always keep in mind what I wanted to share with the world as a scientist," Simcox says. "I knew I wanted to be a community-based scientist and make the science around me better."

Now, in her own lab, Simcox cultivates a community of researchers who work independently but collaborate easily. They also engage with members of the broader community around them, such as aspiring scientists and grade-schoolers interested in STEM fields.

"From the start of talking with Judi, I saw her focus was not just on science but also on reaching out to other populations, and it spoke to me," Davidson says. "Outreach is a focal point of what we do in the lab. For example, we do outreach with a lot of high schools, and we give talks to the American Indian Science and Engineering Society."

The lab also hosts a scholar as part of the Post-baccalaureate Research Education Program (PREP), an NIH-sponsored initiative that Simcox was instrumental in bringing to UW–Madison.



Scholars are individuals from underrepresented groups who have earned bachelor's degrees and are looking to learn about graduate programs in biomedical research fields. PREP completed its first academic year on the UW campus in 2022–23, and Simcox's scholar during that time was Autumn Chevalier, an enrolled member of the Menominee Tribe.

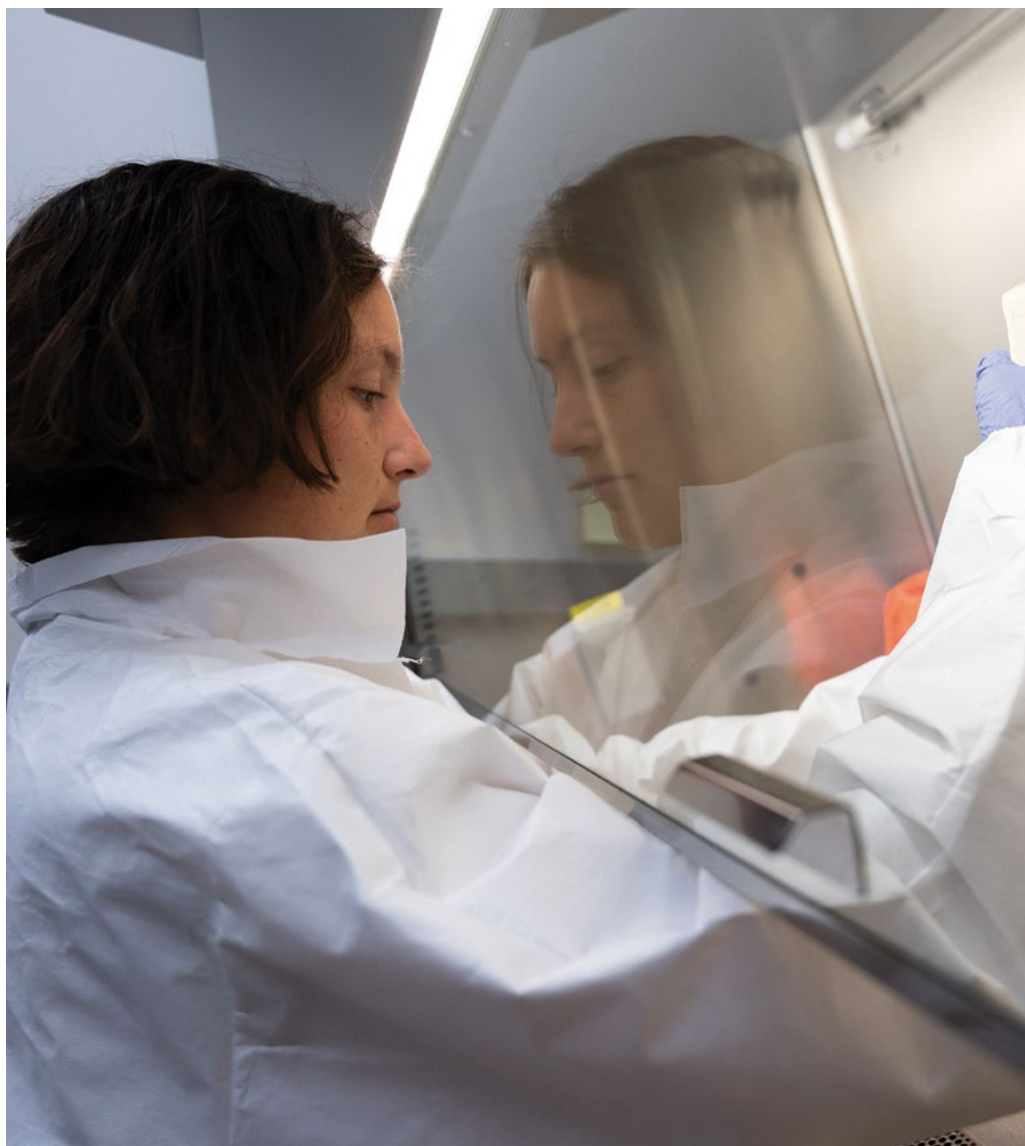
Davidson sees the effort that Simcox puts into outreach and supporting diverse populations, and she aims to do the same in her own career. Hoping to become a professor herself, Davidson also wants to run a lab and provide mentorship to underrepresented students.

"Judi is an incredible resource for any student," Davidson says. "She offers support and is willing to have hard conversations. She's an advocate for anyone that needs it. I knew early on she was the kind of person and scientist I want to be."

Simcox is always seeing opportunities to pay it forward. From her perspective, the doors that were opened early in her schooling should be accessible to everyone, not just those who can afford certain programs or those whose parents and grandparents went to college. The focus on creating opportunities led Simcox to serve as co-mentor for the American Indian Science and Engineering Society Chapter at UW–Madison, work at the national level with the Society for the Advancement of Chicanos and Native Americans in Sciences, and with the Native American Center for Health Professionals.

Diversity in science and health is fundamentally important to Simcox, and her work in these areas was recognized in May by the Howard Hughes Medical Institute when she was named a Freeman Hrabowski Scholar. The program supports early-career faculty who have shown outstanding commitment to diversity, equity, and inclusion in science.

"Science has to be driven by people in the community," says Simcox. "There's diversity in the community, so there should be diversity in labs. Diversity changes the types of questions people ask. If you have people from different backgrounds, they ask different questions and answer them in different ways."



Simcox's passion for supporting diversity and equity merges with her research as she works to make sure that all populations have access to responsive and accurate health care. In addition to her work on lipid markers of cardiovascular disease, she is involved in a new Alzheimer's disease study.

Carey Gleason leads the Inclusion of Under-Represented Groups Core at the Wisconsin Alzheimer's Disease Research Center and is an associate professor in the UW Department of Medicine. She is also a clinical neuropsychologist who focuses on patients with memory disorders. In her efforts to invite Black and Indigenous groups to be part of the conversation about Alzheimer's treatment and prevention, she wanted to find researchers who were members of those communities.

"We do better science when we do inclusive science," Gleason says. "I wanted to partner with Judi to make sure that we brought into the science leadership someone who understands that cultural lens and also brings the highest caliber of scientific skill and creativity."

Gleason and Simcox have just started their work together,

Above + Right Isabella James, a graduate student in the Integrated Program in Biochemistry, performs a tissue culture under a fume hood in the lab of Judith Simcox in the DeLuca Biochemistry Laboratories building.



but they're already bringing Indigenous trainees into their labs who have an interest in the bench science and in being present in the community. Earlier this spring, they welcomed the first scientist to be co-mentored through their collaboration. Lauren McLester-Davis (who goes by her Oneida name, Yowelunh) will study characteristics and markers of Alzheimer's disease in Native American populations.

Diabetes represents another overlap in Simcox and Gleason's work. It's one of the major risk factors for Alzheimer's disease, and metabolic dysfunction is closely tied to early changes in Alzheimer's patients.

"American Indian populations have a high prevalence of diabetes," says Gleason. "And a recent study found that American Indians and African Americans are the two groups at highest risk for Alzheimer's disease."

Gleason hopes that a better understanding of these relationships and statistics can lead to increased quality of care for all Alzheimer's patients. She also sees a role for the communities themselves — with Indigenous scientists as a vital piece of that puzzle.

"Collaborating with Indigenous scholars means there are people on the

team who have a bridging perspective intrinsically connected to their science," explains Gleason. "We want to work with these Indigenous scientists in ways that honor the different ways of knowing. It can't just be the Western scientists imparting Western knowledge; instead, we want to demonstrate an intercultural sharing of knowledge. To do this, we need to acknowledge and let go of our hubris as Western scientists. Many Indigenous scientists bridge these worldviews every day. They can mentor us."

In Simcox's view, the concept of two-way community engagement expands the Wisconsin Idea, the principle that the university should influence the lives of people beyond the classroom. She started her lab shortly before the pandemic hit, and those uncertain times broadened the meaning of the Wisconsin Idea in her mind. Not only were researchers sharing their findings and expertise beyond the walls of the university, but people in the community were reciprocating with questions, comments, and trust in the experts. For Simcox, it was another chance to connect.

"I get incredible emails from people in the community asking about their children with metabolic issues or for resources on treatments and vaccines," says Simcox. "We think a lot about what we give to the community, sure, but since being here, I've really seen what the community gives back to us. We all help each other."

Coe, the psychology professor emeritus from MIDUS, witnessed the Wisconsin Idea in action in his work with Simcox. He has nothing but the highest praise for the work she does, inside and outside the lab. "Judi fulfills the ideals of the university, and we are fortunate to have someone like her as a member of our faculty," he says. "She truly lives up to what former [Chancellor David Ward] once described as the university's mission: the creation and transmission of knowledge."

That knowledge grows out of challenging questions that Simcox continues to ask: How can connections with communities lead to better health care for all? How can diversity improve the process of science and its outcomes? Years after that formative high school assignment, she now regularly asks many tough questions that don't yet have answers. She knows it will take many people — and many years — to find some of them. And she knows that, with more diverse voices asking the questions, it becomes more likely the answers will serve everyone.

"Judi has always said how important it is for science and academia to have a structure that promotes support for under-represented groups, such as Indigenous communities and first-generation students," Davidson says. "She is very adamant about putting in place programs that will exist beyond our timeline so that these structures can continue for many years."

As she continues to study, experiment, mentor, and inquire, Simcox is working to ensure that future generations, and those excluded in the past, will have the opportunity to ask questions, find answers, and make the lives of all communities better. **9**





This summer marks 175 years since the founding of the University of Wisconsin, the state's very first public university.

Throughout this time, UW has led the way in everything from groundbreaking research discoveries to defining cultural movements.

The UW-Madison campus will honor these historic moments as part of a yearlong celebration beginning on July 26, 2023, which is 175 years to the day since the university was established. Programming will run through May 2024, and you can stay up to date at 175.wisc.edu.

CALS will be making its own contributions to this important occasion, and highlights of the college's rich history will be included here in the pages of Grow.





The Agriculture Library Through the Years

By NIK HAWKINS

The official library for the study of agriculture at UW has been housed in three different locations on campus. Its original home was South Hall on Bascom Hill. Professor and pioneering dairy scientist **Stephen Babcock** committed his first paycheck to its founding in 1888. In 1903, the collection moved to what was then the recently constructed Agricultural Hall. A sign for the library is still etched into the building's north facade to this day.

In 1969, the library relocated to its own building on University Drive. Known as Steenbock Memorial Library, it's named for biochemistry professor **Harry Steenbock**. The library's benefactor, Babcock, was renowned for his butterfat test, a simple but accurate way to measure the quality of milk. But Steenbock was known for developing an inexpensive method of enriching foods with vitamin D, which led to the eradication throughout most of the world of the bone-deforming disease called rickets. About half of the funds for the library's construction came from royalties for research patents Steenbock had filed with the Wisconsin Alumni Research Foundation.

Today, as part of UW's General Library System, Steenbock serves CALS, engineering, botany, computer science, statistics, zoology, human development and family studies, consumer science, veterinary medicine, and the Division of Extension. It also houses the university's archives.

Men and women study in the College of Agriculture Library on the lower level of Agricultural Hall.

Far left, top: Steenbock Memorial Library was built in 1967 as the College of Agriculture Library. This image shows the front entrance under construction on Babcock Drive.

Photos courtesy of UNIVERSITY OF WISCONSIN-MADISON ARCHIVES

Far left, bottom: The BioCommons at Steenbock Memorial Library hosts a STEM majors fair in 2019.

Photo by MICHAEL P. KING

From Pesky Weed to Biofuel Resource

With gene editing, a team of scientists co-led by bacteriology alum Nancy Reichert could turn a fast-spreading grass into a major energy boon.

By GEORGE SPENCER

It may be time for corn to take a back seat. This most widely used and cheapest source of ethanol could lose its top spot to miscanthus, a sun-loving, reedy grass that has the potential to become a go-to plant for biofuel, renewable chemicals, and carbon sequestration.

Nancy Reichert BS'79, a biology professor at Mississippi State University, and a team of researchers unlocked this perennial's potential by editing miscanthus genes to knock out or change their function. This success opens the door to future advances. New genes that make further beneficial modifications can now be inserted at precise points in the miscanthus genome.

"There were a lot of head-banging moments that I didn't know would happen. Science has a way of humbling you. I was humbled many times," says Reichert, the past president of CAST, the Council for Agricultural Science and Technology. "But you chip away at it until you solve that problem. I never lost hope that it could be done."

The perennial plant, which can grow 8 feet high each year, has long intrigued researchers. Easy to grow, adaptable, tolerant

of drought and cold temperatures, miscanthus also thrives in poor soil. But there had been one big problem. Many states regard fertile miscanthus as a weed and have barred it from commercial use. Reichert's gene-editing achievement has special significance — it marks the first time scientists have edited the genes of both the fertile and sterile species and lines of miscanthus.

"We've laid the groundwork for miscanthus to become a viable crop, probably in the next five to 10 years, because we can genetically improve sterile miscanthus, and dedicated plant breeders can also generate new lines of sterile miscanthus," she says. "It can only make clones of itself through underground runners, called rhizomes, which are a lot easier to control than seeds that are so tiny you can never capture them."

The research took place under the auspices of CABBI, the Center for Advanced Bioenergy and Bioproducts Innovation, a network of Department of Energy-funded research centers, where Reichert is a co-principal investigator at Mississippi State. UW has a similar federally funded endeavor, the Great Lakes Bioenergy Research Center, housed at the Wisconsin Energy Institute and operated in partnership with Michigan State University.

Reichert has long marveled at the resilience of plants. "It's so fascinating that they can survive, given everything that's thrown at them," she says. "In my research, we're helping ourselves by generating 'ideal' biomass plants for production and harvest, and we're helping the plants by introducing resistance to stresses or diseases that makes it easier for them to grow."



■ ENGAGE

JOIN THE STATE TOUR IN HONOR OF UW'S 175TH



UW is turning 175 this summer! Catch the anniversary celebration and share your Badger spirit when the state tour rolls into a town near you. Highlights include fun family activities, complimentary Babcock ice cream (including the unveiling of a special commemorative flavor), games, giveaways, a UW-themed trivia contest, music, and more. Find additional details at 175.wisc.edu/state-tour.

■ ACCOLADES

HIGHEST HONORS IN SCIENCE

Jo Handelsman PhD'84, professor in the Department of Plant Pathology at CALS and director of UW's Wisconsin Institute for Discovery, has been elected to the National Academy of Sciences. Membership is a widely accepted mark of excellence in science and is considered one of the highest honors that a scientist can receive. Handelsman, a molecular biologist whose scholarship includes transformative studies in microbial communication and metagenomics, holds

23 patents and has served as associate director for science at the White House Office of Science and Technology.

FARMING EXCELLENCE

Kyle and Rachel Zwieg (both FISC'07, '08) of Ixonia, Wisconsin, were among four couples named National Outstanding Young Farmers at the National Outstanding Young Farmers Awards Congress, hosted by the Wisconsin chapter in Appleton in February 2023. The Zwiegs were also named Wisconsin Outstanding Young Farmers in 2022.

Her miscanthus breakthrough builds on her earlier gene transfer research with kenaf, a close relative of cotton. "Decades ago, we tried using it to tap into the bioenergy market, but the market and processing infrastructure didn't exist. Miscanthus came along, and I applied all the tools and methods on it that I used on kenaf," says Reichert, who is also a fellow in the Society for In Vitro Biology. "Kenaf was so much easier to work with than miscanthus. The species, especially the sterile ones, are prima donnas and a pain in the butt to work with in the lab, but we persist."



Reichert's love of plants began as a child when she played in the forest at her grandparents' 40-acre dairy farm near Manitowoc, Wisconsin. She had dreamed of becoming a nurse, like many of her female relatives, but that hope crumbled at UW due to her fear of needles. By chance, in 1976, she took a course called Elementary Bacteriology taught by **Kenneth Todar**, now senior lecturer emeritus.

"It was serendipity. It changed my life," she recalls. "A lot of the techniques I learned in those labs at UW I still use to this day. I'm a confirmed lab rat. I enjoy the outdoors, but give me a lab, a lab coat, and the equipment I need, and I'm just a happy kid. I love working in labs. It's the meticulous work that I really enjoy."

More than 40 years later, **John Kemp**, then a professor of plant pathology at CALS, remembers how Reichert stood out. "When she was an undergraduate working in my lab, I recognized that she was really brilliant," he says. "I've been very, very proud of her."

Unable to find work after graduation in food quality control, Reichert's career got an early boost when Kemp hired her to

work as a lab technician at Agrigenetics Advanced Research Lab, a small start-up biotech company in Madison.

At the time, researchers were racing to perfect gene-transfer technology. Agrigenetics became the world's first company to confirm that a gene taken from one plant could work in another plant that diverged from it evolutionarily millions of years ago.

"That was heavy stuff. It was absolutely amazing what we were able to accomplish," says Reichert. Then, when Kemp took a post at New Mexico State University, Reichert went as well. She earned her Ph.D. in molecular biology there, and Kemp was her thesis advisor.

For eight of her 33 years at Mississippi State, Reichert chaired the biology department. Besides overseeing a \$12 million building renovation, she helped secure \$1.6 million in new donations and boosted the number of undergraduates declaring majors in the department by 200.

Of her career, she says, "It's been one surprise after another. It's been total serendipity. I never went out and said, 'Hey, I'm gonna do this, and I'm gonna persist.' Things have come to me. It's just, like, wonderful chance. Then the hard work begins — to prove I'm worthy of it."



Left: Nancy Reichert in the growth chamber of her lab at Mississippi State University. Photo by MEGAN BEAN, Mississippi State University

Right: Sterile miscanthus grows in a research plot at Mississippi State University. Photo by BRIAN BALDWIN

Research Fellowship Aims to Diversify the Brewing Industry

By PEYTON MUELLER BSx'24

Photo by MICHAEL P. KING

"There's so much more that goes into brewing beer than just the ingredients," says **Tony Bugher**, president of the Jacob Leinenkugel Brewing Company. The people involved, and the groups they represent, he explains, are absolutely critical to the whole process.

This is why, in 2021, the brewery established the Jake Leinenkugel Diversity in Brewing Award, to create a pathway for diverse communities to enter the industry. The award provides an undergraduate research fellowship for a UW student each year.

"We chose UW—Madison because the university is synonymous with Wisconsin, just like Leinenkugel's," Bugher says.

Leinenkugel's was founded in 1867 in Chippewa Falls, which is still home to the company's main brewery. Their German-inspired beer has been enjoyed for more than 150 years, but the company is aiming to create new opportunities in the field of craft brewing.

Endowed by a \$50,000 donation from Molson Coors, the parent company of Leinenkugel's, the award is open to students from the Latino, Black/African American, American Indian, Asian, Pacific Islander, and LGBTQ+ communities. By offering a unique research fellowship, Leinenkugel's is hoping to attract underrepresented students to the industry, Bugher says.

Babayosimi (Simi) Fadiran BSx'24, a microbiology major, is the first recipient of the award. "I thought [the award] would give me a really good opportunity to figure out what it takes to do research, understand how long it takes, the resources needed, and everything else," he says.

For his fellowship, Fadiran worked in the lab of assistant

professor of food science **Victor Ujor** during the summer of 2022. This gave Fadiran exposure to fermentation science, the basis for brewing, through research on transforming fermentation waste into usable products. Specifically, the lab explores how to convert whey, a cheese byproduct, into succinate acid by genetically modifying the bacteria involved in fermentation. This acid can be used as a flavoring agent or in bioplastics and food processing. Fadiran's role included coupling genes, an essential part of engineering microorganisms.

"The work is still going on, but [Simi] helped provide a building block," Ujor says.

The Department of Food Science houses the Leinenkugel's award, and Ujor's lab hosts the fellowship. This summer, the next Leinenkugel's fellow will focus on brewing beers with different types of grains.

Outside of the lab and classroom, Fadiran pursues a host of activities. He's part of the UW club ultimate frisbee team, plays cello in the All-University String Orchestra, and volunteers at the Madison Boys and Girls Club. Although brewing is not on his radar at this time, he says the chance to work in Ujor's lab solidified that he wants to continue his path in science.

"This experience opened my eyes in terms of what it takes to do research," Fadiran says. He came away with lab proficiencies and techniques that he will carry into his graduate work and career. Fadiran is planning to study either pathology or infectious disease through a joint MD/Ph.D. program, and during his upcoming junior year, he will join a pathology lab in the UW School of Medicine and Public Health.

"Simi picked up the skills he needed to work with very quickly," Ujor says. "This award is going to make a real contribution long term to the industry, to the lives of the students, and to the lab."

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Rohan Shivkumar uses calipers to take measurements during a lab exercise in which students examined and identified canid skulls in Noland Hall in July 2022. The activity was part of a CALS Summer Term course called Animal Sciences 240 Ancient Animals and Peoples.

Photo by MICHAEL P. KING