FALL 2022

grow

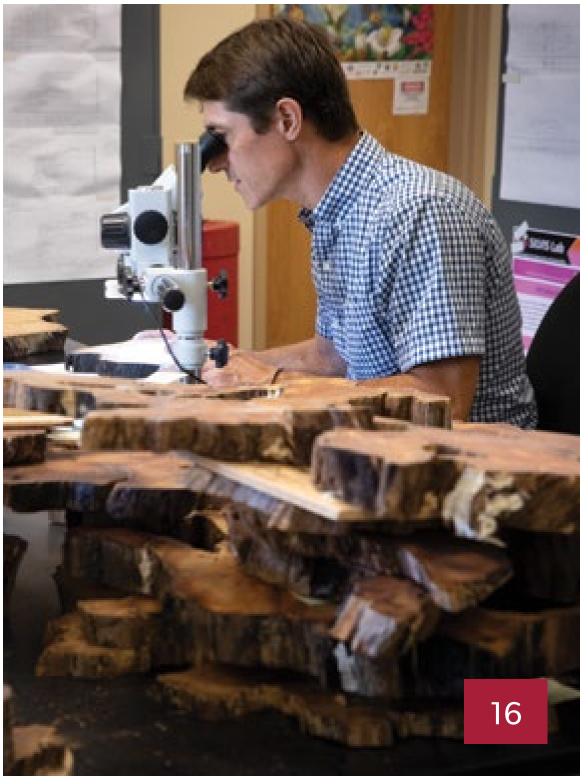
College of Agricultural & Life Sciences
University of Wisconsin–Madison

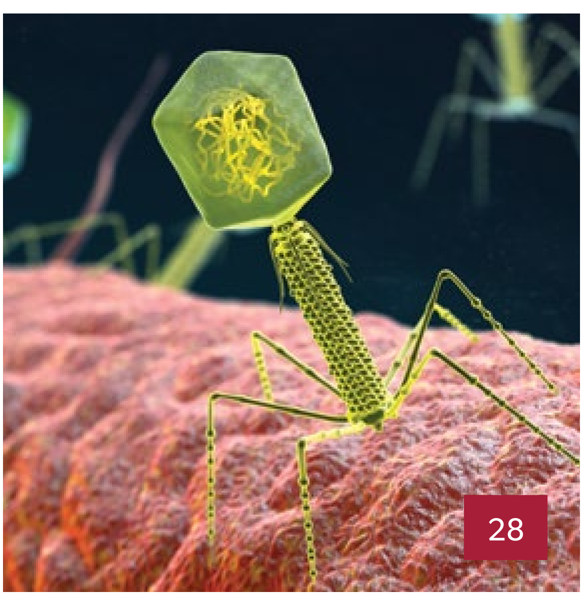
COLD-HARDY CRANBERRIES

PAGE 20

+
PHAGES VS. SUPERBUGS
FIRE HISTORY REVISITED
ECO-FRIENDLY INSECTICIDE
KESTREL CONSERVATION

Students from horticulture professor Irwin Goldman's lab use a stretcher made of a tarp and wooden stakes to transport pumpkins from a field to the trailer that will take them back to the UW campus in October 2021. They were gathering the huge gourds for use in the Giant Pumpkin Regatta, an annual event in which contestants convert pumpkins into boats and race them on Lake Mendota. See a photo story about the event at **go.wisc .edu/regatta-2021**. Photo by ALTHEA DOTZOUR





Wisconsin's Magazine for the Agricultural and Life Sciences

grow

VOLUME 16, ISSUE 1 | FALL 2022

FEATURES

DEPARTMENTS

ON THE COVER Cranberries encased in ice and frost. CALS scientists and their partners are developing cold-hardy varieties of this native fruit crop. Read the cover story on page 20. Photo by MICHAEL P. KING

Photos, from top, by MICHAEL P. KING (2) and iSTOCKPHOTO.COM/iLEXX

Photo by MICHAEL P. KING

DEAN GLENDA GILLASPY

An Introduction

Greetings, readers of *Grow* — my fellow lovers of the agricultural and life sciences! Welcome to the fall 2022 issue. It's my honor and privilege to be sending you this message through our magazine. But it's my first time "here," so it seems only proper that I should tell you a little bit about myself and how I plan to work with others to promote excellence in CALS.

As some of you already know, I became the new dean of the college in August. I come to UW from Virginia Tech, where I was a professor in the Department of Biochemistry for 24 years, the last seven of which I served as chair. Like the biochemistry department here at CALS, my former academic home at VT was also housed in the university's College of Agricultural and Life Sciences. And VT, like UW, is also a land-grant college, with a tripartite mission of research, education, and extension. So, while my geographical setting has changed, I find myself in familiar territory in terms of college and institutional goals.

My research has mostly focused on phosphate signaling in plants, and it could be described as both basic and applied. On one hand, I explore how plants communicate. But I also investigate methods for remediation of phosphate, which is a serious pollutant that sometimes results from agricultural activity.

That's a little about my academic interests. But, to help you get to know me, I want to tell you more about where I typically spend my time and energy.

Throughout my career, I've placed a heavy emphasis on undergraduate and graduate education. At VT, for example, I helped lead efforts to modernize the curriculum, and I worked on a teaching and mentoring initiative aimed at diversifying the scientific workforce. Outreach and extension (vital parts of the storied Wisconsin Idea here at UW) have also been top priorities of mine. I'm proud to have been involved with high school outreach programs that help young scholars find their love of science early. I also helped create a federally funded partnership that gives undergrads a chance to interact directly with farmers and connect basic science in the lab with applied science at agricultural research stations.

That's some of the background I bring with me as I step into this new role. And I'm excited by what I see here. My predecessor, **Kate VandenBosch**, stepped down from the deanship following a decade at the helm of the college, and CALS accomplished a great deal under her leadership. I now find myself in a truly exceptional place rich with possibilities, looking to carry on in the college's tradition of success.

CALS has a stellar overall reputation. It's renowned for its research, and there's a willingness to innovate in education here. I see talented and experienced leaders throughout the college's departments, centers, and units. This includes a new team focused on diversity, equity, and inclusion that is committed to making CALS an even more welcoming place. The college also benefits from the strong support of its alumni, donors, and other stakeholders throughout the state. And I could go on.

Many of these strengths, highlighted in the pages of this magazine, dovetail with my past efforts and with the areas where I hope to focus and collaborate as dean of CALS. How that focus and collaboration happen will be decided and refined as I spend my first weeks and months on campus listening and learning. That includes hearing from students, faculty, and staff but also alumni, donors, representatives of industries connected to CALS, and other members of our college community. I look forward to your thoughts and ideas.

EDITORIAL STAFF

Managing Editor Nik Hawkins

Writers Nicole Miller MS'06, Caroline Schneider MS'11, Jori Skalitzky BS'22

Designer Janelle Jordan Naab

Photographer Michael P. King

Editorial Assistant/Writer Aspen Oblewski

CONTACT

136 Agricultural Hall, 1450 Linden Drive
Madison, WI 53706

Grow 608-890-3912, grow@cals.wisc.edu
grow.cals.wisc.edu

CALS 608-262-1251, info@cals.wisc.edu
cals.wisc.edu

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN–MADISON

Six Facts about Antioxidants You Won't Learn from Advertising

By BRAD BOLLING BS'02, PhD'07

It's hard to walk through the grocery store without encountering at least one product that touts the health benefits of antioxidants. Marketed as the enemy of "free radicals" (those sometimes pesky molecules that can damage cells by causing oxidative stress), antioxidants are commonly found in fruits, vegetables, nuts, whole grains, and fish, among other foods. "Antioxidant" is also a marketing buzzword printed on labels for everything from soft drinks and supplements to frozen fruits and flu relief. But what are antioxidants, really? What's the science behind their benefits? And can there be too much of a good thing? Here are some answers.

1. Some antioxidants are essential, others are a bonus.

Many types of food components can act as antioxidants, but only a few are essential. The human body needs the essential ones but can't produce them on its own, which means they need to be acquired through dietary sources. The essential antioxidant nutrients include vitamins A, E, and C and certain carotenoids (red, orange, and yellow organic pigments), such as provitamin A. These antioxidant nutrients are needed to support life. They help prevent oxidation, which can cause damage in cell DNA, lipids, and proteins. Some micronutrients, such as selenium, are needed for the function of antioxidant enzymes in cells. Other dietary antioxidants include natural colors, tannins, lipids, and peptides.

2. Non-nutrient antioxidants can also affect the human body.

In addition to preventing oxidative stress, essential antioxidant nutrients have regulatory functions and are involved in maintaining other biological processes. Similarly, nonessential antioxidants may have direct antioxidant effects, but it is likely that their non-antioxidant functions are more important. These actions include inducing cellular antioxidant defenses; changing the gut microbiota; and inhibiting enzymes and cell-signaling processes relevant to inflammation, cancer, cardiovascular disease, and other chronic diseases.

3. You can have too many antioxidants.

There is an optimal level of antioxidant consumption — too little yields no benefits, and excessive consumption could lead to toxicity or increased risk of cancer. Usually, this would mean taking high levels of dietary supplements or excessive levels of specific antioxidant-rich foods. Overconsumption of green tea extract can be toxic, and antioxidant supplementation is not advised during certain chemotherapy treatments because some drugs work by inducing oxidative stress in cancer cells. Also, some antioxidants may interfere with the absorption and metabolism of certain therapeutic drugs.

4. It is hard to say how many non-nutrient antioxidants you should consume.

While we have dietary recommendations for nutrient antioxidants, it is difficult to give precise guidance for the amount of non-nutrient antioxidants needed to improve health. We know most people in the U.S. do not eat enough antioxidant and nutrient-dense fruits, vegetables, nuts, and whole grains. Increased consumption of these foods is associated with reduced risk of some cancers and heart disease. However, the chemical complexity of antioxidants, limited understanding of their distribution in foods, and limited evidence from human intervention studies prevent precise intake recommendations.

5. The way you absorb and metabolize non-nutrient antioxidants is unique.

There's a high degree of variability in how individuals metabolize dietary polyphenols (plant-based nutrients). Age, diet, gut microbiota, and expression of metabolizing enzymes affect how these compounds are extracted from foods during digestion, broken down, and transformed to be more easily absorbed or excreted. Scientists, including several research groups at UW–Madison, are still working to understand how all of this affects the health-promoting properties of antioxidant-rich foods.

Curious about #6? Visit **go.wisc.edu/grow-antioxidants** to learn how antioxidants help reduce food waste.

Brad Bolling is associate professor in the Department of Food Science and the Fritz Friday Chair of Vegetable Processing Research.

Illustration iSTOCKPHOTO.COM/ROBUART, /MARHARYTA MARKO

ELIAS KEMNA

Run, Research, Repeat — Until There's Food for All

A microbiology major and Goldwater Scholar looks to use his skills in the lab to help feed a growing population sustainably.

By CAROLINE SCHNEIDER MS'11

Photo by MICHAEL P. KING

Elias Kemna BSx'23 is on track in his college career, and in more ways than one. First, he's a member of the Wisconsin Track Club, where he enjoys running and spending time with his fellow "cows," as he calls his teammates due to their bovine mascot. But Kemna is also on course when it comes to his academic pursuits. He recently won a prestigious national scholarship, and he's worked in three labs since high school, with research spanning topics from enzymes to soil microbes.

Kemna, a senior working toward a degree in microbiology and a certificate in global health, found his research interests early. While attending high school in McFarland, Wisconsin, he participated in the Dane County Youth Apprenticeship Program, which gave him the opportunity to conduct research in the lab of biochemistry professor **Brian Fox**.

"Eli was a highly valued member of our research team," Fox says. "His consistent contributions while he was an intern offer a great example of how effort and engagement can lead to great steps forward."

Those steps carried Kemna into his freshman year at UW, where he discovered his interest in promoting food security. Food security means having access, both physically and economically, to a sufficient amount of food for a healthy life.

"Starting in high school, I became fascinated with the hidden half of nature," Kemna says. "During my first semester, I participated in a first-year interest group focusing on global food security, and I became interested in the role of microbes in food security and agriculture. Researchers are finding ways to use microbes to provide plants with nutrients and decrease the need for fertilizers. They're also studying microbes that live symbiotically with plants that could increase plant yield and resilience."

Always pushing to stay in the fast lane, Kemna joined the soil microbial ecology lab run by **Thea Whitman**, assistant professor of soil science, for his freshman and sophomore years. He studied the interactions of soil microbes and compounds called pyrogenic organic matter, which are created during wildfires. And in summer 2022, Kemna took on a new project in a functional genomics lab at the University of Nebraska–Lincoln, where he used CRISPR genome editing technology to study the genetics of algae commonly used in research.

"From my research, I have learned how much I don't know. The vastness of nature is humbling — and inspiring," Kemna says. "I have also learned the importance of failure. It's to be expected, not dreaded, and it's a necessary part of learning."

In the midst of classes, research, and running, Kemna also found time to apply for and receive a Barry Goldwater Scholarship. The award is one of the most prestigious in the country for undergraduates studying the natural sciences and gives winners in their junior year up to $7,500 for their senior year of study.

"The amazing undergraduate academic awards staff at UW–Madison actually reached out to me to make me aware of this award," explains Kemna. "It is an honor to be considered part of such a talented group of student researchers."

The Goldwater Scholarship Program encourages students to pursue research careers in science, and that's just what Kemna intends to do. After graduation in spring of 2023, he plans to take a gap year and then start graduate school.

"I hope to do research," says Kemna, "and develop agricultural biotechnology that will help farmers be more sustainable, be better able to handle the challenges of climate change, and meet the demands of a growing population."

Photo by MICHAEL P. KING

Renewable Fuel Policy Refresh?

A Grassland 2.0 study shows a federal program designed to help combat climate change spurred the conversion of grassland into cropland, with unintended consequences.

By ALEX STEUSSY-WILLIAMS MS'18

Reducing greenhouse gas emissions is a critical step in mitigating climate change. One way to do this is to expand renewable fuels, which can also decrease reliance on imported oil. That was the intent of the U.S. Renewable Fuel Standard (RFS) Program, created by Congress in 2005. But a recent study of the program's impact shows it may have backfired, and additional policy changes are needed to get it back on track.

The study was conducted by researchers at UW–Madison and several other universities, including faculty and staff from CALS and Grassland 2.0 — a diverse group of scientists, farmers, and professionals that studies and facilitates conversation around grassland-based agriculture. The team found that the greenhouse gases stemming from corn ethanol actually negate any of its advantages over gasoline. Why? The RFS policymakers did not predict the full-scale impacts of the land-use change that would result from its implementation — mainly more corn and less carbon-storing grassland.

"Any time you drive up demand for commodity crops like corn and soybeans, you're going to stimulate more of those crops on our landscapes," says study coauthor **Tyler Lark**, a lead scientist at UW's Center for Sustainability and the Global Environment and Grassland 2.0 collaborator. "Alternatively, policies that support grassland-based agriculture could help sustain our rural economies while also enhancing carbon sequestration, water quality, and wildlife habitat."

The research team used data-driven analyses and explanatory modeling based on actual observations of changes in crop prices and land use. They found that, during the first eight years of the policy's implementation (2008 to 2016), the RFS led to a 31% increase in corn prices. This increase spilled over to other crops, driving a 19% increase in soybean prices and a 20% increase in wheat prices. The result? Incentives arose to plant more corn, grow more continuous corn, and devote more

> “…THE CONVERSION OF GRASSLAND TO CROPLAND SPURRED BY THE [U.S. RENEWABLE FUEL STANDARD PROGRAM] LED TO MORE SOIL CARBON LOSS…"
>
> – Eric Booth

land to crops. The RFS incentivized corn and disincentivized grasslands, such as pasture and land enrolled in the federal Conservation Reserve Program, which pays farmers to maintain environmentally sensitive agricultural lands as perennial vegetation.

The increase in corn production correlated with a 3–8% increase in annual fertilizer use, which, in turn, increased water pollutants by 3–5%. Studies show that the transition to more corn and less grassland also means less carbon storage on the landscape. And research from Grassland 2.0 demonstrates that grassland and well-managed pasture store more carbon than annual row crops, thereby helping to mitigate climate change.

“One of the main arguments for the RFS at its inception was its potential to reduce greenhouse gas emissions,” notes **Eric Booth**, a scientist in the Department of Agronomy. Booth is a coauthor on the paper and a member of Grassland 2.0’s grassland modeling team. “Unfortunately, as some initial critics suspected, the conversion of grassland to cropland spurred by the RFS led to more soil carbon loss; and additional corn acres, which require high levels of nitrogen fertilizer, released even more greenhouse gases. On top of that, land converted to crops, which tended to be more marginal, is much more susceptible to erosion and nutrient loss. Our models, grounded in real-world observations, were able to capture these important processes.”

The Grassland 2.0 study adds to the discussion on the types of public policy needed to support the nation’s food, energy, and water needs. The research team contends that the study also provides critical evidence that policies incentivizing perennial grassland such as well-managed pasture can be a critical step to reducing greenhouse gases while meeting those needs.

The Environmental Protection Agency is scheduled to release proposed RFS requirements in November 2022; the CALS and Grassland 2.0 team published their results just in time for them to be part of the discussion. As Lark notes, “Decisions made this year have the potential to impact our climate and landscape for decades to come.”

EXPLORE ONLINE

Learn more about Grassland 2.0 and its research on grassland-based agriculture at **grasslandag.org**.

What do you think of our new look?

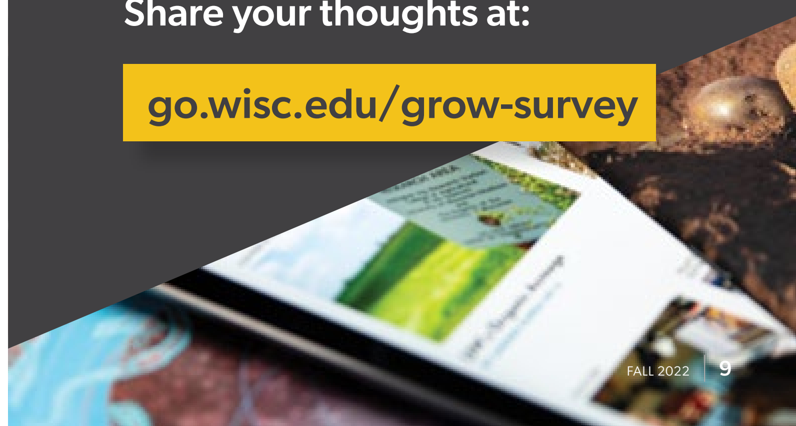
grow

Back in fall 2021, we unveiled a refreshed version of *Grow* magazine. We launched a new masthead, updated the fonts and color palette, retooled the content structure, and more. **And now we’d like to know what you think about it!** You can help us make sure we’re sharing the wonderful stories of the people and discoveries of CALS in the best ways possible. Please let us know your thoughts through our short online survey.

Your time and attention are highly valuable, so we would like to show our appreciation. Anyone who completes the questionnaire can be entered in a drawing for a **free gift box of Babcock Hall cheese!**

Share your thoughts at:

go.wisc.edu/grow-survey



Sweet Solution

UW food scientists are turning a Greek yogurt offshoot into something more saccharine — and potentially more profitable.

By JORI SKALITZKY BS'22

Greek yogurt is a relatively recent food fad in the U.S. But its unique taste and thick texture appeal to many, and it accounted for as much as 51% of the nation's retail sales of yogurt in 2021. To satisfy hungry customers, Greek yogurt production has increased, but so has a byproduct stemming from this creamy creation, one without much value. It's called Greek yogurt acid whey, or GAW, for short.

Every pound of Greek yogurt produces about two pounds of GAW, so it poses a significant disposal dilemma. But GAW could be a boon rather than a burden. A UW research team believes they have discovered a way to turn this byproduct into a coproduct — something of value produced alongside another output — by modifying the lactose in Greek acid whey and creating a dairy-derived sweetener syrup.

Greek yogurt is made by adding yogurt cultures to milk and allowing fermentation to occur. The milk-turned-yogurt is then strained and concentrated, which removes a yellowish, acidic whey liquid. This is GAW. Its low protein and mineral content (relative to whey produced from cheese) are unappealing to manufacturers, so the most economical fate for GAW has been to discard it. It's often spread onto farmlands or sent to wastewater treatment facilities, but its high acidity can decrease soil productivity and pollute the environment in the form of runoff.

However, nested away in GAW is lactose, a natural sugar associated with that infamous ailment lactose intolerance. The prevalence of lactose intolerance has made lactose an unattractive ingredient for food companies. But other sugars, such as glucose and galactose, are much more marketable.

"We can take lactose and very easily turn it into something that actually has a lot of functionality and value," says **Scott Rankin**, professor and chair in the Department of Food Science and part of the research team. "[The GAW syrup] would be a true coproduct for Greek acid whey and a commodity that people could sell."

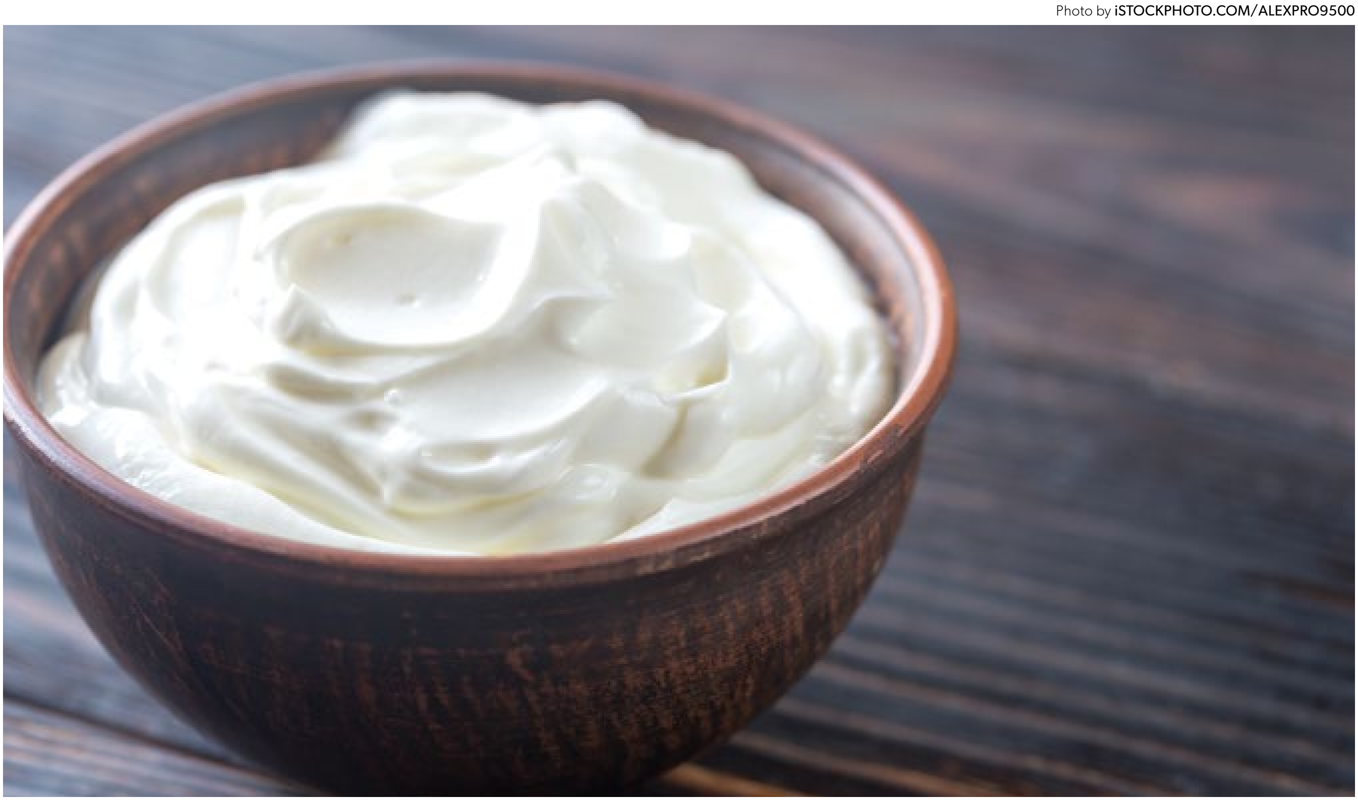
Rankin and coinventors **George Huber**, a chemical and biological engineering professor, and chemical and biological engineering graduate student **Mark Lindsay**, devised a process for producing a glucose-galactose syrup (GGS) — what the researchers are calling a "dairy syrup" — from lactose. And they do this with the help of catalysts.

To transform GAW into GGS, it first needs to be filtered and purified. Then an acid catalyst is applied, which breaks lactose into two different sugars — glucose and galactose. This process is spurred by hydrolysis, a reaction that takes place in the presence of water, and the initiating catalyst. The mixture is filtered once more and then concentrated to form a syrup.

Instead of becoming a waste product, innovation has helped transform GAW into something useful. With a sweetness similar to corn syrup, GGS could be used in many food products, from soda to baked goods to ice cream, just like any other sweetener.

"I think we can be the leaders in developing this new type

Photo by iSTOCKPHOTO.COM/ALEXPRO9500



of dairy sweetener for the market from these underutilized dairy products," says Huber. "We are creating value from dairy waste products that are produced today."

The application of catalysts is new to the food industry, but there are endless opportunities.

"We could deploy this technology against just milk, ice cream, cheese — so lactose malabsorption is not an issue with dairy products," says Rankin. "I see the potential to expand this type of technology to a very broad application in the dairy world, so more people can consume dairy."

For now, the team is working on expanding from the lab into the real world with the help of **Jarryd Featherman**, a technology development lead in the UW Department of Chemical and Biological Engineering, and the Center for Dairy Research at CALS. Together, they are scaling up the technology to produce larger quantities of GGS. Potential manufacturing partners will soon be able to test out the syrup with their products — and hopefully bring this sweet solution to stores.

"Companies have spent a lot of time and resources trying to figure out a profitable way to deal with [production] waste, but no successful method has been implemented to our knowledge," Featherman says. "The thought of our technology filling that gap and providing a new revenue stream to the dairy industry — while also improving the industry's environmental footprint — is what keeps me motivated to bring this technology to market."

For with Much Wisdom Comes Much

CHEESE

Ace our Final Exam and you could win a gift box of cheese from the Babcock Hall Dairy Store! Test your CALS knowledge at **grow.cals.wisc.edu**.

Photo by MICHAEL P. KING

FOLLOW-UP

CRAFT CIDER RESURGENCE RESUMES

By SUSAN LAMPERT SMITH BS'82

In "Craft Cider's Comeback" (*Grow*, Fall 2018), **Nicole Miller** MS'06 introduced Brix Cider owners **Marie** MS'10 and **Matt** MS'10 **Raboin** at an apple grafting workshop hosted by the Center for Integrated Agricultural Systems at CALS.

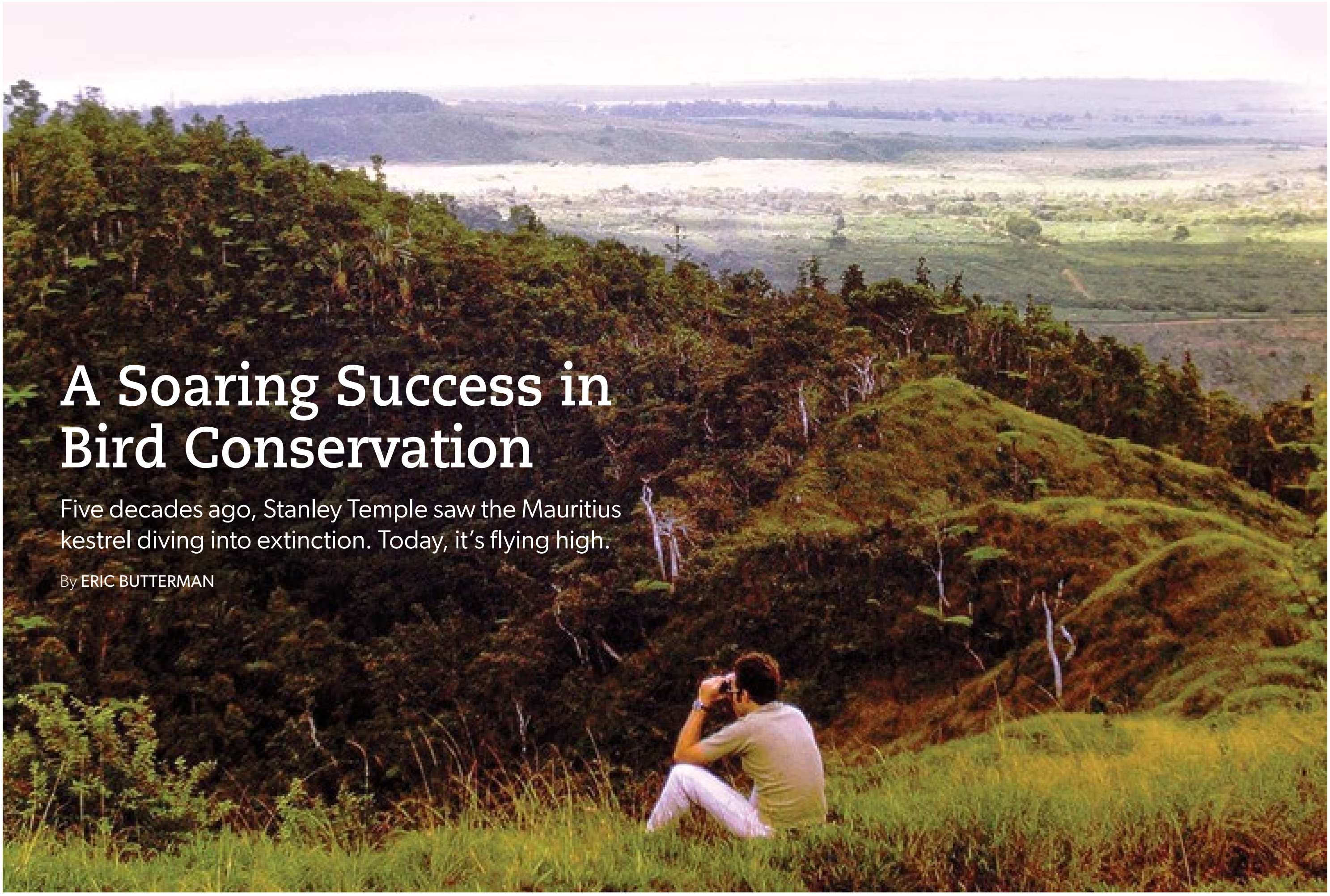
Since then, their dream of opening a cidery and restaurant has come true. If you bike through Mount Horeb, Wisconsin, on the Military Ridge State Trail and see a crowd eating local sausage pizza and drinking hard cider, you've found Brix. On summer Thursdays, the outdoor stage hosts open mic nights, and on Wednesdays, the Small Batch Science series features CALS graduate students talking about topics ranging from rotational grazing to agroforestry.

After opening in early 2019, Brix survived a rocky first year and had just turned the financial corner when COVID hit. Brix shut down its storefront and pivoted to grocery pickup and delivery for locally sourced produce, meat, and other products.

An unexpected benefit of this new business model: closer ties to local farmers and producers. These new relationships led to The Brix Project, a collaboration between Black Krim Creative and UW to showcase local farms. They've produced 12 short documentaries and hosted "Crash the Kitchen" dinners in which local producers and chefs create three-course dinners from local foods they find in the Brix kitchen.

Meanwhile, the Raboin family, which includes **Teddy**, 7, and **Vera**, 4, bought the historic Donald farm south of Mount Horeb and are planting a new orchard there. Things finally settled down in 2022, allowing Matt to take a week to travel to Poland as a volunteer cook for Ukrainian refugees with World Central Kitchen.

"It feels like we finally have time to have a normal family life," Matt says.



A Soaring Success in Bird Conservation

Five decades ago, Stanley Temple saw the Mauritius kestrel diving into extinction. Today, it's flying high.

By ERIC BUTTERMAN

[Above] Stanley Temple scans the remnant native forests of Mauritius for the last few kestrels in 1972.

Photo courtesy of STANLEY TEMPLE

A Mauritius kestrel (*Falco punctatus*) adult perches on a branch.

Photo by iSTOCKPHOTO.COM/NEIL BOWMAN

You could say **Stanley Temple**'s life has been for the birds. His interest in all things avian was nurtured at a young age by his mentor, **Rachel Carson**, the author of the seminal environmental book, *Silent Spring*. It continued into graduate school — and then beyond.

Just before he finished his Ph.D. in ecology at Cornell University in 1972, Temple would receive a fateful phone call from **Dillon Ripley**, who at the time was president of the International Council for Bird Preservation. Years before, Temple had sent the council a report he authored that reviewed the world's endangered birds of prey and how to save them. Ripley remembered it. And when he received a gift earmarked for conservation work on the rarest birds in the world, he decided to ask Temple if he would like to put his ideas into practice.

This opportunity would take Temple to Mauritius, a remote island in the Indian Ocean, about 700 miles east of Madagascar. The island was once the home of the dodo, perhaps the most famous bird that has gone extinct. Temple was looking to achieve a better outcome this time.

The bird he hoped to save was the Mauritius kestrel, about the size of a pigeon, reddish in color with a great deal of barring on its back and numerous spots on its breast. It had evolved into a forest predator, its primary prey being endemic geckos. By the late 1960s, Temple says, it was considered the rarest bird in the world.

"After I got there, my fieldwork could only account for seven of the birds," says Temple, who is the Beers-Bascom Professor Emeritus in Conservation in the Department of Forest and Wildlife Ecology at CALS. "Some said trying to save the kestrel was a waste of time, that the bird was beyond hope. The rescue effort I launched would involve taking birds in captivity and starting a captive breeding program." Eventually that led to reintroducing birds back into the wild.

Temple worked in Mauritius from 1972 to 1975, and his efforts from 50 years ago are paying dividends today. According to **Vikash Tatayah**, director of conservation at the Mauritian Wildlife Foundation, there are roughly 400 Mauritius kestrels in existence; and, in March 2022, the country named the kestrel its national bird.

Like the kestrel, Temple continued to prosper following his work in Mauritius. He was hired by CALS in 1976 as professor of wildlife ecology and stayed there until his retirement in 2008.

"This was the first faculty position of its kind at any university when **Aldo Leopold** was named to it in 1933," Temple says. "Leopold introduced the conservation approach that we now call wildlife management. I've worked on projects involving many endangered birds, designing management programs to help them recover. It's been very rewarding work." None of the species Temple has worked on have gone extinct, and most are recovering.

Temple, who edited *Endangered Birds: Management Techniques for Preserving Threatened Species* and coauthored *Wisconsin Birds: A Seasonal and Geographical Guide*, has remained an active emeritus professor after retirement. He says his work for the Mauritius kestrel was just the start of the bird's decades-long turnaround, and that others contributed to its recovery over the years, including Welsh biologist **Carl Jones** and many dedicated people in Mauritius committed to the bird's continued success.

"It's because Stanley Temple was the one to point to the bird being in the most dire circumstances and, despite the negativity, did something about it," Tatayah says. "At the low point, there was only one single breeding pair in the wild. He had to make contacts with people all around here, dealing in other languages, thousands of miles away from home, but he was committed. To nurture all the relationships he needed to, now that's dedication."

> "SOME SAID TRYING TO SAVE THE KESTREL WAS A WASTE OF TIME, THAT THE BIRD WAS BEYOND HOPE."
>
> – Stanley Temple

Temple reflects on the course of his career and how it was inevitably linked with the fate of a bird once perceived as doomed. "I think it's fair to say that if the kestrel had gone extinct, in spite of my efforts, then most of what I went on to do with other endangered birds would never have been possible," he says. "I'm thrilled to see it doing well today. My love of birds started at an early age, and I feel fortunate to have been able to devote my career to helping keep the kestrel and other threatened birds around for others to enjoy."

NUMBER CRUNCHING

The Mauritius kestrel's flight path back from near extinction was long but successful. Around 50 years ago, only one breeding pair was known to be living in the wild. Today, there are around 400 of the kestrels in existence, according to the Mauritius Wildlife Foundation.

Images by iSTOCKPHOTO.COM/RAINER LESNIEWSKI, /M-REINHARDT

Americans Put Carbon on a Diet

Shifts in eating patterns, including less meat consumption, reduced the U.S. food-related carbon footprint by 35% in 15 years.

By JILL SAKAI

Photo by UNSPLASH.COM/SONNY MAURICIO

Every choice we make as consumers has a climate impact. It's often measured in terms of a "carbon footprint" — that is, the amount of greenhouse gases emitted in the process of producing a good or providing a service. This includes our choices related to food.

"Food accounts for 10 to 30% of a household's carbon footprint, with the higher proportions more typical of lower income households," says **Rob Anex**, a professor of biological systems engineering.

Globally, food systems contribute about one-quarter of all human-caused greenhouse gas emissions, says **Clare Bassi**, a recently graduated master's student in environmental studies who worked with Anex. That includes emissions associated with food production, processing, transportation, cooking, and waste. And different foods have very different environmental impacts.

"Meat products have large carbon footprints compared to vegetable and grain products," Anex says. "This is because of the inefficient conversion of plant material into animal energy. It also stems from the methane released from the management of animal manure and the enteric fermentation that takes place in the digestive systems of ruminant animals like cattle."

However, according to a recent study led by Bassi and coauthored by Anex, changing dietary

FINDINGS

Screen capture from YOUTU.BE/IXD-PKSXFQO

'SYMBEEOSIS'

In spring 2021, associate professor of entomology **Shawn Steffan** and members of his lab hosted film company Day's Edge Productions. The crew shot extensive footage of the lab's bee-microbe projects, including installed nests and other locations in the UW Arboretum and Allen Centennial Garden. The final production, a short film entitled "SymBeeOsis," was released earlier this year. It highlights the key role that microbes play in the lives of bees and offers insights into why these crucial pollinators are in decline. The film also features Steffan's collaborators at other universities. View the film at **go.wisc.edu/symbeeosis**.

patterns in the U.S. are leading to lower emissions of food-related climate-warming gases. And much of the reduction can be attributed to eating less meat.

The study explored how Americans' eating patterns — and their associated carbon footprints — have changed in recent decades. In just 15 years, the carbon footprint of the U.S. diet fell by more than 35%, mostly due to Americans eating less meat and other carbon-intensive foods. Lower consumption of beef, dairy, chicken, pork, and eggs accounted for more than 75% of the observed diet-related carbon dioxide savings during the study period; beef alone was responsible for nearly half of the drop.

"The trend is quite exciting," Bassi says. "Over the study period, national greenhouse gas savings from dietary changes alone is roughly equivalent to offsetting emissions from every single passenger vehicle in the country for nearly two years."

As an individual, sometimes it feels like you don't have much power to make positive change, Bassi notes. But the findings show that "our collective behavior changes are making a difference," she says. By choosing foods with a smaller carbon footprint, "you can feel empowered that you can reduce your impact in a significant way."

The researchers calculated greenhouse gas emissions based on individual daily diets reported by more than 39,000 U.S. adults in the National Health and Nutrition Examination Survey between 2003 and 2018. They looked at how the averages changed over time and also examined trends based on demographic factors, such as sex, age, household income, and race/ethnicity.

Every demographic subgroup analyzed showed a 30–50% reduction in diet-related greenhouse gas emissions during the study years. In general, females ate lower-impact diets than males. Females had an average food-related carbon footprint of about two kilograms of carbon dioxide emissions per person per day in 2018; for males, it was about three kilograms per person per day.

When the data were grouped by race/ethnicity, average carbon footprint was slightly higher among Hispanics than among non-Hispanic whites, and it was lowest among Blacks. In a breakdown by income level, diet-related carbon footprint was greatest in the highest income group (annual household income more than 1.84 times the federal poverty level, or about $46,000 for a family of four in 2018) and lowest in the lowest income group (annual income less than 1.3 times the poverty level, or $32,600 in 2018).

The lowest income group also showed the largest percentage reduction between 2004 and 2018 (46.4%), compared with 39.3% in the highest income group. When analyzed by age group, the youngest eaters showed the largest reduction in diet-related carbon emissions, with a 15-year drop of 47.2%.

"All of that saving is essentially from people eating less greenhouse gas-intensive foods," Bassi says. Calorie intake stayed steady over the years of the survey, and the analysis used constant values for emissions related to production and other systemic factors to focus just on changes due to eating patterns.

These positive trends are encouraging, she notes, but Americans are still exceeding their fair share of food-related emissions compared to other parts of the world. A 2019 scientific report from the international EAT-Lancet Commission identified global thresholds for diet-related greenhouse gases that would adequately feed the world's population while keeping global warming below 2° C by 2050. The average U.S. diet-related carbon footprint in 2018 was still nearly twice as high as the global targets.

"People's actions are making a difference," Bassi says, "but we still have a long way to go."

This study was published in March 2022 in the *Journal of Cleaner Production*.

FINDINGS

WHICH WINTER WHEAT?

The CALS agronomy and plant pathology departments have released the results of the 2022 Wisconsin Winter Wheat Performance Trials. Conducted each year along with cooperating farmers, the trials take place at four Wisconsin locations (Arlington, Chilton, Fond du Lac, and Waterloo). They include released varieties of wheat, experimental lines from university breeding programs, and lines from private seed companies. The trials are designed to help growers select the best-performing varieties for their specific goals and regions and to help breeders determine whether to release new varieties. Read the report at **go.wisc.edu/winter-wheat-2022**.

ONCE AND FUTURE WILDFIRES

Jed Meunier, a wildlife ecology alum and great-grandson of Aldo Leopold, is changing perceptions of bygone infernos and how to prevent them in the years ahead.

By SUSAN LAMPERT SMITH BS'82

Headline background photo by ISTOCKPHOTO.COM/DAVE ALAN

On a blustery spring day, Jed Meunier MS'05 and his team are climbing Wisconsin's Castle Rock bluff, searching for treasure. From the outside, the gnarled pine stumps look dull. But cut them open with a chainsaw, and they can reveal centuries of the state's fire history.

"It's like cracking open a geode," Meunier says. "You can't really predict what's inside."

Instead of looking for sparkly minerals when he takes them back to his dendrochronology lab at the Wisconsin Department of Natural Resources (DNR), Meunier seeks out the dark rings that tell the story of centuries past, including fire scars, formed when the trees attempt to heal their burns.

Fire ecologists know that these sandstone cliffs in the state's southwestern Driftless area are a good place to find the oldest pine relicts because they were too steep and rocky to be cleared for farming. Today, his search crew includes DNR scientist Bob Smail, UW–Platteville geography professor Evan Larson, and James Riser, a former DNR employee who works as a freelance researcher. Riser spots a likely "snag," a standing dead tree, on the next cliff, and the team sets off to cut a sample from it.

In 2014, Meunier found a stump in the nearby Snow Bottom valley that was a sapling in the 1600s. It now bears the scars of some of Wisconsin's big

[Far left] Jed Meunier, ecologist and research scientist with the Wisconsin Department of Natural Resources, takes a break while traversing the steep hills at Castle Rock, state-owned land near Montfort, Wis. Photo by MICHAEL P. KING

Aldo Leopold, circa 1940–1945, performs a controlled prairie burn at the UW Arboretum with a small group using mops to put out the fire. Photo courtesy of UW–MADISON ARCHIVES

wildfire years — 1754, 1805, 1891, 1895, and 1910. The later years are corroborated by newspapers and settlers' accounts. But before the settlement era, the trees themselves are the main historical record of the blazes that swept the land.

In northern Wisconsin, Meunier has found fire scars that link Wisconsin to one of the country's first reported massive fire events, known as "New England's Dark Day." On May 19, 1780, the skies of New England grew so dark that candles were lit at noon, and the preachers prophesied the end of the world. The cause was actually massive fires around the Great Lakes, where thousands of acres of forest were ablaze. Ash would follow, dropping like sooty snow across New England.

Meunier's research has also rewritten our understanding of what happened Oct. 8, 1871, when the Peshtigo fire roared up both sides of the Bay of Green Bay, killing as many as 2,500 people in the deadliest fire in American history. Generations of Wisconsin schoolchildren learned that the lumberjacks were to blame because they left behind piles of flammable pine slash. But it turns out the loggers were just scapegoats. The true story is more complicated.

Using land surveyors' records of "witness trees" and tree ring analysis from 659 fire-scarred trees from 25 sites in Wisconsin and Michigan, Meunier built a history of fire in the north from 1548 to 1947. In a study published earlier this year in the journal *Fire Ecology*, Meunier concluded that the trees that fueled the Peshtigo inferno were the same hemlock, cedar, beech, tamarack, and sugar maple that grow in that region today. The great cutting of the pinery had not yet begun.

What fueled the Peshtigo fire were two dry years that spawned numerous smaller fires. That year it was so smoky on Green Bay that a lighthouse was kept lit during daytime hours to guide ships. Then, in October, cyclonic winds swept in from the Great Plains, whipping those small fires into a maelstrom.

"What we learn from Peshtigo is that it was climate and weather driven . . . and we need to be prepared for that to happen again," Meunier says.

While the *Fire Ecology* study prompted a reinterpretation of the past, another study published last year in *Forest Ecology and Management* may change U.S. Forest Service (USFS) practice going forward. A team of researchers (including Meunier, Eric Rebitzke of USFS, professor Volker Radeloff PhD'98 of the Department of Forestry and Wildlife Ecology, and Colleen Sutheimer MS'21, a recent forestry master's student that Radeloff and Meunier co-advised) looked at fire history in the peatlands of the northern forest.

This cross section was taken from a pine tree that survived multiple, relatively frequent fires. The pencil tip points to a fire scar. Photo by MICHAEL P. KING

Peatlands have been a "carbon sink" since the last Ice Age, sequestering as much as 25% of Earth's soil carbon and thus keeping the planet cooler. Rebitzke, a fire manager for the USFS, said he contacted Meunier after seeing research about historical fire regimes in Missouri and asked him to work together on studying the peatlands of the Hiawatha National Forest. It's part of a larger effort that includes the Sault Ste. Marie Tribe of Chippewa Indians. Tribal members interviewed elders, who told of burning peatlands to encourage the growth of medicinal plants and berries.

"Peatlands are just magnificent carbon sinks," Meunier says. "They make up less than 3% of the world's surface, but they sequester more carbon than all the trees on earth combined, tucking it away in these unique, low-oxygen environments."

They studied fire history via tree rings from islands within three peatland complexes in the Northwoods, finding that between 1548 and 1955 low to moderate intensity fires burned through these wet areas every seven to 34 years.

"To our surprise, we found that low severity fires were quite frequent prior to the middle of the 20th century," Meunier says. Fire suppression ended those historical fires. But just as Western states now face catastrophic fire seasons because of all the built-up fuel, Meunier says that halting peatland fires could be a mistake.

"Peatlands are really well engineered by nature," Meunier says. "A low-intensity fire burns only the top of the peat, and it regenerates. What happens when we suppress fire is that we risk changing the system from low-severity fires to high severity. The worst thing imaginable is a fire that burns down into the mineral soil and releases 10,000 years of carbon."

Because of Meunier's research, Rebitzke says, the USFS is going to include peatlands within the Ottawa and Hiawatha national forests in its prescribed burns. A new joint research project in the western Upper Peninsula is also being planned.

"He's filling in major gaps in our knowledge about the historical role of fire in the upper Great Lakes," says Rebitzke of Meunier. "We're using that data to inform our prescribed fire implementation strategies."

Some of Meunier's current research is using dendrochronology to understand the role of fire

Jed Meunier studies a freshly cut cross section of a pine stump at Castle Rock.
Photo by MICHAEL P. KING

in encouraging the regeneration of red pine, an iconic Wisconsin species that is threatened by climate change.

Before earning a doctoral degree from Colorado State University, Meunier received a master's degree from the CALS Department of Forestry and Wildlife Ecology, which was founded by his great-grandfather, Aldo Leopold, in 1936. Meunier is the DNR's first "disturbance ecologist," which means he studies how factors such as wind, fire, and harvest have shaped Wisconsin's landscape.

"People know about his changing views on predators," Meunier says of Leopold's famous essay about seeing the "green fire" die in the eyes of a wolf he shot in New Mexico. But few know Leopold also went through a similar evolution in his thinking about fire.

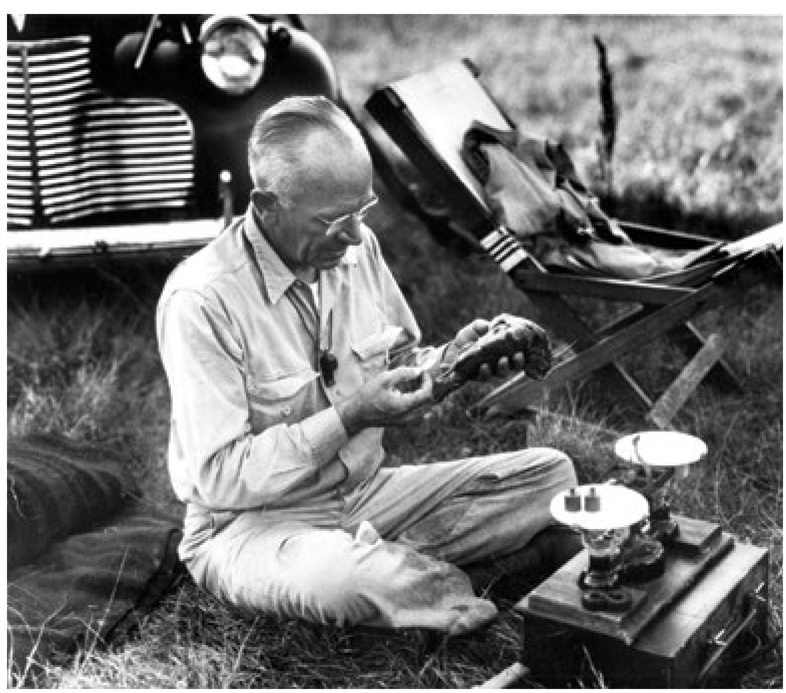
Meunier notes that his great-grandfather began his career in the Southwest in 1909, a year prior to some of the most destructive wildfires ever recorded in the northern Rockies. In 1923, Leopold wrote an article calling fire "a scourge of all living things," although he noted that he had to give the "fire devil" its due because it did encourage beneficial species. By the mid-1940s, Leopold and his UW students were setting fires to restore prairies at the UW Arboretum.

"When he was a young USFS employee, he thought that fire was the evil of all evils," Meunier says. "But he came to see it as a powerful tool."

Meunier is the fourth generation of the Leopold family to study how fire shaped the American landscape. His great-aunt Estella Leopold is a well-known paleobotanist emerita at the University of Washington, and great-uncle Starker Leopold BS'36 wrote the 1963 Leopold Report that advised the National Park Service to restore natural processes such as fire. That recommendation was highly controversial, as was Starker's call for California to use fire to manage quail.

Meunier's grandmother, Nina Leopold Bradley, and her husband, Charles C. Bradley, returned to the famed Leopold shack on the Wisconsin River to start and direct the Aldo Leopold Foundation. Meunier grew up nearby in Baraboo. Later, at UW, he studied woodcocks for his graduate work, using methods he later learned were developed by his great-grandfather.

"I came across a photo of Aldo weighing and sexing a woodcock in front of the Shack," Meunier says. "Until then, I didn't realize the methods we are still using were developed by him."



[Top] Jed Meunier works in his lab. Photo by MICHAEL P. KING

After a woodcock hunt, Aldo Leopold weighs specimens. Photo courtesy of UW–MADISON ARCHIVES

Frost clings to the surface of a cranberry with water droplets nearby.

COLD HARD SCIENCE
in the Heart of Cranberry Country

At the Wisconsin Cranberry Research Station, CALS scientists team up with growers to solve some of the toughest problems that arise while cultivating this native fruit crop — including exposure to frigid temperatures.

Story by Nicole Miller MS'06

Photos by Michael P. King

In early March of 2017, Nicole Hansen found herself kneeling in a cranberry bed, drilling into the soil to check the amount of frost in the ground. She had a tough decision to make.

Sandy soil clings to a cranberry on a plant at the Wisconsin Cranberry Research Station.

A multiday heat wave hit in late February, and it melted much of the ice protecting her cranberry vines. Normally at this time ofyear, the plants would be covered by a one-foot-thick slab of ice, which insulates the vines from extreme cold and biting winds. But much of that ice had disappeared, and a cold front was rolling in. Hansen had to figure out what to do about the exposed vines, which were already carrying the precious buds that would flower and turn into that year's crop of red, shiny berries.

"When everything melts early, that's where your biggest risk is. Then you have March and April when, all of a sudden, you're vulnerable again," says Hansen, plant health and operations manager at Cranberry Creek Cranberries, a cranberry marsh located near Necedah, Wisconsin. "Then you have to make decisions about flooding."

For most of the year, it's clear what growers need to do. Guidelines for the growing season, developed by UW researchers, list low-temperature thresholds at which growers need to take action (i.e., turning on irrigation sprinklers) to protect the delicate flowers and berries. In winter, there's the thick layer of protective ice over the vines.

However, in late fall and early spring — when growers protect their dormant vines by temporarily covering them in standing water, known as "flooding" — there's no data-based information about how much cold the vines can handle. This gap didn't used to be a problem. But things have changed.

"Growers have a system that worked really well for a long period of time. So it's a fair question to ask: Why are you working on cold hardiness?" explains Amaya Atucha, an associate professor and extension fruit crop production specialist in the Department of Horticulture. "Well, climate change, climate change, climate change. The winters aren't as consistently cold as they used to be."

This is the research that growers asked Atucha to do when she first moved to Wisconsin, she says, to help them make better-informed decisions.

Cranberries are native to Wisconsin, which means they're adapted to survive the state's harsh winters. But they are still a challenging crop to grow. Commercial operations need to protect and nurture these woody perennial plants to produce an abundant harvest of the gleaming, round, red fruits that consumers expect. In part, this is because cranberry plants are an evergreen shrub — their leaves keep their color and functionality through more than one growing season.

"I don't know of any other evergreen fruit crop that grows in cold climate; that makes cranberries really special," says Atucha. "It also makes cold damage a year-round threat, since growers can experience a frost event any time during the season."

Atucha, a plant physiologist and the Gottschalk Chair for Cranberry Research, started her cold hardiness research with laboratory-based studies, looking at tissue responses to cold. She is now gearing up for field studies, the final steps that will enable her to develop a research-based computer model that growers can consult to make crop protection decisions.

It's a fortuitous time for Atucha to shift into field research. She will be able to conduct her experiments at the state's new Wisconsin Cranberry Research Station, a facility near Black River Falls designed to house cutting-edge cranberry field studies.

The station, which started hosting research projects in 2021, is a public/private partnership between the Wisconsin Cranberry Research and Education Foundation (WCREF), the Agricultural Research Service at the U.S. Department of Agriculture (USDA-ARS), and UW–Madison. Its work is supported by an outreach specialist from the UW Division of Extension as well as several Extension-funded faculty in CALS, including Atucha.

The facility was built for UW researchers to continue their innovative studies, or even expand their programs, for the benefit of cranberry growers in the state and beyond. It's a place where growers' challenges will be addressed and their questions will be answered — including those about cold tolerance.

"In retrospect, we should have flooded [that spring], and we didn't. So we had injury to the plants," says Hansen. "Growers need good research about what's actually happening to the plants from a physiological standpoint and what temperature tolerances they have. We need this information so we can take the actions needed to keep our plants healthy and make sure that our crop potential is being maintained to the highest level."

Wisconsin is the top cranberry producer in the nation and accounts for more than half of the total U.S. crop each year. It's also the top-producing region in the world. Yet Wisconsin didn't have a research station dedicated to cranberries until relatively recently.

"The long and short of it is, our leadership looked at continuing to be a major player in cranberry growing, continuing to be able to pass farms from generation to generation, and being a leader in sustainability," says Tom Lochner BS'77, director of the Wisconsin State Cranberry Growers Association (WSCGA). "We determined that we needed to develop a research station for cranberries here in Wisconsin, and we needed to up our game on cranberry research."

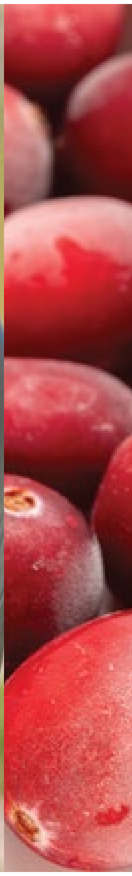
The association established a nonprofit, the WCREF, to lead a fundraising effort and administer the station. Growers contributed $750,000 to the project, which included some large in-kind donations in the form of cranberry vines.

"There are [quite a few] research questions that growers want the answers to, and they're willing to support the station in order to get that work done," says Lochner, who has shepherded the project through its various stages.

The new Wisconsin Cranberry Research Station sits on 140 acres of sandy soil in Jackson County, in the heart of the state's cranberry-producing region. The property has the kind of fine sand that's perfect for growing cranberries, and it sits alongside Robinson Creek, a picturesque and reliable source of water for the operation. It's dotted with fresh structures — a research and education building with meeting, lab, and office space; a water control structure on the creek; and a large pollinator garden.

In 2017, the property was purchased from — and, in part, donated by — the Bible family, who grew cranberries for Ocean Spray. Major renovations to the property's beds took place in 2018, bringing them up to modern industry standards. Vines were planted in

Amaya Atucha, associate professor of horticulture and extension specialist, talks with field day attendees at the Wisconsin Cranberry Research Station.



the new commercial production beds in 2019 and 2020, and the station now has 27 acres in commercial production.

"Once you plant the vines, it takes two to three years before you get a first crop, and then probably three to five before they get in full production," Lochner says. "We harvested our first crop off the new plantings last year, and we're hoping to see the yields improve [this year]. It looks like we should get a good crop."

Revenue from the crop helps support facility operations, including the work that takes place in the station's designated research beds. One large research bed hosts thousands of genetically unique plants produced via a plant genetics and plant breeding program.

There's also a set of four small-scale beds — each just two-fifths of an acre — with individual impermeable membrane liners beneath the beds, making them hydrologically insulated from each other and the surrounding groundwater. These mini-beds are ideal for water quality and quantity studies as well as replicated trials. They are the designated places for research that may involve significant vine damage or crop loss. Before the station was established, all the field research in Wisconsin had been performed on grower-volunteer marshes, limiting some areas of investigation.

"The great thing about the station is that we can do [so many types of experiments], especially things where we know the vines are going to get damaged and there will be less crop, like my flooding studies," says Atucha. "Or like when a researcher would want to introduce a disease. You're never going to introduce a disease at a grower's marsh, but you can potentially do that at the research station."

The station was built to support the programs run by UW's fruit team, a group of four cross-disciplinary faculty members with expertise in weeds, entomology, plant pathology, and plant physiology. In recent years, more research power has been added in the form of three new USDA-ARS staff members, focused specifically on cranberries, who have research affiliations with CALS. A fourth hire is in the works.

"Through our partnership with ARS, we advocated for USDA-ARS positions specific to cranberry," says Lochner. "Now that we have the station, we can start getting more people working on cranberry to build momentum in research and innovation."

There's a clear theme to the research taking place at the station: sustainability. Projects tend to focus on using less (or better) inputs and sprays and conserving water and energy, all while maintaining or improving fruit yield and quality.

"Research is the key to helping us be sustainable long-term and helping us to understand best management practices and just being good stewards," says Hansen. "I want to understand [how to] treat everything around me the way it should be treated, whether that's the plant, the soil, the water, everything."

This sustainability theme also encompasses Atucha's cold-hardiness research, which, at its core, is about conserving resources.

"When you have to be flooding, flooding, flooding repeatedly, the amount of water that needs to be moved on the entire property is huge," explains Atucha. "And the amount of time and energy that is needed to pump that water is huge."

"I want to understand [how to] treat everything around me the way it should be treated, whether that's the plant, the soil, the water, everything."

– Nicole Hansen

When water freezes, it forms crystals that grow and grow.

"Those crystals, they're just like little knives," explains Atucha. "They can penetrate inside the [plant] tissue, rupturing the entire tissue. Then, when the plant thaws, all the contents inside of those cells leak out, and then the tissue dies because it cannot recover."

Fortunately, plants have a number of strategies for surviving frigid temperatures, and that's what Atucha first sought to discover when she launched her cold-hardiness research program. Her research question: How does cranberry protect itself — especially its precious buds — from cold? The goal: to leverage the answer to provide practical guidance for growers. A series of experiments revealed the plant's approach, a phenomenon called freeze-induced dehydration.

"We figured out that those little buds, in order to withstand those really cold temperatures, they dehydrate," says Atucha. "The less water the tissues have, the lower their freezing point."

One of the key experiments involved peering inside the plant, and that required the development of a special imaging approach. It was no easy

Field day attendees walk through a field trial at the Wisconsin Cranberry Research Station. The breeding trial is directed by professor of horticulture Juan Zalapa, right.

[Left] Field day attendees tour the rebuilt Robinson Creek Dam at the Wisconsin Cranberry Research Station.

feat, considering the buds of a cranberry plant are smaller than a grain of rice.

"In order to see the freezing events in an intact bud, we needed to use a technology that gives you a different contrast for water and ice. MRI does that," explains Camilo Villouta PhD'21, who conducted these experiments as a doctoral student in Atucha's lab. "We found a small animal imaging center in the [UW Carbone Cancer Center]. They had an MRI for rats, with a tiny opening."

Villouta ended up partnering with the Fab Lab at the Morgridge Institute for Research to develop a novel device that could fit inside the mini-MRI and keep the plant samples frozen without damaging the machine.

"The device needed to have this circulating system [of coolant inside it]," he says. "And everything had to be MRI-friendly. You cannot use metals."

After a year and a half of iterative tinkering, the team perfected the device and published a technical paper on its fabrication. For Villouta, now a postdoc at Harvard University, it was a lot of fun — and a lot of work.

"It had moments of intense effort, because every two months or so we would have an [updated version of the device] to test," Villouta says. "I had to drive out to the marsh and get vines and then come back to campus and run the samples. It took a whole day. Ultimately, we were able to visualize the liquid water leaving the internal parts of the bud."

A series of studies funded by the USDA, the Cranberry Institute, Ocean Spray, and the Wisconsin Cranberry Board showed that a plant's cold hardiness from fall to spring follows a classic U shape. Right after the fall harvest, the plants are very sensitive to the cold. As they dehydrate over the course of the fall, the plants become more and more cold hardy. Come spring, as they begin to rehydrate, the plants slowly turn sensitive again.

This work set the stage for the next big step: a tool for growers. This year, Atucha received a Specialty Crop Block Grant from the USDA to build a cold-hardiness prediction model. It will use local weather data to forecast the cold hardiness of the buds.

"Now, when growers ask me, 'My ice is gone because it melted [earlier] and it's going to get cold [again], should I flood or not?' I can tell them, 'Well, run the model. With the temperatures that your vines have experienced at the location where you are, run it, and see what the model tells you,' " says Atucha, who was named Researcher of the Year by the WSCGA in 2022, in part for her cold-hardiness work.

Field day attendees walk through a field trial featuring 3,700 different selections at the Wisconsin Cranberry Research Station.

The field studies for her new project, which will take place in the replicated research trial beds at the Wisconsin Cranberry Research Station, will test how much cold the plants can take in the late fall and early spring before they need to be protected by flooding — and how long the beds can remain flooded before it causes plant damage.

"This is an example of a project where we really had to start from the basement, building up very basic knowledge about the plants to understand how weather impacts them," says Atucha. "The model is definitely something that has been a dream of mine, always, because it's a tool that I can give the growers."

In addition to being a site for knowledge creation, the Wisconsin Cranberry Research Station will be a place for knowledge sharing. The station started hosting events this spring; and, moving forward, it will be the primary site for many outreach events and trainings for the state's cranberry growers. Each year, the station will host mini-clinics in the spring, lunch-and-learn webinars during the growing season, and a fall field day — all involving UW researchers. It will also be the place for the annual end-of-season research roundtable, an important gathering to discuss the year's experimental findings and set new priorities.

"After the growing season, we bring in 25 to 30 growers and industry people and all of the research faculty," explains Lochner. "We sit down and talk about the season and what the researchers are working on. Then we break into small groups and [work on developing] priorities and future directions for the research programs."

All of these station-hosted events help establish and reinforce the vital two-way relationships between growers and researchers.

"It's key that UW researchers are in touch with what's happening with the industry," says Hansen. "They need to get out into the cranberry beds and engage [with growers] so they can get our input on what we are seeing — the trends and our theories — and utilize that information to set their research priorities." Even with the station up and running, UW researchers will still be visiting growers on their marshes, notes Atucha. Research needs to be replicated on growers' marshes as much as possible so the findings represent what's happening on the state's commercial operations.

Cranberry Creek Cranberries, notes Hansen, has been hosting 10 or more UW research projects per year in recent years. And she looks forward to the ongoing connections with UW researchers — and how the new station can support the good work being done.

"We're blessed to have the research crew that we do at UW," says Hansen. "We have an amazing team there, and I truly appreciate the work that we do together because it does take a team, and it needs to be cooperative. They're here to help us, and we're here to help them in whatever way we can to move forward together. That's the beauty of it, just continuing to work together and now utilizing this wonderful station." g

Beyond Cold-Hardiness Research

Over the past two years, research has been gearing up at the Wisconsin Cranberry Research Station. And more is yet to come. Here are some quick snapshots of station-based projects, which are supported by funding from the Wisconsin Cranberry Board, the Cranberry Institute, and the USDA.

- **New cultivars.** The station hosts the largest collection of cranberry genotypes ever assembled in Wisconsin — over 3,000 genetically unique plants created through conventional plant breeding. The plants are being evaluated for fruit quality, yield, and other characteristics, with the goal of developing new and improved cultivars for growers.

- **Better herbicides.** New compounds are being evaluated at the station to provide options for slowing the development of resistance to widely used herbicides and for filling gaps in cranberry weed control for problematic species. The majority of the evaluated products are more environmentally friendly than their predecessors.

- **Fruit rot prevention.** To minimize crop losses due to fruit rot, a common disease of cranberries, researchers are exploring the environmental sources of fruit rot fungi as well as assessing fungicides to control the pathogen. Findings will help improve fungicide management strategies.

- **Stress-resistant genes.** By identifying the specific genes and proteins involved in cranberry's ability to resist freezing stress damage, this project will yield information to help plant breeders develop more cold-hardy varieties.

- **Fruit firmness.** Over the past decade, the cranberry market has shifted from mostly juice production to more products with higher value, such as sweetened dried cranberry. The new products require higher fruit quality parameters, including firmness. This study explores the ability of calcium applications to boost fruit firmness.

- **Pest control.** Cranberries get nibbled on by a variety of insects, including leafhoppers and flea beetles. An evaluation of insecticides seeks new and better approaches to help growers keep these pests at bay.

[Above] Jed Colquhoun, professor of horticulture and extension specialist, talks with field day attendees about herbicide testing at the Wisconsin Cranberry Research Station.

A New Tactic in the Superbug Battle

Vatsan Raman is "supercharging evolution" to create an army of **bacteria-killing phages** that can combat antibiotic-resistant microorganisms.

By Hal Conick

A 3D bacteriophage virus particle on a bacterial surface.
Illustration by iSTOCKPHOTO.COM/iLEXX

During a 2015 trip to Egypt, Tom Patterson suffered a gallstone attack and soon fell terribly ill. But that's not what nearly killed him.

Patterson had been infected by *Acinetobacter baumannii*, a superbug that grew in a cyst inside his abdomen. The particular superbug — a bacterium resistant to multiple antibiotics — is often found in troops returning from the Middle East. The World Health Organization has named it one of the 12 most deadly superbugs on the planet.

The infection spread throughout Patterson's body, leaving him fighting for his life. Soon, he was in a coma.

His wife, Steffanie Strathdee, felt chagrined — it was like the universe was playing a cruel joke. She's an epidemiologist, professor, and associate dean of global health sciences at the University of California San Diego School of Medicine, but the force of the superbug blindsided her. She couldn't believe it was stealing her husband's life and didn't know the superbug crisis was on track to kill one person every three seconds by 2050.

Strathdee watched as her husband went in and out of septic shock. Reality hit her: Tom was going to die unless something drastic happened. "If he's going to die," she recalls thinking, "then I want to know that I left no stone unturned."

Sepsis is an exaggerated immune response to a bacterial infection, often triggered by a superbug infection that remains undeterred by antibiotics. Each year, nearly 300,000 people die from sepsis and 1.2 million die from superbugs. And more are dying each year. The problem has become worse amid the COVID-19 pandemic, and Vatsan Raman is well aware of its tragic consequences.

"Bacterial infections are a slow-burning epidemic that has been happening for the last 20 years," says Raman, associate professor of biochemistry and bacteriology at CALS. "It's a compelling societal problem. If you were to list some of the grand challenges that society faces, bacterial resistance to drugs is among the top three."

Raman wondered if molecular methods and synthetic biology could be applied to the superbug crisis and potentially save lives. When he learned about phage therapy, Raman felt cautiously optimistic — it seemed to hold true promise.

In nature, bacteriophages are the natural predators of bacteria. Phages, as they're commonly known, are classified as viruses; they infiltrate the walls of bacteria and hack their biological machinery to make a slew of baby phages. Those baby phages fill the bacterium until it explodes; then they seek other bacterial cells to destroy. Bacteria mutate to survive these attacks from phages, Raman says, in an evolutionary arms race that has been raging for billions of years.

As Raman studied phages, he wondered whether their natural powers could be harnessed to fight multidrug-resistant bacteria. If an effective process could be found, thousands — perhaps millions — of lives could be saved. "That's the idea that got me involved in this space," he says.

What's a Nonillion?

One nonillion is equivalent to 10^{30}, or 1 followed by 30 zeroes.

"I have thought of the phage as the ultimate smart drug," Raman says. "It precisely targets a pathogen, unlike traditional antibiotics , which cause collateral damage. It is evolvable, which means that if bacteria become resistant to a phage, we can evolve the phage using synthetic biology to remain effective against the bacteria. With traditional antibiotics, once bacteria become resistant, it is a dead end. Finally, there is a limitless supply of phages in nature to work with. Some estimates suggest there are more than [one nonillion] phages on Earth."

The goal of Raman's lab has always been to repurpose nature's processes in ways that are beneficial to humans. For the last five years, he and his team have been working on ways to make thousands of mutations to phages. With phage therapy, they want to see what mutations can best kill the deadliest bacteria in the world, hoping to fight back against the superbug crisis.

"You can think of this as supercharging evolution," Raman says.

As Strathdee scoured medical journals for ideas to save her husband, she read about phage therapy. She knew what phages were but didn't know much about how they could be used as medicine. Strathdee felt thrilled to find a lead, far-fetched as it may be. But as Patterson was fighting for his life, phage therapy was still on the fringes of U.S. science, where it was never widely studied as a human therapy.

Strathdee read the history of phage therapy, finding that many U.S. scientists had turned their backs on it in the 1930s. Scientists in the Soviet Union were studying phage therapy, and few Americans of that era wanted any associations with communism. Then, after Scottish scientist Alexander Fleming discovered penicillin, the Western world found its own way to treat bacterial infections. The idea of phage therapy remained dormant for decades in U.S. research labs; it was practiced primarily in Eastern European countries, such as Poland, Russia, and Georgia.

But perhaps phage therapy could help Patterson, who lay in a two-month coma. Strathdee's colleague, Chip Schooley, chief of infectious diseases at the UCSD School of Medicine, thought that phage therapy could be approved for Patterson as a last resort. He contacted the Food and Drug Administration to get approval for compassionate use of phage therapy, which, at the time, was the only way it could be administered to humans stateside.

Schooley and Strathdee recruited colleagues from universities around the world to search their phage libraries and send any phages that had the potential

Vatsan Raman, associate professor of biochemistry, stands in a skywalk connected to the DeLuca Biochemistry Laboratories.

Photo by MICHAEL P. KING

to destroy Patterson's bacterial infection. They also engaged in phage hunts to source them from sewage, barnyards, and bogs. Within three weeks, Patterson's doctors had two phage cocktails ready, even receiving reinforcements from the U.S. Navy. Researchers purified the first phage cocktail and started treating Patterson, the first time in U.S. history that doctors delivered phages to a patient intravenously. They did so out of urgency, as Patterson seemed to have little time left.

In a frustrating turn, Patterson's infection became resistant to all phages except for one the Navy had sent. The Navy had found that this new phage matched mutated bacteria discovered in a Maryland sewage treatment plant. Once again, doctors purified a phage cocktail, injected it into Patterson, and hoped for the best.

In 2021, Raman was one of 12 investigators across the U.S. to receive a grant from the National Institute of Allergy and Infectious Diseases (NIAID), which is a branch of the National Institutes of Health, to study phage therapy. These were the first series of phage therapy grants NIAID had ever given.

"It was an exciting grant to get," Raman says. "Now we're at the point where we've developed some of these tools."

Raman and his team published a paper in the journal *eLife* in March 2021 highlighting a method they created, one that would systematically map how altering a phage's DNA sequence changes how it interacts with bacterial hosts. The process is about removing roadblocks that impede the phage's ability to attack bacteria, Raman says.

The method, dubbed ORACLE — optimized recombination, accumulation, and library expression — makes tens of thousands of changes to the phage's DNA. While evolution makes one change at a time to see if a version of a phage can kill the current version of its host, ORACLE makes thousands of changes at once, searching for the phage mutations that will kill drug-resistant bacteria.

"We've accumulated mutations of phages that are highly effective at killing each host, much more so than in nature," Raman says.

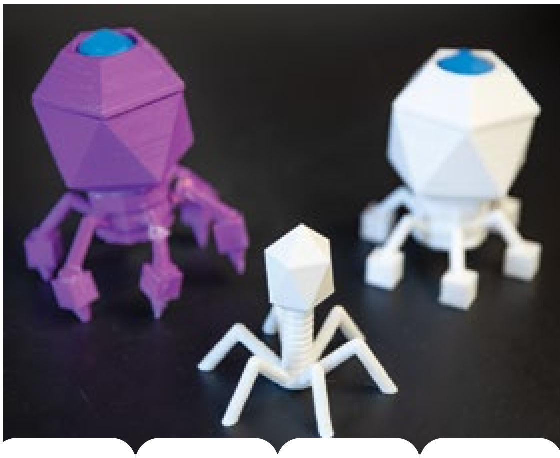
Each phage genome generally has dozens of genes, Raman says, some of which are good candidates for laboratory-guided evolution to improve a phage's ability to kill bacteria. In his lab, they identify the most effective genes and then acquire synthetic DNA from a commercial manufacturer to introduce mutations into the phage's gene pool. ORACLE searches for the most effective phage genes, introducing mutations that will make the phages even more effective at fighting bacteria.

"We have the spool of DNA — it could be 10 or 1,000 changes you want — and we replace the native DNA of the phage with all the synthetic changes that we designed," Raman says. "Now that we have a million different baby phages, and each baby phage has a new sequence, we put them through a giant competition. We give these phages bacteria to attack — the phage that is the most effective at killing the bacteria will make more of itself. The phage that has an ineffective mutation will just drop out simply because it can't make more baby phages. After a few cycles, we can select the fittest phage. It's just like how nature does reproduction, except we're doing it much faster. It's highly effective."

Raman credits Phil Huss PhD'22, who recently graduated from UW's Microbiology Doctoral Training Program and now works as a researcher in Raman's lab, as the creator of ORACLE. Huss said that he was inspired to create ORACLE when he wanted to do deep mutational scanning on phages, but no way to do so existed. "I had to make a way," Huss says.

Over the course of about 18 months, Huss created a process that combines cutting-edge synthetic DNA and genome editing technologies to create a tool to precisely modify the phage genome. Recombining synthetic DNA into the phage genome was the hardest piece of the process to integrate, Huss says. In recombination, pieces of DNA are broken and reassembled to create new combinations of alleles (the different versions of DNA sequences). For ORACLE, Huss says that recombination had to take place as the phage was already attempting to destroy the host. "That was the one process when, once it worked, I knew that the whole thing could work," he says.

The promise of ORACLE, according to Huss, is that it will help researchers know more about different parts of the phage that can be effective killers of bacteria. If a phage is good at killing *E. coli* or *salmonella*, researchers can use that knowledge to design phages that will target these bacteria, thus fighting back against the problem of drug-resistant bacteria.



PHAGE DEMONSTRATION

These models, designed by CALS graduate students Sarah Schmidt-Dannert, Rebecca Back, and Silas Miller, were created with a 3D printer to be used as teaching tools for elementary school students at science outreach events. They include functioning mechanical and electronic parts. The models, along with balloons representing bacteria, demonstrate how phages recognize specific receptors on the surface of a bacterium; attach to and infect the bacterial cell; and then rupture the cell wall, releasing their progeny to attack other bacteria.

View a video of these models in action at **go.wisc.edu/grow-phage-models**. Photo by MICHAEL P. KING

Researcher Phil Huss explains how two genetic sequencing machines are used in Vatsan Raman's lab in the DeLuca Biochemistry Laboratories.

Photo by MICHAEL P. KING

And ORACLE is a much speedier process than traditional methods of phage-finding. Searching through phage libraries to find a phage that could kill a multidrug-resistant bacteria could take weeks, even months. ORACLE moves faster, finding and creating effective bacteria killers within two to three days, according to Raman.

"Biologists have accumulated that information [in phage libraries] over decades of work," he says. "We're standing on their shoulders. We know what phages can infect what bacteria. Now, the question is, can we supercharge evolution and make them really good at infecting that bacteria?"

Three days after Patterson began receiving intravenous phage therapy, he woke up from his coma. The phage cocktail seemed to work in concert with one of the antibiotics he had been receiving. Within three months, he was free of infection. Soon, Patterson was back to work as a psychology researcher at UCSD. Something drastic had truly happened.

Strathdee was amazed and grateful. After deep reflection, she decided to become an advocate for phage therapy and an activist for solutions to antimicrobial resistance.

"My husband and I were very privileged," Strathdee says. "Initially, we thought it was the worst thing that could ever happen. But if we lived anywhere else, or if I didn't have resources and connections, then he would have died. And that's what happens to the majority of people in middle-income countries. We're trying to pay it forward by helping other people get this treatment more easily than we did."

Patterson's story went viral, receiving news coverage and case-study write-ups in top medical journals. Together, Patterson and Strathdee wrote the book *The Perfect Predator: A Scientist's Race to Save Her Husband from a Deadly Superbug*. Strathdee, alongside Schooley, also became codirector at UCSD's Center for Innovative Phage Applications and Therapeutics (IPATH). Strathdee has had more than 1,500 people around the world contact her to ask for help in accessing phage therapy, and IPATH has been able to help many of them.

As Patterson's story became widely known, the U.S. science community rediscovered phage therapy. The Food and Drug Administration began making it easier for people to get access to phage therapy earlier, while the NIH and NIAID began giving grants so researchers could study phage therapy, which includes the funding Raman's lab received. The FDA also launched the first series of clinical trials for phage therapy.

"We're entering a new era now," Strathdee says. "Hopefully, these trials will show that phage therapy works on a broader scale so that the FDA can approve it. Until then, they have to be approved on a case-by-case basis, and it's generally only for life-threatening cases."

Raman has seen interest in phage therapy explode since it brought Patterson back from the brink of death.

"There's a line of companies that are now developing phages and testing them to see how effective they are against different kinds of bacteria," Raman says. "We're not at the point where we can administer phages in the clinic, but we're getting closer and closer."

In his lab, Raman has seen just how effective phages can be against multidrug-resistant bacteria. His lab picked a drug-resistant bacteria from the CDC's urgent threat list — one that is completely resistant to more than 35 antibiotics and is partially susceptible to only two last-resort antibiotics. Using ORACLE, they created phages that killed these bacteria in the lab. Raman believes that, once approved clinically, phage therapy will offer medicine a new opportunity to treat stubborn infections.

"The mechanism that the antibiotics use is different from how phages do business," Raman says. "Bacteria may have picked up all these mutations over time to defend itself against every antibiotic, but the phages get through using a different cell surface protein — it's essentially like they use a different door to enter the bacteria. That's what makes the phages attractive, and that's why we were able to design phages that could kill bacteria that are resistant to 35 different variants."

Watching a phage kill a multidrug-resistant bacteria in the lab truly sold Huss on the promise of phage therapy. "That was one experiment where we were looking at one region on the phage," Huss says. "I can only imagine how effective it would be if you look at all the different areas across the phage genome. To me, that made phage therapy seem more real."

Huss sees ORACLE as a process that will be useful for finding hotspots across phages, information that can be used to better treat multidrug-resistant bacteria. He hopes this method can give other researchers a broader view of the phage structure. "If you're just trying to look at individual phage variants, you're only getting this really small piece of the picture," Huss says. "Our goal was to create tens of thousands of variants to get the entire picture."

Now Raman's lab is researching ways that phages and ORACLE can be used to precisely edit the microbiome, for both humans and livestock. And the lab will likely keep taking on new projects. "We like to foster innovation," Huss says. "Vatsan encourages fresh ideas from everyone in his lab and enjoys exploring the feasibility of those ideas with us."

Strathdee felt hopeful when hearing about the work from Raman's lab. She believes that one of the biggest bottlenecks in phage therapy research has been hunting for phages and modifying them genetically — the more solutions look to address this problem, the better. The first genetically modified phage cocktail was used successfully on a human in 2019, she says; and she, like Raman, has noticed that many biotech companies are entering this space. She hopes that research can make up for the lost years when phage therapy went unstudied.

"New antibiotics take 10 to 15 years to develop, and my husband's phage cocktail was developed within three weeks," Strathdee says. "Imagine having a phage library, where somebody could just take an already characterized phage and then see if it matches the bacterial isolate. That can be done in 24 hours. There's an initial start-up cost, but the more it gets done, the cheaper it will get."

This leads to what Raman considers to be the biggest question for phage therapy: Is it commercially viable? Phage therapy may be a tough sell for large pharmaceutical companies, Raman says, because it's a treatment that quickly and inexpensively solves a problem. There will be few repeat customers for successful phage therapy treatments, which means it may be hard to profit from phages.

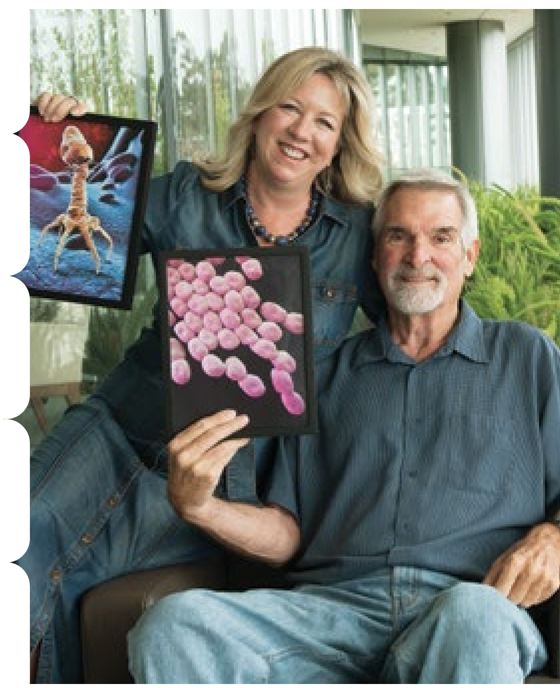
"It's not obvious to me that there's a strong business model," Raman says. The thought of solving this problem himself and entering the commercial side of phages has crossed Raman's mind. "But," he says, "we're not there yet."

For Strathdee, who has seen the impact of phage therapy firsthand, the biggest question is how to push past the business challenges and bring phage therapy to more patients. Superbugs are a global issue, she says, that will take a collective political will to solve.

"This is a global health problem," Strathdee says. "We need to have a global health solution."

Raman believes phage therapy offers a solution to this global health problem, which has caused grief for millions while promising grief for millions more. But while the crisis is tragic, Raman feels a sense of hope. At first cautiously optimistic about phage therapy, now he's certain that it will save lives.

"I'm more convinced now than ever," Raman says, "that the phage revolution will have a large impact." g



Stephanie Strathdee and her husband, Tom Patterson. Strathdee is holding a rendition of a phage and Patterson has a scanning electron micrograph of *Acinetobacter baumannii*, the superbug that nearly killed him.

Image courtesy of UC SAN DIEGO HEALTH

Eco-friendly Pest Control

For Russ Groves, research on insecticide resistance genes in the Colorado potato beetle has led to partnerships to develop more targeted and sustainable bug-neutralizing options.

Interview by NICOLE MILLER MS'06 | Photos by MICHAEL P. KING

Wisconsin has a long history of vegetable production. It's a leading producer of the nation's processing vegetables, such as snap beans, sweet corn, carrots, and potatoes. As a professor and extension specialist in the Department of Entomology, it's part of **Russ Groves**'s job to protect these vegetable crops from insect pests — and that includes safeguarding the state's potato crop from the voracious Colorado potato beetle (CPB).

The beetle is one of the most harmful pests of potato, capable of munching so many leaves that it reduces tuber yields, so growers turn to insecticide sprays to keep the bugs at bay. Groves notes that some of the state's surface and groundwater reflect an unfortunate legacy of long-term pesticide use in select areas with high agricultural intensity. That's a big motivator behind his efforts to develop more environmentally sustainable insect pest control options for growers.

In recent years, Groves has been working with biotech industry partners to develop and fine-tune a new, more eco-friendly insecticide option involving RNA interference (RNAi) technology. The approach, which utilizes double-stranded RNA (dsRNA) to silence critical genes in the beetle, is much more targeted than traditional insecticides. Under Groves's supervision, it's being tested on Wisconsin fields this summer. He anticipates seeing the first RNAi-based insecticide on the market later this year.

WHAT MAKES THE COLORADO POTATO BEETLE SUCH A FORMIDABLE FOE?

The Colorado potato beetle evolved to live on a poisonous plant. It eats the foliage of members of the nightshade family of plants, which are full of alkaloids, so it was important for populations of this insect to evolve detoxification mechanisms to cope with all the toxins.

Because of these innate coping mechanisms, the insect has a high potential to develop insecticide resistance. When a Colorado potato beetle is subjected to a new insecticide, it is already equipped to cope with these compounds. As with the plant-based toxins that the beetles have evolved to deal with, they sequester insecticides, detoxify them, and excrete them. Consequently, over the years, the potato industry has lost more and more insecticidal options. So, growers are always looking for novel approaches, especially more environmentally conscious, reduced-risk approaches.

WHAT DOES YOUR WORK STUDYING INSECTICIDE RESISTANCE INVOLVE?

For the past 8 to 10 years, we've been studying the response of CPB to new and existing insecticides; and, more recently, we have attempted to discover the principle set of genes involved in insecticide resistance. We've investigated different populations of Colorado potato beetle collected in different states, knowing that the insect has different patterns of resistance in different places. In collaboration with **Sean Schoville**, a professor of entomology, we continue to learn about the suite of genes that encode for this resistance.

In recent research, we have observed that a discrete set of genes appears to be involved in this resistance. And to further confirm the function of these genes, we use loss-of-function analyses based on RNAi to better determine gene function. Very simply, this means we synthesize and introduce a piece of double-stranded RNA that is analogous to a critical gene inside that insect. Once inside the cells of the target insect, in this case the CPB, its cellular machinery is "tricked" into knocking out, or knocking down, the function (in other words, the translation) of its own genes.

Several of the genes identified turned out to be multifunctional but were mostly associated with metabolic detoxification. Much of this work has been the focus of recent publications, which triggered new contacts and new relationships with biotechnology companies interested in developing RNAi-based approaches to pest management.

WHAT HAS HAPPENED SINCE THESE INITIAL CONTACTS?

Our publications led to three different biotech companies reaching out to our group. These biotech groups explore recently published genome sequence databases, such as the Center for Biotechnology Information, or NCBI, in efforts to identify genes unique to select groups of organisms, like the Colorado potato beetle. While our goals in utilizing RNAi approaches have largely been to ascertain resistance gene function, these companies are exploring gene targets that result in a lethal phenotype. In other words, they wish to develop RNAi-based approaches that can be used in pest control — to kill the insect.

In our lab, we use very small needles to inject the dsRNA into individual beetles, but you can't do that on a field scale. Fortunately, Colorado potato beetles are leaf-eating beetles, and they have the capacity to process and transport RNA across their midgut and move these molecules into their bloodstream, which allows the RNAi effect to become systemic throughout the insect.

Biotechnology companies have formulated dsRNAs that can be sprayed directly on the plants. And once on the leaves of potato plants, then the Colorado potato beetle will consume these small molecules, where they make their way into the bodies of insects — and mortality results. It's really quite amazing that it functions in this way.

Importantly, these dsRNA on the leaf have a very short functional life of about three to four days. After this time, the compounds denature relatively quickly. Equally important is that this technology is very target specific. It only kills Colorado potato beetle. In addition to being very targeted, we view these kinds of pest management approaches as reduced-risk and quite environmentally friendly in terms of pest management outcomes.

THAT SOUNDS AMAZING. DOES THIS SPELL THE END FOR CPB AND OTHER PESTS?

Of course, you can't rely on a single technology. We all knew, and we can anticipate in the future, that CPB will continually develop resistance to selections like pesticides, even RNAi-based approaches. We will always be in an "arms race" with mother nature. There's no silver bullet.

In fact, research has already demonstrated the Colorado potato beetle's ability to generate resistance to select RNAi approaches. When resistance to these new technologies develops in the future, we will need to consider other gene targets and develop new dsRNA molecules that will target other important genes [to account for mutations in the beetle population].

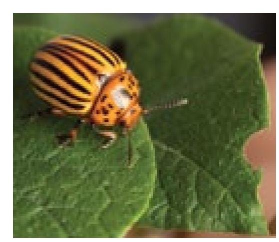
Unfortunately, [simply spraying dsRNA on potato leaves] doesn't work to control all pests of the crop, such as aphids and leafhoppers, potato's other top insect pests. These insects, which possess piercing-sucking mouthparts similar to mosquitoes, simply avoid the dsRNA on the leaf surface, as their mouthparts are going to go right past it.

WHAT'S COMING UP NEXT FOR THIS PROJECT?

We continue to work with pest management and agribusiness companies to develop and test these new technologies. We have several projects at the Arlington and Hancock agricultural research stations in 2022, as we have for the past four to five years, looking at timing of delivery, adjuvants that can help extend the life of the compounds on the leaves, and how the dsRNA works in tank mixes with other active ingredients like fungicides and fertilizers. Simple, but very practical investigations are still warranted.

The very first sprayable RNAi targeting the Colorado potato beetle is anticipated to be registered later this year. It will be called Calantha, and Wisconsin's potato growers are eager for this.

+ ONLINE EXTRA
Want to learn about how RNAi works? Read more in the digital version of this article at **go.wisc.edu/grow-groves**.



A Colorado potato beetle clings to potato leaves in the lab of Russ Groves.

Left, Russ Groves, professor of entomology, poses for a portrait with Colorado potato beetles in his lab at Russell Laboratories on the UW campus.

For the Love of Food and Family (and Spice)

Zainab Hassen is bringing the full flavors of North African cuisine to a small town in southern Wisconsin.

By CAROLINE SCHNEIDER MS'11
Photos by MICHAEL P. KING

When getting to know someone, we often ask the same questions: What do you do? Where do you live? Do you have any hobbies? A question we seldom ask, however, is "What is your favorite spice?" But if you were getting to know **Zainab Hassen** BS'08, MS'12, the answer would tell you quite a bit about her.

Hassen is co-owner of MENASpice, a Middle Eastern and North African spice shop in Stoughton, Wisconsin. Spices are a part of her everyday life, and they have been since she was a small child.

Hassen has lived in Madison for the past 24 years, but her parents are immigrants from Libya. She was homeschooled through high school, and she spent much of that time with her mother, **Fatma**, watching her cook Libyan recipes — and tasting her food.

"Food became one of the main things we shared together," says Hassen. "I never actually made a meal myself at that time, but when I got older, I was able to try things and taste it and know if it was right. If it doesn't taste like Mama's, I know there's something wrong."

Hassen's love of food and cooking spilled over into college at UW. While she first considered entering the medical field, a suggestion from an aunt steered her toward nutrition. She looked into nutritional sciences, saw she could utilize her love of food, and her undergraduate major fell into place. Hassen stayed at CALS to get a master's degree in nutritional sciences and followed that with a master's degree in public health from the University of Massachusetts Amherst.

“I enjoyed the nutritional sciences program [at CALS] very much, and I loved many of my professors,” says Hassen. “I use the skills I learned at UW all the time — communication, being able to write, managing projects, and being proactive.”

Taking initiative is important for someone as busy as Hassen. During the week, she works as a project manager at a pharmaceutical company. She spends her free time and weekends at MENASpice with her brothers, **Abdurrahman (Abdu)** and **Ibrahim Hassen**, where they focus on spices from the North African countries of Libya, Tunisia, Algeria, and Morocco.

“North African spices aren’t readily available in the market,” explains Hassen. “Nobody really knows what North African flavors and cuisines are. Because there’s this gap in the market, I wanted to jump into that niche.”

The store currently offers a variety of spices and six custom blends. The Libyan blend, hararat, is Hassen’s mother’s recipe. The rest of the blends are Hassen’s interpretation of other North African spice mixes. Tabil, b’zaar, and Tunisian black pepper are Tunisian blends; ras el hanout is usually associated with Morocco; and shawerma is a more general blend. Hassen works with her mom to create all of her mixes.

“If I make something, she has to approve it,” Hassen says with a smile. “She tells me if it’s not up to par, and then I will not be putting it on the market. It’s a great process.”

Working with her family is a huge perk for Hassen and a main driver of the business. Abdu helps maintain the store and manage the operations. He also loves to cook and helps create new flavors. Ibrahim co-owns the business, and, although he’s not a cook, he *is* a great taste tester, Hassen says with a laugh.

“It’s a team effort between the three of us, which is really great,” Hassen says. “This business is something that all of us can have for our kids in the future. It’s amazing to be able to create something for the family.”

Hassen’s efforts in establishing and running MENASpice are consistent with her nature and hard work in graduate school, according to **Tom Crenshaw**, a professor of animal and dairy sciences. Hassen worked with Crenshaw on pig nutrition research while she completed her master’s degree at CALS. “She was willing to learn new areas in her research, and, at the same time, she maintained a strong commitment to her core beliefs,” he says. “She was and still is open to new adventures.”

Hassen is excited to see where this spice store adventure leads. Her immediate goal is to offer new products and blends. She also aims to provide cooking classes and maybe even a food cart going forward. Her ultimate dream is to develop a community program that would bring in kids and adults who want to learn to cook and understand the basics of nutrition. In any way she can, Hassen looks forward to sharing her enthusiasm for food and her love of spices with the community.

Oh, and her favorite spice? She’s happy to share that too.

“While I love our Libyan blend because it reminds me of home, outside of that, my favorite would be tabil. The garlic base comes through with the sweetness and the garlicy flavor, and it also has mint in it. It’s warm and earthy and sweet,” says Hassen, her passion for the topic shining through. “I truly enjoy making the spices and feeding people. It is one of my love languages.”

■ ENGAGE

LISTEN TO WOMEN IN POWER

Propelling Women in Power is a podcast about the careers of women in energy at UW’s Wisconsin Energy Institute and its sister institution, the Great Lakes Bioenergy Research Center. Its fourth episode features life sciences communication professor **Dominique Brossard** discussing how to converse about things that matter to us with people with whom we disagree. The podcast is available on Apple Podcasts, Google Podcasts, and Spotify.

■ ACCOLADES

GLOBAL HEALTH LEADER

Jorge Osorio MS’88, PhD’96, an international expert in epidemiology, virology, and vaccines, was recently named director of the UW Global Health Institute. A professor of pathobiological sciences in the UW School of Veterinary Medicine, Osorio also codirects the Colombia-Wisconsin One Health Consortium, a joint effort between UW and Universidad Nacional de Colombia that is focused on studying emerging diseases.

THE FUTURE OF PUBLIC GARDENS

Erin Presley BS’06 has received the inaugural Gerry Donnelly Future Leaders Scholarship from the American Public Gardens Association. The award is given to an exceptional candidate who is a rising leader in the public garden industry. Presley is a horticulturist at Olbrich Botanical Gardens in Madison, Wisconsin.

Anonymous Gift Grows More Space for Organic Agriculture

By ASPEN OBLEWSKI

Photo by ANDERS GURDA

Wisconsin is among the nation's top producers of organic agriculture. It ranks second in number of organic farms, according to a recent survey by the U.S. Department of Agriculture. The state's leadership in this area has spanned more than a decade, and demand for Wisconsin's organic products continues to grow.

UW has 42 faculty and staff involved in advanced research and outreach who are committed to helping organic producers satisfy this growing appetite. For this purpose, they have access to more than 145 certified organic acres at multiple CALS research stations. But finding space for these projects can still be difficult.

"With the expanding number of research projects led by CALS faculty and staff, our certified organic land base was not sufficient to support the needs of researchers wanting to conduct research on certified organic land," says **Erin Silva**, associate professor and extension specialist in the Department of Plant Pathology.

Fortunately, an opportunity to expand arrived not long ago. In 2018, the owners of 70 acres adjacent to the Arlington Agricultural Research Station offered UW the chance to purchase the land, and an anonymous donor gave CALS $500,000 to put toward the deal. CALS then matched the donation for a combined $1 million to purchase the land and boost its organic agriculture acreage.

"Organics is a growing program that needs more dedicated acreage to meet our research mission," says **Mike Peters** BS'95, director of the UW Agricultural Research Station network. "We can do a better job having more robust demonstrations and options for visitors who come to the station to learn how they can adapt on their own farms some of the methods that our researchers are using."

The new organic acres, which will be managed and stewarded as required by National Organic Program regulations, will allow the station to have more organic crop rotations and more space to compare organic and conventional methods. The expansion will also help the station engage with more farmers and other researchers through outreach programs and provide additional opportunities for students.

One research project planned for next season will investigate no-till organic dry bean production. This study builds on the UW organic team's success in growing organic soybeans without tillage by instead using a winter rye cover crop as a weed suppression tool and utilizing a roller crimper to terminate winter rye.

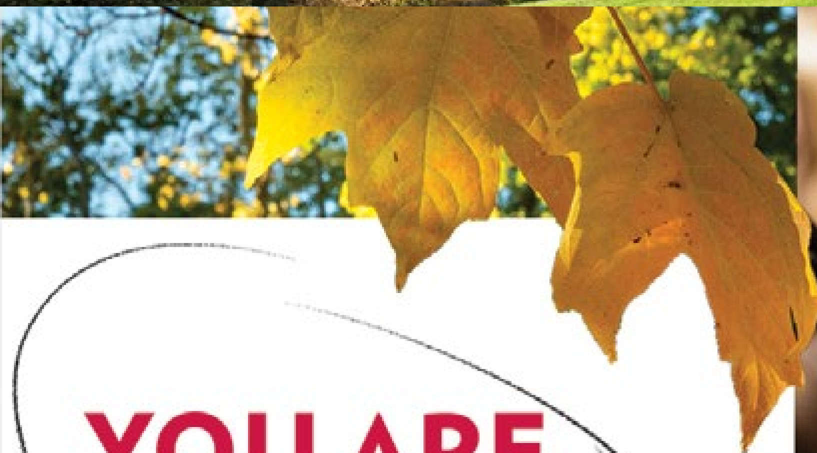
"We hope to extend this work in the coming years to include growing dry beans under organic no-till conditions," says **Ben Brockmueller**, a research specialist in the plant pathology department. "Dry beans are an emerging crop in organic markets, and our work looks to optimize their agronomic management by identifying varieties and seeding rates suitable for organic no-till production."

Other projects slated for the new acreage include testing organic relay crop systems (in which crops are planted in close proximity with overlapping growing seasons) and developing organic no-till systems for corn. Pursuit of these and other studies is vital for the future of organic agriculture, Silva says.

"Research delivers valuable information, tools, and resources that help all farmers — both organic and nonorganic — increase the environmental and economic sustainability of their operations," says Silva. "The continued growth of organic agriculture requires investment in research, education, and extension programs that provide sound information and assistance to America's farmers."

INVEST IN CALS

Want to support organic agriculture at CALS? Contact Annie Engebretson at 608-206-1244 or andrea.engebretson@supportuw.org.



YOU ARE THE KEY TO OUR STORY

"Strong start" programs, such as CALS QuickStart and First-Year Interest Groups, are a critical component of success for CALS students. These programs help undergrads explore different areas of study, learn how to access student services, and develop a network of mentors, classmates, and friends.

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN–MADISON

You can help CALS students get a strong start by making a gift to the college at

go.wisc.edu/GiveToCALS

College of
Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN–MADISON

136 Agricultural Hall
1450 Linden Drive
Madison, WI 53706

grow.cals.wisc.edu

Nonprofit
Organization
U.S. Postage
PAID
UMS

A buried fire scar abides within a pine cross section in the lab of Jed Meunier MS'05, an ecologist and research scientist with the Wisconsin Department of Natural Resources. The great-grandson of famed ecologist Aldo Leopold, Meunier and his research collaborators are changing how we approach wildfire management. Read more on page 16. Photo by MICHAEL P. KING