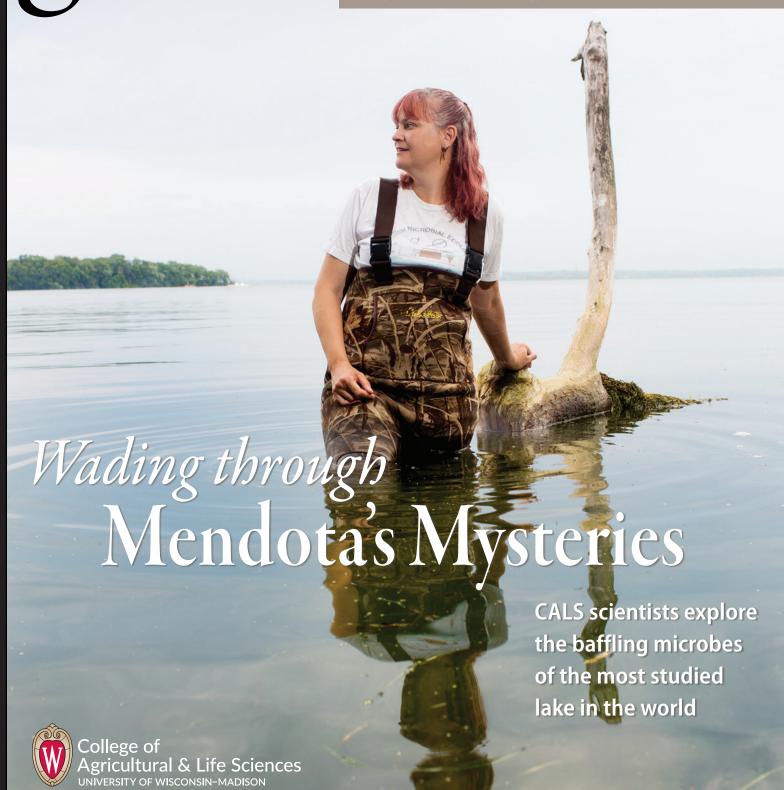
grow

Wisconsin's Magazine for the Life Sciences • Fall 2017

food systems • health • bioenergy • environment • climate • communities







Wisconsin's Magazine for the Life Sciences

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On the Cover: Trina McMahon wades through the shallows of Lake Mendota, often called the most studied lake in the world. The nearly 9,800-acre body of water is home to the puzzling microbes she studies. Learn more starting on page 16.

Photo by Sharon Vanorny

Dean Kate VandenBosch

'There Is Nothing So Stable as Change'



Throughout its remarkable 128-year history, CALS has continually embraced change. To keep us at the forefront of the agricultural and life sciences, our leaders have seized new opportunities just as other endeavors have passed from the picture. In fact, our college formed in response to great change, during a time when Wisconsin's farmers began to recognize the vital role of scientific agriculture in their success.

But one does not have to delve far into the past to find other examples of such adaptation. Only a decade ago, the departments of Forest Ecology and Wildlife Ecology merged, partly to put themselves in a better position to address new challenges related to natural resources.

Today is no different. We face a constant flow of change — in higher education, in funding, in scientific advancement, in our disciplines. Except the changes seem to have picked up the pace. Now the need for expertise is growing ever more rapidly as our challenges expand, from the threat of new invasive species to the difficulties of feeding a growing population. And the tools we use have advanced dramatically in the last two decades. We find ourselves in a postgenomic era where the mining of massive data sets has become as commonplace as microscopes. What, then, do we do?

The answer: we become more flexible, more responsive, more focused. But this cannot be achieved without careful thought about how we select and support our priorities in CALS. This is why, in late 2016, we began an organizational redesign process for our college. Led by a multidisciplinary team of our faculty and staff, we are undergoing a thorough analysis of the trends that affect our work as well as the strengths of our departmental programs. Based on their findings, our team will propose a new conceptual design for the college, one that helps us concentrate our work where it can have the greatest impact, and one that positions us to be more responsive to global challenges, changing scientific opportunities, and student needs.

As we go forward, this proposal will be thoroughly vetted by the CALS community and guided through the implementation phase. This fall, our team is presenting the design options it has distilled for CALS, which will be followed by exciting discussions about shared priorities and vision, and how we can work together in the future. We look forward to reporting on all of this activity as this process continues. And if you would like more detail about the redesign now, please visit orgredesign.cals.wisc.edu.

In the meantime, one important change has already happened. After much deliberation over the past two years, including discussions among the faculty and administration and consultations with students and alumni, the departments of Landscape Architecture and Urban and Regional Planning have merged to form the Department of Planning and Landscape Architecture, effective July 2017. This new department will be housed in the College of Letters & Science, but we will always embrace those who earned their degrees from CALS as our alumni.

Change can be difficult, but this is an exciting time, and I am optimistic about the opportunities it will bring.

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On Henry Mall

News from around the college

Saving an American Icon in England

The legacy of Eugene Smalley's efforts to breed a hardier elm lives on at Windsor Castle.

On a mild spring day in 1980, a handful of men gathered on the sprawling lawn of England's Windsor Castle, there to do a little landscaping. But these chaps wore suits, and one of them brought a silver-plated shovel.

The ornate spade cleared a hole for a new tree as any other would, but the laborer just happened to be Prince Philip, husband of Queen Elizabeth II. And the tree that would take root in British soil just happened to be a hybrid elm from America. This simple act was part of a broader campaign to save the species from widespread annihilation.

Accompanying Prince Philip that day was Eugene Smalley, a professor of plant pathology at UW-Madison who had been tasked with fighting the spread of Dutch elm disease (DED) more than two decades earlier. First identified in the Netherlands in 1919, DED quickly spread through Europe via elm bark beetles before arriving in the United States in 1930. Since then, more than 50 million American elm trees have been felled. The towering Ulmus americana once stood as an elegant staple in communities across much of the United States.

"The American elm tree has had a unique niche in American life," Smalley told The New York Times in 1989. "Before the disease, you could find streets lined with elms in almost every American town."

Ray Guries, a professor emeritus in the Department of Forest and Wildlife Ecology and a former associate of Smalley's, called the rapid decline of the American elm a "traumatic experience" for residents of urban areas. "When they disappeared, it was as though an icon had been lost."

Early efforts to halt the spread of Dutch elm disease were ineffective. Smalley was hired in 1957 as part of a state initiative, and he immediately went to work planting elm seedlings at the Arlington Agricultural Research Station north of Madison. This stand became known as "Smalley's Elms," and many can still be seen today as one drives northbound on State Highway 51.



Smalley theorized that hybrid species with natural pest resistance — not pesticides — offered the best defense against the beetles. Through 20 years of research, he and his colleagues produced several hybrids — Regal, American Liberty, New Horizon, and Cathedral — that proved to be hardy against the cold and generally resistant to DED.

Another promising hybrid was Sapporo Autumn Gold. When Prince Philip set one in the ground at Windsor Castle, he also planted the seeds of hope. That elm still stands today and has since propagated more than 100 others on the property.

Smalley died in 2002, but his legacy lives on. His disease-resistant elms have served as replacements all over the world. Even the embattled American elm may be bouncing back. Guries has spotted them being planted once again in Madison. Although it's unlikely ever to reclaim its former status, the tree and its hybrid cousins serve as reminders that Smalley's work will continue for decades.

"In developing the right tree, we don't deal in years," Smalley once told the Wisconsin State Journal. "We deal in generations."

-BEN VINCENT

The elm tree as it stands today on the grounds of Windsor Castle.

Catching a 'Silent' Cow Killer

UW scientists have developed a simpler detection system for sub-clinical ketosis to help dairy farmers stay ahead of the costly disease.



Heather White (left), assistant professor of dairy science at UW-Madison, talks with dairy farm owner and UW alumnus Mitch Breunig (right) at his farm in Roxbury, Wisconsin. White and her students are looking for ways to detect ketosis in dairy cows.

Mitch Breunig BS'92 has been around dairy cows long enough — all his life, to be exact — to suspect something was amiss with two of his Holsteins.

And he's been around the Department of Dairy Science long enough — considering he's an alumnus and his 450-cow farm in Roxbury, Wisconsin, is practically a field research station for the department to suspect ketosis.

This "silent killer" is caused by excessive toxic particles released by the liver, usually when a cow starts to produce milk after giving birth. So it was fortuitous that Heather White, an assistant professor of dairy science and one of the world's experts on detecting ketosis, was visiting Breunig's Mystic Valley Dairy, within sight of the St. Norbert's church steeple in northwestern Dane County, on that day in March.

The start of lactation is the moment of maximum metabolic stress for a dairy cow, when her overworked liver can crank out molecules called ketones that provide energy to other tissues in the body. But if ketones reach excessive levels, they can reduce milk output, set the stage for disease, and even cause the cow to be culled from the herd.

Milk output from the cows in question had dropped, which could have had many causes. Ketosis, however, appears in 40 to 60 percent of lactating American dairy cows.

Even though ketosis costs farmers an average of \$290 per cow, it's often undiagnosed because the blood tests are laborious and expensive. Far better would be a test for telltale molecules in the milk. which is exactly what White has been working on, in collaboration with dairy science department chair Kent Weigel MS'92 PhD'92 and Gary Oetzel, a professor of medical sciences at the UW-Madison School of Veterinary Medicine.

The result of their labor, called KetoMonitor, is now incorporated in the AgSource system used by dairy farmers across the state to track their herds and milk output. AgSource relies on a sophisticated spectrometer to look for two milk-borne compounds that signal ketosis and then refines the prediction through an advanced computer analysis.

When Ryan Pralle BS'15 and Rafael Caputo Oliveira, both graduate students who work with White, sampled blood from the two cows, Breunig's hunch proved correct. The cows had a silent, or

"subclinical," ketosis. Armed with that knowledge, Breunig began corrective measures that usually tame ketosis, such as dietary supplements.

Blood tests are the old-fashioned but still gold standard method for detecting ketosis. But KetoMonitor's milk tests and computation have become the first line of defense.

By testing milk from "fresh" cows every week or so, KetoMonitor first estimates the prevalence of ketosis in the fresh cows. Then, by analyzing the data on milk production, reproductive history, and other matters on each fresh cow, it identifies cows that might need a blood test for ketosis.

KetoMonitor already catches 85 percent of cows with the condition, which is almost enough to avoid blood tests entirely. Once they reach 90 percent accuracy, blood tests for every fresh cow would no longer make economic sense, White says.

To reach that magic number, Pralle is using a computational tactic called "machine learning" (think digital self-help class). When the software makes a mistake, it combs through the data, looking to do better next time around. The accuracy is improving, he says. "When we compare it to some other non-blood tests, I think our tools are very competitive."

White and her collaborators began tackling the problem about 10 years ago. "We recognized there is a lot of money lost in subclinical ketosis," she says. "A cow is having negative outcomes — she's making less milk and is not going to rebreed as easily, but she



PHOTO BY BRYCE RICHTER

The result of a blood

sample test used to

cows is displayed.

detect ketosis in dairy

can't walk up and tell you she's sick."

Due to the efforts of White and others at UW-Madison and beyond, that has changed. "Ketosis has become something that producers really want to manage because they recognize the cost of the disorder," says Pralle.

None of this is lost on Breunig, who sees a future with more constraints as a prime reason to focus on efficiency. "We will be in a position where we will need to grow more food on less land with fewer cows."

KetoMonitor can help in unexpected ways, Breunig says. "When we adapted to the market by eliminating BST [the hormone bovine somatotropin], we had to change nutrition and management, and we used KetoMonitor to assess the impact of those changes."

"Advances like KetoMonitor help us keep the herd healthy and allow us to stay competitive," he says. "That's the kind of help we really need."

—DAVID TENENBAUM

Frozen Fuel

What do you get when dairy plant experts team up with specialists from the athletics department? The answer is a tasty ice cream — with all kinds of added benefits.

Looking for a special way to take care of UW-Madison's studentathletes, director of performance John Dettmann and dietitian Jeremy Isensee BS'00 connected with Bill Klein BS'83, manager of the Babcock Hall Dairy Plant. After a long process of trial and error, they created a final formula containing tart cherry, known for its anti-inflammatory properties, and hibiscus, a potent antioxidant. Dubbed Frozen Fuel, the mixture has no lactose, about 30 percent less sugar than regular Babcock ice creams, and double the protein. It's topped off with probiotics and beet root for coloring.

And now anyone can enjoy the healthy perks of the new ice cream by purchasing a scoop (or a pint, or a half-gallon) at the Babcock Hall Dairy Store.

PHOTO BY JOSH KATHER, MITCHELL MONSON, AND NIK HAWKINS



Clean Tubers, from Test Tube to Plate

The Wisconsin Seed Potato Certification Program uses a high-tech campus facility to help keep spuds disease free for state farmers.

Years before that french fry landed on your plate, the plant that would eventually give rise to the spud your fry was cut from was sealed away deep in a secureaccess building, growing slowly in a test tube inside a locked growth chamber.

At least, that's the case if it was the product of the Wisconsin Seed Potato Certification Program (WSPCP), a 104-year-old CALS program dedicated to supplying Wisconsin seed potato farmers with quality, disease-free tubers.

All that security helps keep these important plants clean, and clean is a big deal for potatoes. Because they are grown from the eyes of tubers, or seed potatoes, rather than from true seeds, potatoes

Brooke Babler and Andy Witherell check on micropropagated potato plants housed in test tubes at the **Biotron Laboratory.**

can easily carry bacterial and viral diseases in their starchy flesh from generation to generation. The solution is exacting cleanliness and rigorous testing at every stage of potato propagation.

WSPCP supplies 70 percent of the seed potatoes for Wisconsin's 9,000 acres of farmland dedicated to propagating seed potatoes. The program certifies 200 million pounds of seed potatoes every year, enough to plant roughly 90,000 acres for commercial growing. Those spuds are then sold to commercial potato growers in Wisconsin, in other states, and around the world to be turned into farm-fresh potatoes, chips, and fries.

Each one of those potatoes' progenitors once

passed through the hands of two plant pathology researchers at UW-Madison, Andy Witherell and Brooke Babler BS'06 MS'10. In about three months, they can turn a handful of small potato plants growing in test tubes into hundreds. Multiply that by dozens of different varieties of potatoes — Caribou Russet, Magic Molly, German Butterball — and together Witherell and Babler produce tens of thousands of potato plantlets every year.

The two scientists work out of the Biotron, a facility on the UW-Madison campus designed to replicate any climate needed for research. The building's secure access and clean protocols help them scrub the potato plants of any diseases and propagate

> them in sterile environments until they're ready to plant in soil.

"This is a good place to grow plants because we've got a system that's really clean," Witherell says. "The Biotron air is filtered, and we have a clean room to work with."

The researchers start by sterilizing an eye of a tuber and then inducing it to grow in a sterile container full of a jelly-like growth medium containing bacteria- and virus-inhibiting chemicals. As the spud sprouts into a small plant, they ramp up the heat to try to kill off any viruses. Then they clip off a portion of the shoot and replant it in a clean test tube of growth medium.

Babler and Witherell can keep their plantlets in stasis in cold storage until the call comes in — 308 plantlets of Dark Red Norland are needed

by July. Babler pulls out a box with several plantlets and takes them to the clean room, a space about the size of a parking space. On a sterile work surface, she takes out a scalpel and slices the plants into several pieces before replanting them in a new box. Just a small portion of one plant's stem will grow an entirely new plant under the right conditions.

In this way, eight potato plants become 30. Four weeks later, those 30 become 80; then 80 become 310. They are all genetically identical clones of one another, and they are all still clean.

Thousands of plantlets of different varieties are shipped to the program's farm in Rhinelander, Wisconsin, where they are grown hydroponically



PHOTO BY BRYCE RICHTER

or in pots to begin producing tubers. Over several generations, one plant gives rise to many spuds, which in turn are replanted to make even more potatoes. In a few growing seasons, what once was handled by Witherell and Babler in the Biotron now weighs hundreds of millions of pounds and requires the work of two dozen independent, certified farms to manage.

Along their journey, the potatoes are screened for diseases that might have crept in. After Babler and Witherell leave the Biotron for the day (they only enter the facility once per day to better avoid bringing in pathogens from outside), they work in Russell Laboratories, where they help run diagnostic tests on potatoes to screen for viral and bacterial infections.

"Part of the certification process is to walk the fields and visually assess plants for the disease," says Babler, a native of Viroqua, Wisconsin, who earned her UW-Madison degrees in both plant pathology and horticulture. "You can visually assess plants, but sometimes you can't tell exactly what the disease is. So the inspectors ship the plants back to us, and we do diagnostics throughout the growing season."

As part of her research, Babler is developing an improved test for a relatively new potato disease, Dickeya. The bacteria can spoil up to a quarter of a farmer's yield under the right conditions and has



recently taken hold in North America. Seed potato programs like the WSPCP are designed to detect and restrict the spread of new diseases like Dickeya, which spread primarily through infected seed potatoes.

Only those potatoes with a healthy pedigree get the WSPCP seal of approval. A portion of the sale of each bag of potatoes that commercial growers buy, certified to be as clean as possible, supports this years-long, labor-intensive process.

It's a certification well worth the price — ensuring that Wisconsin potato growers continue to succeed, helping keep the state one of the top producers of potatoes in the country.

-ERIC HAMILTON

(Above) Microtuber potato cultivars used in research by the Wisconsin **Seed Potato Certification** Program inside an environmentally controlled growth room in the **Biotron Laboratory at** UW-Madison.

(Left) Workers at a potato farm near Coloma, Wisconsin, pick through harvested potatoes as they come down a conveyer system.

classAct

Caroline Hanson

The 'Patio Tomato Project'

For sophomore genetics major Caroline Hanson, growing tomatoes goes beyond community gardens and farms. It could be the key to healthier lifestyles.

With that in mind, she teamed up with campus and community partners in summer 2017 to distribute free patio tomato plants to low-income families, introducing them to



Caroline Hanson laughs as a young boy reacts to the taste of an unripe cherry tomato.

easy, low-maintenance gardening that yields health benefits and encourages long-term healthy practices.

Hanson's interest in food security began to take root after completing a First-Year Interest Group seminar in plant pathology with professor Jeri Barak-Cunningham. The course inspired her to secure a Wisconsin Idea Fellowship from UW-Madison's Morgridge Center for Public Service to help pay for the materials for her project. As

a part of the grant, she proposed teaming up with the River Food Pantry on Madison's north side to distribute the tomato plants. Hanson and her team of fellow CALS students grew the project's cherry tomatoes in two campus locations and then transplanted them into donated five-gallon buckets that act as inexpensive patio pots.

When distributing the plants during workshops at the pantry and community centers on Madison's north side, the team provides tomato care instructions, recipes, and arts and crafts for kids. They also offer free samples of dishes that incorporate cherry tomatoes — cheddar tomato cobbler, tomato risotto, parmesan tomato chips — many of which can be made for \$4 or less. The workshops get families involved in working with vegetables and understanding more about healthy lifestyles.

"The health benefits are obvious, and you see kids become passionate about something they can do on their own and is good for them and is good for their community," Hanson says.

The project was initially slated for a single summer, but Hanson is working with different organizations to secure funding for another year and eventually make it an official student organization. With possible expansion, Hanson is determined to keep the project simple and rooted in helping people.

"What we love about this project is, even if you can't start a community garden, it's focused on container gardening," Hanson says. "You don't need a fancy gardening system. You can just get a bucket and some dirt, and you can get to work."

-Andrew Pearce

RECOGNIZED as an outstanding mentor by the UW-Madison Ronald E. McNair Postbaccalaureate Achievement Program, **Shiela Reaves**, a professor in the Department of Life Sciences Communication who specializes in visual communication. The McNair Scholars Program helps undergraduate students prepare for the rigors of graduate education.

NAMED director of UW-Madison's Agricultural Research Station (ARS) network, Mike Peters BS'95. A system of 11 research stations located throughout the state, the ARS network provides facilities and support for various programs at CALS to help create and spread new knowledge in the agricultural and life sciences.

RECIPIENT of the Shaw Scientist Award, **Ophelia Venturelli**, an assistant professor of biochemistry whose work focuses on the function of microbes in the human gut. The award, which has supported early career scientists for 30 years, comes from the Greater Milwaukee Foundation and includes grant funding for projects aimed at finding innovative approaches to advancing human health.

CHOSEN as president-elect of the American Society of Landscape Architects, **Shawn T. Kelly**, faculty associate in the former Department of Landscape Architecture in CALS (now the Department of Planning and Landscape Architecture in the UW College of Letters and Science) and director of the UW Center for Sustainable Design.

SELECTED to receive Alfred Toepfer Faculty Fellow Awards, assistant professors **Amaya Atucha** (horticulture), Christelle Guedot (entomology), and Heather White (dairy science). The award is given to pre-tenure faculty whose research benefits agricultural activities in the United States and whose areas of interest lie in crop research, improvements in crop yield and quality, or animal sciences.

Number Crunching

FOR 50 YEARS, a long-term study,



PHOTO BY SEVIE KENYON BS'80 MS'06

the second-oldest of its kind in the country, at the Lancaster Agricultural Research Station has been exploring the effects of different crop rotations on fertilization needs and corn yields. The study originally set out to determine whether alfalfa could be replaced in rotation with corn by way of artificial fertilizer, but it has since expanded into many different rotations involving a variety of crops.

New Clues to Healthy Bones for People with PKU

For approximately 15,000 people in the United States, a vital amino acid can become their worst enemy.

Individuals with the metabolic disorder phenylketonuria, or PKU, cannot metabolize the amino acid phenylalanine. Without careful dietary management, it can accumulate at high levels in their blood, leading to cognitive impairment, seizures, and other serious health problems.

There is no cure for PKU, and patients must adhere to a lifelong diet of medical foods that contain protein but are low in phenylalanine. Traditionally, these medical foods have been made using synthetic protein substitutes derived from mixtures of amino acids. But these amino acidbased medical foods could be contributing to the skeletal fragility seen in many PKU patients, according to a new study led by nutritional sciences professor Denise Ney and Bridget Stroup PhD'17.

The researchers also discovered that an alternative medical food, developed by Ney from a protein called glycomacropeptide (GMP) — a natural by-product found in the whey extracted during cheese production — could allow PKU patients to manage their diets without compromising their bone health. This study represents the first human clinical trial comparing how different PKU-specific diets affect the bone health of people living with the disease.

Ney helped develop GMP-based foods for PKU patients just over a decade ago. In subsequent studies, she has shown that mice fed GMP-based diets have larger and stronger bones than mice on amino acid based diets. "It was a vital clue that there could be a link between amino acid medical foods and the skeletal fragility seen in many PKU patients," says Ney, a researcher at UW-Madison's Waisman Center.

For the current study, Ney and her research team assigned eight individuals with PKU to a diet of amino acid-based medical foods before switching them to GMP-based foods with a low dietary acid load. The researchers found that PKU patients had higher amounts of calcium and magnesium in their urine while on the amino acid based diet, a sign of bone breakdown, which can impair bone health.

"The amino acid medical foods have high acid loads, which can change the overall acid-base balance within the body," Stroup says. Bones are able



Denise Ney and Bridget

Stroup with a collection

of Glytactin GMP medical

foods, which were used in

a clinical trial investigat-

affect the bone health of

ing how different diets

people with phenylke-

tonuria, or PKU.

to buffer high acid loads in the body, but over time this leads to a breakdown and release of minerals. On the other hand, Glytactin (the trademarked brand name for the formulation used in the study) GMP medical foods do not have high acid loads.

Although the researchers did not directly measure bone breakdown and density in this study, other studies have found that reducing the acid content of diets leads to lower urine-calcium excretion and increased bone density.

These findings, Ney says, could also help patients with other kinds of metabolic disorders, like maple syrup urine disease. And although the sample size of the study was relatively small, it is typical of investigations into rare diseases; Ney hopes to secure additional funding for further study.

Ney is working on a larger clinical trial to study the metabolism of calcium and other minerals in PKU patients consuming amino acid or GMP medical foods. "We will be looking at bone health and also other physiological aspects, such as the gut microbiota," she says.

—ADITYARUP "RUP" CHAKRAVORTY

 $Disclosure: Denise\ Ney\ is\ a\ co-inventor\ of\ GMP\ medicals\ foods, which$ is licensed to Cambrooke Therapeutics through the Wisconsin Alumni Research Foundation. Cambrooke Therapeutics Inc. donated the GMP medical foods used in the study. A portion of the proceeds from the sale of these products helps fund further research at UW-Madison.

Five things everyone should know about . . .

Birds, Buildings, and Avian Mortality

By Anna Pidgeon

- Glass is invisible to birds. When birds see clouds or vegetation reflected in glass, they perceive it as open sky or habitat. Also, if they see plants on the inside of a building through glass, or if they see completely through to the other side of a building, they don't recognize that there is a solid surface in front of them.
- **Timing and location increase collision risks for birds.** When birds are in close proximity to expanses of glass that reflect habitat, they are in a dangerous situation. This can occur when birds are foraging during the day any time of the year. It can also happen during migration, when



many bird species launch into long flights around sunset; they fly for several hours and then land to rest and refuel. When they land near houses in unfamiliar territory, they risk running into glass as they search for food or fly toward reflections of what they typically use for cover from predators and weather.

- 3 New buildings present opportunities to decrease collisionrelated bird deaths. With new construction, a good way to design a bird-friendly home or commercial building is to use glass that has patterns etched into it, which breaks up reflected habitat images. This is called fritted glass; an added benefit is that it also helps control heat and light. For existing buildings with large glass expanses, films can be applied that decrease reflectivity. A great source for more information is collisions.abcbirds.org.
- Bird feeder placement matters. One best practice is to put feeders relatively close to a house or building. This may seem counterintuitive, but this way, when birds leave the feeder suddenly because they are startled, they can't build up enough momentum to hurt themselves if they mistake nearby glass windows for habitat. Placing netting between feeders and windows is another good solution. Also, because birds can perceive ultraviolet (UV) light, window decals have been developed that reflect the UV portion of the electromagnetic spectrum. Birds can see these extremely well, but people cannot, and sunlight still passes through. These decals need to be reapplied frequently because they degrade in sunlight. Other ways to break up habitat images are creating patterns with washable tempera paint and installing Acopian BirdSavers, which are evenly spaced nylon strings that hang in front of window glass.
- Birds face many risks beyond architecture. Buildings and glass are not the only major hazards for birds. Habitat loss is the primary factor causing avian mortality. Beyond that, best estimates point toward cats as the biggest direct mortality factor caused by humans. Building collisions are right up there at number two. Other mortality sources from humans include collisions with automobiles and communication towers.

Anna Pidgeon is an associate professor in the Department of Forest and Wildlife Ecology.

GUATEMALA



Back to Farming Basics in Guatemala

When Claudia Calderón touched down in the fertile highlands of western Guatemala, she was stepping into a sociological experiment already afoot.

What brought her to the verdant country in Central America in 2016 was a collaborative study conducted alongside her peers from Universidad de San Carlos in Guatemala. The group wanted to determine how two different types of small-holder farms (less than about 2.5 acres) perform in two key areas of sustainability — food security and climatic resilience.

The study compares semiconventional farms (those that use agrochemicals like pesticides, herbicides, and fertilizers and grow a comparatively limited array of crops) and agroecology-adopting farms, which largely eschew modern pesticides for organic alternatives and are characterized by a sense of self-reliance, a concern for community well-being, a deeply rooted land ethic, and a tightly knit "solidarity economy" where food production and exchange occur for reasons beyond capital accumulation.

"They're really focusing on the well-being of their families, of their communities," says Calderón, an assistant faculty associate in the Department of Horticulture. "And not just the individual profit, but also the community profit."

The first thrust of the study — food security is a prominent issue in Guatemala. Large parts of the country lack the proper infrastructure to transport excess goods to market in time, and most rural households need to buy more food than they can produce. Combine this shortage with high levels of poverty, and malnutrition follows.

The group also investigated the agroecological method's adoption and resilience to climate change. Agroecological farmers tend to grow a greater diversity of crops, including maize, bean, brassicas, leafy greens, potatoes, carrots, and fruits. This allows them to bounce back even if one crop is devastated by drought or rain. They also utilize terraces, contour planting, and live fences to mitigate the effects that washouts can have on their steep hillside plots.

"The whole world is talking about climate change, but particular regions of the world are especially vulnerable to the effects," Calderón says.

Both agroecological and semiconventional agricultural methods are not without their chal-





lenges. Political will is fragmented. Property rights are murky or altogether absent. Extractive industries take advantage of this, hoping to ply the ground for valuable minerals in the soil.

But Calderón is intrigued by the symbiotic relationship between Guatemalan small-scale farmers and their land. She notes that women have become more involved in decisions about crop management. The takeaway? A set of farming practices aimed at optimizing yields, rather than maximizing them, may hold promise for the future of farming in Guatemala.

"What consequences are coming from particular ways of doing agriculture?" says Calderón. "We need to see the whole picture and recognize the role that small-holder farmers play for food security around the world."

-BEN VINCENT

(Above) Don Dionisio, a farmer Claudia Calderón worked with in Guatemala, hangs heirloom maize to dry.

(Left) Claudia Calderón visits farmer Don Ocaviano's potato fields 12,800 feet above sea level.

Kernza: Perennial Crop with Perks

Agricultural systems have a major role to play in feeding the world while protecting the planet, and Valentin Picasso looks to new crops and new techniques that can further this monumental task.

Interview by Sevie Kenyon BS'80 MS'06 and Ben Vincent

VALENTIN PICASSO's career has taken him across two continents — and always from the ground up. His research as an assistant professor in the Department of Agronomy focuses on forage and grazing systems in the United States and around the world.

A native of Uruguay, Picasso earned his Ph.D. in sustainable agriculture from Iowa State University before returning home to teach for seven years at the University of Uruguay (UDELAR). Now back in the Midwest, he is intrigued by the ways sustainable agricultural methods, such as the use of perennial crops (those that can be harvested year after year), can build resilience to worldwide threats like climate change. Because perennials have deep roots, they hold soil in place, reduce water contamination, and rebound quicker from drought or extreme temperatures. One such crop is Kernza, which was developed through selective breeding of a Eurasian forage grass related to wheat. In addition to its use as feed for livestock and its environmental benefits, it also serves as a grain crop, weed fighter, and money saver, all of which is boosting its popularity among farmers.

Picasso is excited to collaborate with his new colleagues at UW-Madison. "There are lots of opportunities to develop interdisciplinary projects to solve the most critical problems we are facing today in terms of agricultural sustainability," he says.

And in an era of increasing globalization, Picasso has cast his gaze beyond the borders of Wisconsin. He maintains an international focus as he studies the agroecological intensification of grazing systems around the globe, especially in Latin America.

You're working with Kernza. Can you tell us what that is?

Kernza is a perennial grain and forage crop, so it is a dualpurpose crop. You can harvest grain out of it, and you can harvest forage out of it. Once you plant it, you can harvest it for many years. The grain can be used as human food, just like wheat; you can use it for flour for making bread. You can ferment it and produce beer or other drinks. We're also looking at weed management. This crop has the potential to really clean a field of weeds because it's really competitive. Once it is established, it outcompetes a lot of weeds.

Where does it come from?

This plant is originally from central Europe and Asia. It was introduced as a forage crop to the U.S. in the early 1900s, and it's been bred over the last 10 years by The Land Institute in Kansas. When you think about this, the breeding for grain of this crop started only 10 years ago. The breeding for grain for other crops started thousands of years ago and have been in modern breeding for hundreds of years.

And here in Wisconsin, which people are interested in Kernza?

The main interest here in Wisconsin comes from farmers who want to have a flexible crop that they can use for harvest grain, but at the same time they may have some dairy or beef — farmers who have cattle and want to be able to harvest forage or to graze this crop. So, we're doing research on what the impact of grazing is on the grain production. You can either graze it in the spring or graze it in the fall, before or after the grain harvest. So, it produces a lot of forage and a lot of biomass, but at the same time you can harvest grain, which is what everybody wants.

How long will it last when it's planted?

A crop of intermediate wheatgrass can last a long time. You can have it for 10 or 20 years. The grain production in the first two years is usually very good and then declines in the third year. We're trying to understand why this happens. Every time we talk to farmers, they're very interested in trying it both for forage and for grain. It would fit very nicely here in Wisconsin because we're a dairy state, and dairy farmers have that unique set of skills as grain and livestock farmers. So that's exactly what we need.



Valentin Picasso points out the benefits of Kernza, a perennial relative of wheat that can be harvested for grain and forage, at UW-Madison's **Walnut Street Green**house.

PHOTO BY BEN VINCENT

Is there any need for special equipment or agronomic practices?

Well, this is basically a forage grass, so anybody with machinery to plant forage grass can plant it. For harvesting, you can use a small grain combine. So, it's just normal agricultural practices. The main issue now is the learning curve for farmers because every new crop requires learning new methods.

What is the market for the grain?

There's a lot of interest right now in that grain. For instance, there's Patagonia Provisions, which is a food company that has just produced what they call "Long Root Ale," which is basically a beer brewed out of 15 percent Kernza grain. Recently, General Mills also announced that they are going to incorporate this perennial grain into some of their products in their organic Cascade Farms brand. And then there are a lot of restaurants and bakeries in the area where they are serving products with Kernza as part of their menu or as part of their baked goods.

So a farmer can market this grain if they grow it?

Absolutely. There's a large demand for that. There's a group called Ploygh [in Viroqua, Wisconsin] that a farmer should contact if they're interested in growing Kernza, and they can provide the seed and the basic knowledge how to manage this crop in order to get a harvest. We're very confident that the grain yields will increase. Because this is a new crop, there's a lot of agronomic management issues that we haven't figured out yet. What's the proper harvesting method? What's the proper harvesting time? What machine works best? What are the settings of the combine? All of these are things we're still learning. And that's what makes this really exciting. The research we're doing, everything we learn makes a change in the way farmers can manage the crop, so that's really exciting. And, really, commercial production started two years ago.

Any recommendations for a farmer who might want to try this?

The main thing is to start small. We recommend farmers try it in a small area and get familiar with the crop before deciding to go to larger acres. Ideally, we're looking for farmers who are familiar with growing grains. But at the same time, it's great if you have cattle. That way, you can either graze it or harvest the hay and give it to the cattle, and that's what makes it profitable right now — the dual use. Dairy farmers who are very used to harvesting grain and have cattle are clearly a good target for this grain.

At what point can we expect perennial grain crops to be as productive as annual grain crops?

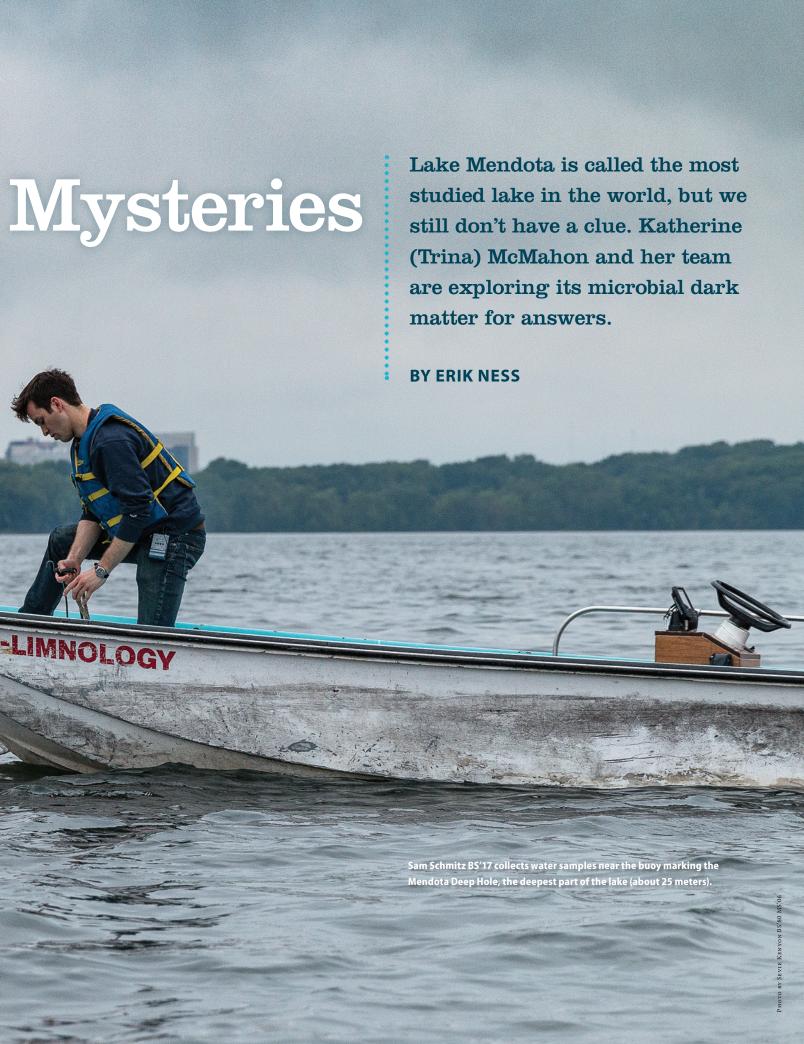
Yields of Kernza have been increasing rapidly and continue to grow. Kernza grain yields are between 400 and 900 pounds per acre in the first year. However, the productivity of Kernza is measured not only in terms of grain yield but also in terms of forage yield. Kernza can produce up to 5 tons per acre of forage on top of the grain yield, which can be grazed or hayed. And inputs like fertilizers, pesticides, and machinery passes are minimal, so costs are much lower than annual crops.

₩hat are the other advantages to Kernza?

The main advantage of growing this perennial grain is the environmental benefits. Because it's perennial, it covers the ground year-round for many years, so there's no soil erosion, there's no leaching of nutrients into the groundwater. It's a great way of conserving soil and water quality. It also has very deep roots, so the amount of carbon that it can fix in the soil is important. In a way, it's also reducing greenhouse gas emissions and climate change. The main reason you would want to develop this are the environmental benefits.

Wading through Mendota's





t was a silly question, so Trina McMahon laughed. What's more important: a lab coat or a Twitter handle? "Twitter handle, for sure. We don't do anything anymore in the lab," she says. "Probably a pair of muck boots is even more important. You've got to get dirty in the field and get your samples, and then maybe spend a day in the lab, but then you spend the rest of your time in front of a computer."

Microbial ecologists like McMahon use computers as their eyes. The bacterial communities they study — microbiomes in the human gut, in a Yellowstone geyser, in Lake Mendota are almost entirely invisible. How, then, to see? "What we're spending so much of our time doing in microbiome research is natural history, what the plant ecologists were doing 120 years ago, running around with their field notebooks," says the Vilas Distinguished Achievement Professor with appointments in both bacteriology and civil and environmental engineering. "Only our field notebooks are our sequencers."

It's the first golden age of microbiome discovery, and this generation of microbiologists has little need for a microscope. Instead they use increasingly sophisticated techniques to read the genetic code of entire ecosystems, running complex statistics on powerful computers to sketch their specimens. It's undoubtedly a paradigm shift — in humans, for example, it's been suggested that the human microbiome is so important to human health that it's like discovering a new organ system.

Could the next breakthrough come from Lake Mendota?

ake Mendota is often called the most studied lake in the world. That's in part because Edward Birge and Chancey Juday helped launch the science of limnology at the University of Wisconsin. The Center for Limnology has been a locus of world-class ecological research for decades, developing some of the most complex ecological models in the world.

It now also happens to be the lake with the world's most amassed microbial data thanks to 18 years of methodical sampling now overseen by McMahon's lab. This shared focus on Lake Mendota implies a certain kinship of purpose, but it also stokes a friendly intellectual rivalry.

McMahon knows all about Lake Mendota's fabled scholarship, but she has her critique: those models ignore microbes. The limnologists say that the microbes are always there, in pretty much the same numbers, and they always do pretty much the same thing: turn dead things back into their constituent nutrients and carbon dioxide. Why worry about them?

"I think Trina has been very bold in being willing to do the Birge and Juday thing, the pure descriptive phase of it," says recently retired UW Center for Limnology director Stephen Carpenter. "As a basic science enterprise, I totally support it."



PHOTO BY SHARON VANORN

At the same time, he acknowledges it wouldn't be hard to find ecologists who would question the return on investment so far.

"That kind of modeling is very important," McMahon acknowledges in return. "But it glosses over all of the mechanism. I want to understand the mechanism."

Just one example: over the last decade, microbial breakthroughs have rewritten our understanding of the nitrogen cycle, the natural processes that convert nitrogen in the environment into different chemical forms. "Because there may be something in the mechanism that fundamentally changes the coarser scale models in a way that you can't predict."

obin Rohwer winces as she opens her laptop to launch R Studio, an interface used for statistical programming. Her left middle finger is broken and bruised, the result of an epic race-day capsize in Lake Mendota. It was so windy the race was canceled, and five of the six sailboats dumped on their way back in.

A lifelong lake junkie, Rohwer knows lakes, the look and feel of them. If you told her what microbes were present, she could probably tell you the color of the water. But if you broke out mugshots of Lake Mendota's most common bacterial species, she wouldn't recognize a single one. For a fish biologist or a botanist, that would be unthinkable.

Rohwer uses R Studio as her X-ray spectacles. She wasn't a programmer when she started in McMahon's lab in 2011, but now she has a library of personal code. "I just make a loop and look at it in a ton of different ways," she says. By season, by week, by top 10, by temperature, depth, and light intensity.

"Respect the microbes" is a motto printed on the back of one of Trina McMahon's T-shirts.

The resulting kaleidoscope of graphs are exploratory plots that guide her toward a more intuitive understanding of the data. "When I visualize them, what I see in my head is the curve over time," she says. "Is it spiky? Is it smooth? That's how I think. Even if you don't see a pattern, it gives you an idea of something to start with."

It's a necessary perspective given the crazy diversity of microbes. Rohwer's been trying to decode 11 years' worth of bacterial samples collected from the deepest point in Lake Mendota between 2000 and 2011. The mission: identify *everything* in these 95 samples.

During this time, as many as 29 fish species were found in the lake alongside 18 species of zooplankton and 16 species of aquatic plants. For microbes, the magic number *might* be 17,437. That's not 17,437 species, but 17,437 OTUs, or operational taxonomic units. "We can't use the word species because that's taken by the microbiologists," she says. They have very strict definitions of a microbial species. "But we need to call it something in order to work with it."

Microbes facilitate the cycling of almost every nutrient through the lake ecosystem, and their DNA contains signatures of these chemical reactions. Rohwer uses these signatures and other genetic fingerprints to sort the microbes into OTUs. What emerges is a rough picture of "who" is probably doing what.

While the majority of bacteria survive using fairly basic life chemistry, bacteria are so prolific and diverse that you can't rule out the possibility of something really funky, something you couldn't even imagine. It's microbes, after all, that have evolved to survive temperatures above boiling and to tolerate toxic heavy metals. "Microbes are crazy diverse," McMahon says. "We don't know if 17,437 actually means that there are truly 17,437 different ways of making a living in the lake, or 25. That's one of the things that we're trying to figure out." Those 25 OTUs are the most common threads, present most of the time, and clearly the workhorses of the lake.

Then there's the remainder, making up the majority, called the "long tail" because that's what their frequency of occurrence looks like when plotted on a graph. Most of these 17,437 OTUs occurred only once, on one day, but this rare biosphere makes up a huge proportion of the data set. "What is this deep diversity doing in the ecosystem?" Rohwer asks. This is a primal question driving microbial ecologists, but she just shrugs: not enough data.

Realistically, they have little idea of what even the common bacteria do. Consider AC1, by a long shot the most prosperous family of bacteria in Lake Mendota. "AC1 is just so abundant and nobody knows what it does," Rohwer says. But here's the kicker: Twenty-five years ago, nobody even knew that AC1 even existed.

Data in the Depths

Investigating Lake Mendota's microbial mysteries requires mining the water for data, but it's not as simple as walking to the shoreline and dunking a bucket under the waves. It's a long, meticulous process of equipment preparation, sampling, and storage.

Students working in Trina McMahon's lab collect samples twice a week from "ice off" (roughly late March) to lake freeze (usually December). Each boat trip takes them to the buoy marking the Mendota Deep Hole, the deepest part of the lake, where they measure water clarity, sunlight penetration, pH levels, temperature, conductivity, dissolved oxygen, and barometric pressure. Next, they collect two water samples using a 12-meter tube, which yields an integrated sample of the entire water column down to that depth. Each sample is stored in a 4-liter container for transport.



A basket of sampling tools rests on the floor of a motorboat.



Sam Schmitz BS'17 lowers a weighted sampling tube.

OS BY SEVIE KENYON BS'80 M.

Microbes are infamous for all kinds of funky metabolic tricks, but this could change the way we think about lakes.

n the beginning, there was the Great Plate Count Anomaly. Early microbiologists noticed that while microbes were abundant and ubiquitous, most of them would not grow in the lab. Even today, it's estimated that fewer than 1 percent of bacteria sampled from the environment can be cultivated using standard laboratory methods. It wasn't until sequencing breakthroughs in the 1990s that scientists could begin to close in on these cryptic microbes.

The most amazing story of microbes hiding in plain sight is an order of tiny oceanic bacteria called SAR11. Until 1990, SAR11 was nothing more than microbial dark matter. But once its genetic signature was catalogued, SAR11 was discovered to be prolific beyond belief — numerically, its various species comprise about half of the microbes in the ocean. When they discovered a virus that infects SAR11, it took little more than a back-of-the-envelope calculation to declare it the most abundant organism on the planet. This is how a microbe shakes up the world.

Before long, the hunt was on for a freshwater equivalent to SAR11. DNA from AC1 was first recovered from an Arctic lake in 1996, and since then it has been discovered in every lake that's been examined. Like SAR11, it is dominant, particularly in Lake Mendota, which McMahon calls an AC1 factory. "They're so small that sometimes people probably thought they were viruses," she says. "We knew that there was something, but we didn't know their names or anything

When Alexandra Linz arrived in McMahon's lab in pursuit of her Ph.D., McMahon suggested a high-risk, high-reward project: cultivating AC1. It's never been done, and success could launch a career. Every month or so Linz collected another sample from Mendota and she'd inoculate another 96 cultures, each recipe unique. She'd return a month later, but nothing took. After a year of this — more than a thousand tries — Linz realized that the potential number of variables in play compounded to a frighteningly large number. She wanted a Ph.D. project, not a lottery ticket, and moved on to broader survey work comparing lakes in northern and southern Wisconsin.

Basic comparisons can be made by using different sets of sequencing data, such as DNA and RNA. "Looking at the genomes is like looking in someone's toolbox," Linz says. "You can probably tell what profession they are, a woodworker or a plumber, just by what tools they have in their toolbox. But looking at the RNA is like looking at what tools they have out on their workbench. What are they doing right now?"

Her Ph.D. work is focusing on the role of microbes in carbon cycling in lakes (an area of particular value in understanding climate change). But along the way she also got involved in looking at seasonality — how the microbial community changes from year to year. Seasonality is one of the baseline rhythms of biology, patterns that humans have probably observed since even before we became humans. Seasonal variation, particularly in lakes that ice over regularly, is a cornerstone of lake science.

Surprisingly, Linz found no seasonality in the microbes that live in a certain kind of lake in northern Wisconsin. "I've looked at the data every way I can think of to try and find a seasonal trend, but I haven't been able to find one," she says. Previous studies had found seasonality in other kinds of lakes, but they'd also noted a higher degree of variability in summer. "Maybe it's not so surprising that we can't predict the summer community based on the previous year," Linz says. But still, the finding hints at a layer of difference and complexity separating microbial ecology and its coarser-scale cousins.

Is there a longer cycle or a more complex link to weather that can't be seen because we haven't been looking long enough? Or maybe, after another decade of research, we'll realize that it's just a dice roll? "We know there is an element of randomness in microbial communities," Linz says, apparently only a little frustrated by the endless enigma. "I think it's really fun that there is so much unknown about microbial ecology. It's a young field, and there's a lot we still have to discover."

inz's efforts to cultivate AC1 in the lab were not wasted. A few cultures produced a drastically reduced mix of microbes, including AC1, and were sequenced to figure out if cooperation was their survival secret. Then Sarahi Garcia, a visiting scientist from Uppsala University in Sweden, helped McMahon's lab sequence a single AC1 from Lake Mendota, part of a search for the light-sensing protein rhodopsin, which had been found in other AC1 specimens. Already well understood because of its sensory role in vision, there's also growing evidence that, in microbes, rhodopsin doesn't just sense light but can also capture its energy.

This is not in your father's biology textbook, and it probably wasn't in yours, either. Microbes are infamous for all kinds of funky metabolic tricks, but this could change the way we think about lakes. "It's a way to get energy without using chlorophyll," McMahon says. "There could be all of this biomass and energy generation going on that we're not accounting for in our models that assume chlorophyll is a main driver."

The best way to prove it would be to create a pure culture of AC1 and show that it can survive on light alone. But recall the Great Plate Count Anomaly and how nobody has successfully cultured AC1. That leads you back to the genome.

AC1 has a very small genome, McMahon says: "Like crazy small, endosymbiont small." She's talking about bacteria that evolve in a symbiotic relationship with an organism and rely on their host for so much that they can afford to jettison many genes. "To find a genome that small in a free living organism is weird."

So AC1 is incredibly abundant, which is to say, highly successful. It also has a very small genome, but its genes include the ability to manufacture rhodopsin. So it stands to reason that the rhodopsin is doing something. But what?

To help unravel the puzzle, McMahon approached her UW colleague Katrina Forest, a bacteriologist who studies photoreceptors — proteins that respond to light. Forest was intrigued by the science and tickled by the implication that everything we understand about the equations for carbon and energy balance in lakes, and not just Lake Mendota, may be askew. "I love it when you realize that, even in our advanced times, when you can justifiably think we've already solved most of the big problems, that there is something so completely not appreciated and novel," Forest says.

Forest's lab has been hard at work teasing out details on a molecular level, getting closer to understanding what the rhodopsin is doing. "We still don't have any proof that AC1 is doing primary production in the lake, but it certainly has got all of the jigsaw puzzle pieces," she says. "This organism is encoding this phototrophy system that really is brand-new in terms of understanding how the lake ecosystem keeps itself alive."

A similar investigation is playing out in the oceans over SAR11, which also has a rhodopsin structure. Dueling calculations disagree over whether primary production is even possible, though McMahon says that the current consensus is that SAR11 isn't doing much of it. One theory is that the rhodopsin may help the microbe survive extreme conditions.

"Nobody has done the calculations in lakes, and I'm not even convinced that the calculations they have done in the ocean really account for everything," McMahon says. She's not willing to declare victory on her AC1 primary production theory, but neither will she concede.

"If they didn't have this, then they probably wouldn't be so ubiquitous and abundant," she suggests. "I think it's still open. I mean, that's your sense of mystery, right?"

he preponderance of evidence in Lake Mendota is clear: phosphorus is the problem. Too much phosphorus leads to an overgrowth of algae, which leads to stinky, pea green lakes. Even McMahon concedes, yes, phosphorus is the driver, the catalyst, the baddest of actors.

Pack in the lab, a small portion of each sample is placed in a tube with a compound that prevents organic cells from bursting when frozen. These samples are preserved so individual cells can be extracted and put through genomic analysis in the future. Larger portions of each sample undergo a filtering process.



A filtration system captures organic material in water samples.



Filters are carefully folded and placed in vials.



The vials and their contents are frozen for future testing.

OS BY NIK HAWKINS



And yet, she really thinks we should be paying more attention to nitrogen. Partly this is about her fascination with AC1. They clearly play a role in the nitrogen metabolism of the lake. But she's also shown that nitrogen may well play a role in the eruption of cyanobacteria that have the ability to turn the lake from merely unpleasant to toxic.

To understand how, you need to envision summer, when the lake is stratified — warm water on top, cool down below. This happens because as water warms it expands and gets less dense. The density difference is so extreme that, once a lake stratifies, the warm and cold regions can't be mixed until the top layer cools in the autumn. Stratification has profound effects on almost everything in the lake. The top layer keeps refreshing its oxygen by mixing with the air. Dead things drift slowly to the bottom to rot. Before long, the oxygen in the bottom layer gets used up. The microbial community switches into anaerobic decomposition.

"So down at the bottom you've got all these microbes cooking, breaking down the dead stuff, making those nutrients available again, but they're trapped down there until the fall," McMahon says. In that autumnal mix, the entire lake rapidly becomes saturated with oxygen and nutrients. Quite often there are huge, nasty cyanobacteria blooms, but these go largely unnoticed because people aren't boating or swimming.

Then the lake, well mixed with oxygen and nutrients, freezes. There's not much sampling under the ice, but the

microbes are still active until, eventually, the spring thaw comes. Nitrogen can take many forms in the environment; in the fall, ammonia is abundant but gets gradually converted under the ice to nitrate. How early the ice forms and how long it stays influences the ratio of ammonia to nitrate at ice off.

Phytoplankton, or regular algae (not the cyanobacteria), prefer ammonia, so they'll consume that first, then start to work on the nitrate. This ratio between ammonia and nitrate, combined with climatic conditions, seems to be a trigger for cyanobacteria bloom. Underneath the ice, the nutrients from the previous summer sit, an echo in the system. McMahon sees this nitrogen reverberate through the microbes in the lake, a rolling mix of cause and effect, and revels in the effort to untangle it all from a background of climate change, land use, and natural variability. "It's possible there is a pattern that we haven't seen because we haven't been looking long enough," she says. And then she laughs: "That's the usual basic science cop-out."

She dreams about finding the key to making all cyanobacteria go away, some microbial trick to starve it of phosphorus, but she knows her field is just at the very beginning of even being able to imagine such innovation. "I want to be able to do something to the system to fix it, not just study it," she says. "But we're pretty far from being able to do something like that."

(Left) Robin Rohwer uses a power auger on Lake Mendota to drill a hole through the ice for water sampling during the winter of 2015.

ake Mendota through the eyes of Trina McMahon is a bit of a paradox. The lake has its seasons, but the microbes may not. It's got incredible diversity, yet we can't even name what's there. Its most common species could be doing the most uncommon things with sunlight. And it's got a phosphorus problem — but don't forget the nitrogen.

"It has this reputation of being the most studied lake in the world, but it's also kind of a weird lake," McMahon says. With high calcium and magnesium concentrations, it's not, chemically, an average temperate lake. It also has a diverse mix of agricultural and urban influences. "Taking what we know about Lake Mendota and extrapolating it to all the lakes in the world is very difficult because it is not really a textbook lake," she says. "But it is the one in the textbook." And she laughs again.

Indeed, Lake Mendota is at a difficult place in its history. In the last decade, it's been hit with a succession of shocks, including two major invasive species and increasing precipitation from climate change. Water clarity is in decline again. State and federal support for research funding and environmental regulation is in serious doubt. Carpenter — perhaps the preeminent aquatic ecologist of his generation — is stepping down.

Carpenter's not going to give microbes or microbial ecology a free pass. Ecologists know that basically all roads lead through microbes, that they are the gatekeepers in nutrient flow through ecosystems. Yet despite an enormous amount of effort, we still don't know how those flows are blocked or limited or enhanced by different microbial groups. "It turned out to be a lot harder than anybody knew," he says. "If you really want to know the rate of sulfate reduction, you might just be better off to measure the rate of sulfate reduction instead of worrying about who did it."

But he also reminds critics that breakthrough understanding was lacking in all branches of ecology for a long, long time. "If we don't really delve into this microbial structure question, we're never going to bridge structure and function in the microbial world," Carpenter says.

That's the challenge for McMahon and her colleagues. On her docket right now is a closer look at how microbes affect mercury in the lake, and she also works downstream with wastewater treatment, where microbes help remove excess phosphorus from the system. Meanwhile, rapidly advancing technology combined with the ongoing in-depth lake studies have generated a backlog of data and hypotheses to test.

"There is just so much that we don't know," McMahon says. "Yes, it's awesome because it's the most studied lake in the world, and we're famous for that reason. But we also don't understand it at all. It's weird. How can that be? We should understand everything if it's the most studied thing, right?"

The filtered portions are frozen and used later to determine the nutrients present in the water at the time of sampling. The filters themselves (and everything they caught) are carefully folded, placed in small tubes, and frozen for future DNA extraction and genomic analyses. The readings taken during sampling and the steps taken throughout sample processing are all painstakingly recorded in a lab notebook and also entered into a database.



Undergraduate Anna Schmidt preps filtered water for cold storage.



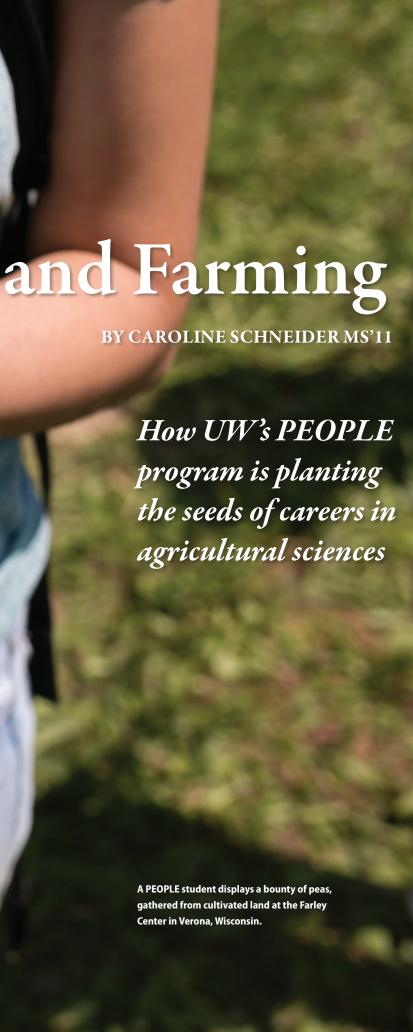
Rows of water samples stored in a freezer.



A lab notebook details two days of sampling.

TOS BY NIK HAWKINS





It's a bright summer afternoon

in 2016, and UW-Madison undergraduate Donale Richards accompanies a small group of high schoolers on a visit to the UW Dairy Cattle Center. They meet the cows — with a mix of excitement and trepidation — and peruse the milking equipment to fully appreciate what goes into milk production. The group then finds itself in a sunlit room occupied by a single Holstein. She has a small, circular door in her side — a fistula.

When their tour guide asks if they want to reach inside to feel the contents of the cow's stomach, most students look unsure. Their noses wrinkle in response to the distinct aroma of the barn and the unusual opportunity in front of them. But one young man steps up to be the first. He reaches inside, a look of awe on his face as he clutches the remnants of the cow's recent meals. Not to be outdone, Richards follows suit, announcing, "Well, I better give it a try!"

An incoming senior at UW-Madison at the time, Richards was serving as a coordinator for PEOPLE (Pre-college Enrichment Opportunity Program for Learning Excellence), which introduces underprivileged teens to the UW-Madison campus, a place they may otherwise know little about. His group of students was taking part in the food and agricultural sciences arm of the program.

Throughout their stay on campus, the students saw many aspects of what the university has to offer. But that summer day in 2016 they learned about a quintessential Wisconsin animal — the dairy cow. They also got the chance to experience some of what researchers do. The contents of cows' stomachs are studied for a number of purposes, including identifying ideal diets, improving milk production, and understanding bacterial communities in the gut. This is why some cows are implanted with fistulas, which serve as a painless and sealable passageway to the gut. The awed (and disgusted) high school students had a rare chance to see — and feel — that research firsthand.



PHOTO BY SEVIE KENYON BS'90 MS'06

"This was certainly their first chance to reach inside a cow's stomach, and for most, even just walking into a dairy barn is a new experience," Richards says.

PEOPLE has been providing opportunities like these since 1999. A college pipeline for students from socioeconomically disadvantaged backgrounds, PEOPLE provides college preparation services and builds academic, interpersonal, and communication skills while also helping students explore academic and career interests. More than half of the program's students are admitted to UW-Madison, where they receive a four-year tuition scholarship. The program's first-year retention rate for college scholars is around 90 percent.

For high school students in the program, the summer provides a chance to live in campus dorms and become fully immersed in the college experience. As soon-to-be, or "rising," sophomores and juniors, students stay on campus for three weeks. Rising seniors take part in a five-week curriculum that includes an internship or research experience. All of these programs are meant to give students who may otherwise not think about college a chance to explore and consider it for their futures.

"It's very rigorous for these students," Richards says. "They are living away from their families, and it can be difficult at first. But it's a great exposure to the campus, and living in the dorms is their first opportunity to experience the university."

Richards knows about the experience firsthand — he is a PEOPLE scholar himself. He took part in the program for a decade, starting in middle school

(Left) Donale Richards took part in PEOPLE for a decade, starting in middle school and earning his UW-Madison degree in August 2017.

(Below) For PEOPLE students, a tour of Babcock Hall always ends with ice cream and a smile.

(Right) PEOPLE students examine the equipment in the milking parlor at the Dairy Cattle Center on the UW-Madison campus.



Рното ву Ветн Skogen

and earning his UW-Madison degree in August 2017. As a coordinator of the summer program, he also served as a role model for its high school students — an up-close example of someone who had benefited from the PEOPLE program.

"The biggest thing I think I'll take from the PEOPLE program is the network," says Richards. "I saw different kinds of opportunities and met people I would have never met. It has really influenced me to make better decisions about what I want to do with my life. And now I get to share those lessons with new students as they go through the program."

RISING JUNIORS The Three-Week Program

CALS has been involved with the PEOPLE program for several years, providing internship opportunities for high school students entering their senior years. In 2012, CALS partnered with PEOPLE to develop a program that introduces incoming high school juniors to careers in food and agriculture while

providing a more complete exploration of the various fields they can pursue.

Their days are spent in a variety of settings. In the mornings, students attend classes to improve math, science, writing, study, and life skills, and they dedicate afternoons to exploring food and agriculture through field trips, lectures, and workshops. For many, these hands-on experiences are the most memorable and are best at helping them understand potential careers.

For one of the 2016 cohort's first field trips on campus, they visited the F.H. King Student Farm, located near the Eagle Heights apartments on the west end of campus. Under clear blue skies, volunteers from F.H. King Students for Sustainable Agriculture showed their young charges around the half-acre plot and introduced them to a variety of plants. The PEOPLE students excitedly pulled carrots and beets from the ground, some expressing amazement at how familiar foods look while growing.

Other field trips included a visit to the aforementioned Dairy Cattle Center and a trip off campus to the Farley



Рното ву Ветн Ѕкоде

Center, a nonprofit organization located just outside of Verona, Wisconsin, that promotes ecological sustainability, social justice, and peace. Each of the field trip locations introduced PEOPLE participants to students, faculty, and professionals working in food and agriculture.

When asked about their favorite parts of the program, it's clear the students find the hands-on experiences and field trips to be the most enjoyable and the most effective. Many students named the Dairy Cattle Center and the garden and farm tours among their favorites, and almost all of them appreciated the interactive learning.

For Tom Browne, CALS senior assistant dean, this introduction to food systems is an important part of the food and agriculture program. He wants to connect students to fields they may otherwise think little about.

"A lot of these students come from urban areas, and they completely dissociate themselves from agriculture and what they think CALS is all about," Browne says. "We try to provide programming that shows them how it affects them and their communities. We want them to have a greater understanding and appreciation of the agriculture world. We try to make those connections for them."

And this is precisely the outcome for many students. As one wrote bluntly on a program evaluation, "When I first came into the class, I thought I'd hate it, but it was actually really fun, and it's now something I'm interested in."

Shaping students' perspectives about agriculture was part of the master plan for Steve Ventura, a professor of soil science and environmental studies, and one of the main drivers behind the PEOPLE food and agriculture program. He was lead author of a U.S. Department of Agriculture grant that established the Community and Regional Food Systems project. This project, which brought together several universities, UW-Extension, and dozens of community partners in eight cities to foster innovation in urban food systems, includes PEOPLE as one of its educational arms.

Inspiration for the grant and the PEOPLE program involvement came from Will Allen, the founder and CEO of Growing Power, a national nonprofit

organization based in Milwaukee, Wisconsin, that supports people from diverse backgrounds by helping to provide equal access to healthy, safe, and affordable food. Allen strives for what he calls the "Good Food Revolution," a plan to grow healthy food and, in turn, healthy communities.

Ventura wanted to instill those same messages in students and use some of the grant money to develop the program in partnership with PEOPLE. "Food, or at least healthy food choices, are limited in some areas," he says. "The idea of taking control of the food system and having independent choices is important. If nothing else, we want to make people, especially young people, more aware of the opportunities to have more say in their food systems."

RISING SENIORS The Internship

Once they reach their third year in the food and agriculture program, seniors take part in an internship that provides an even larger window into food

(Right) Interacting with familiar foods like beets and carrots while they are still growing is a new experience for many PEOPLE students, one they get to indulge in at the F.H. King Student Farm on the UW-Madison campus.

(Below right) Steve Ventura, a professor of soil science and environmental studies who was one of the main drivers behind the PEOPLE food and agriculture program, participates in a "pizza launch party" with the students who developed the recipes.

(Below) A PEOPLE student samples the peas grown at the Farley Center in Verona, Wisconsin.



systems. In recent years, interns created a healthy, frozen pizza, taking the project all the way from raw ingredients through the preservation and packaging stages. Greg Lawless, an outreach program manager with UW-Extension who oversees the internship, has worked for the past two years with Will Green, founder and executive director of a Dane County youth mentoring program called Mentoring Positives, to create the product.

"I was seeing a gap between growing food and eating the food, so I helped develop an internship around food science," Lawless says. "Food processing, making nutritious food and getting it out to communities, is a big need, and a great opportunity for companies and researchers. In 2015, we came up with a whey protein bar, and the past two years were devoted to the frozen pizza project."

Seniors and students from the Mentoring Positives program work closely with Lawless as well as volunteer undergraduates and faculty and staff members from UW-Madison and Madison College to plan and devise their food product. They also visit with chefs and other food development experts.

"We really have a giant team sup-

porting us," Richards says. "The kids get to meet with important players in the industry, and the industry, in turn, gets to inspire the next generation of professionals."

In 2016, the interns took what they learned back to the UW Food Application Lab in Babcock Hall to develop each component of their pizza, from the dough and sauce to the cheese and toppings. After a couple of weeks of learning and experimenting with their pizzas, the seniors invited Richards and the juniors to taste their creations. The joint session gave the juniors a chance to see what they could be working on the next year as interns, and it gave the pizzamakers valuable feedback that they used to tweak their product.

At the end of their summer session, rising seniors took part in a pizza launch party at the Salvation Army of Dane County, where Green and his Mentoring Positives students welcomed the PEOPLE program and honored guests, including potential partners and donors. The students presented their pizzas, including production and marketing strategies. As guests taste-tested the pies — ranging from spinach and tomato to green olive and

mushroom — the students sat down to talk about their experiences in the program. Their enthusiasm shone as they reflected on the summer and indulged in their creations.

Some of the interns began to sound like connoisseurs. "This was all influenced by traditional Italian pizza," one student says. "A major focal point was to create it from scratch to ensure a healthy frozen pizza. We have only vegetable toppings, wheat in the crust, no sugar in the sauce, and less cheese than most frozen pizzas."

Another student gushed about the power of collaboration. "The pizza is gorgeous. It didn't start out this way, but now it's absolutely beautiful to see our product. The cool thing is we had PEOPLE program kids, Mentoring Positive kids, UW kids, so we tried to blend different people's tastes together. I'm trying to not be too sentimental because this is so different than when we first started. This tastes like it was professionally produced, and it's crazy to say that we did this!"

Another boiled his satisfaction down more succinctly: "Dude, this tastes amazing."

The PEOPLE Program's **Lasting Influence**

The positive feedback and enthusiasm of the students is what excites Browne. "I see a lot of really talented and motivated students come through the program," he says. "It's energizing to be reminded that there are a lot of talented kids out there who just need some encouragement. Watching them have these light bulb moments is really rewarding."

Lawless has also found his work with PEOPLE students gratifying. Not only is he able to teach and mentor rising seniors through their internships, he also works with PEOPLE scholars after they become UW students.



PHOTO BY NIK HAWKIN

"I have been on campus for 26 years, and I've worked with tons of students," Lawless says. "Five of the best have been PEOPLE scholars, and Donale is the latest in a long line of really exceptional undergraduates. Even once they get into their careers, we want them to come back and interact with new PEOPLE students."

That network of support and encouragement exemplifies the benefits of PEOPLE and the goals of the food and agriculture program. CALS faculty involved in the program hope that more students are able to take advantage of the opportunities provided by the program and find their passion. For Isaiah Gordon, a junior in 2016, this is exactly what PEOPLE provided.

"The rigorous classes have prepared me for the upcoming year so that I can go above and beyond in school," Gordon says. "One class I found particularly great is the food systems course. It provided me with hands-on experiences that promote health and sustainable food. It has changed the way I eat and how I view the world. There were many field trips that gave me the opportunity to explore different careers in the

food system. I recommend anyone get familiar with the food system because this ultimately can help our society in the future.

"The PEOPLE program also gave me the opportunity to connect with others and meet new friends. I can't think of any other program that gives me all the benefits this program gives. I'm glad to be part of it."

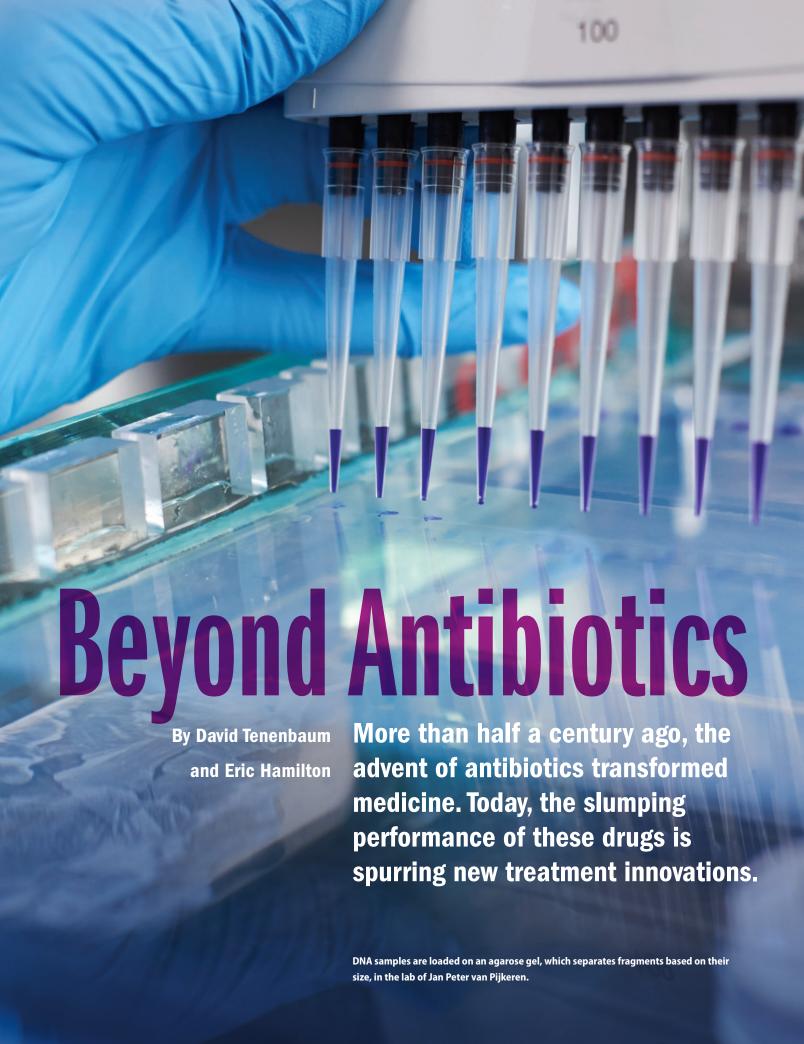
Experiences like Gordon's speak to the heart of what PEOPLE and CALS are trying to achieve. And it's a mission that Richards takes pride in forwarding. Richards graduated in August 2017 with a degree in biological systems engineering and also spent time during the 2017 summer with the PEOPLE program — this time working with Mentoring Positives students as the pizza project manager. He says he hopes to remain involved with the PEOPLE program as much as possible.

'I love working with PEOPLE students and giving back to the program that brought me into this university," Richards says. "I'm actually able to teach them and advise them on healthy lifestyles, and to me, that's so important for minority communities because they



don't often have that type of role model.

"So the more people we get into this field, the more people we'll impact in the long run. It's important to me to get youth involved in projects like these because they get the exposure they might not get otherwise, and we can give them the ability to return to and improve their communities." 🛚



Jan Peter van Pijkeren works with Laura Alexander, a doctoral student of microbiology, in his lab.

ince the beginning of their widespread adoption in the 1940s, antibiotics — the antimicrobial drugs we use to treat bacterial infections — have saved millions of lives. In recent years, however, misuse and overuse of these drugs in human medicine have helped put us on the path to a worldwide crisis. In this environment, harmful bacteria can evolve more rapidly, developing higher and higher levels of resistance. As a result, our "wonder drugs" are losing their effectiveness. This leads to longer and more complicated illnesses; greater risks for spreading infections; more hospital visits; the use of stronger, costlier, and more toxic drugs; and, ultimately, more deaths. Fortunately, scientists at CALS are facing this challenge head-on. From alternative forms of treatment to better methods of infection detection, here are some of the solutions they are working to bring to the world of modern medicine.

Friendly Microbes

Microbiologist Jan Peter van Pijkeren looks at probiotics — those microbes thought to provide health benefits in our bodies — as more than just friendly bugs. He sees them as a way to sneak in antibiotic-free treatment for diseasecausing bacteria like Clostridium difficile.

Known as C. diff, this resilient gastrointestinal pathogen causes stomach pain, diarrhea, and potentially lifethreatening inflammation of the colon. But by loading the probiotic bacterium Lactobacillus reuteri with viruses targeted at C. diff, van Pijkeren aims to deliver genetic instructions that cause the pathogen to self-destruct.

In an ironic twist of fate, C. diff often colonizes the gut after antibiotics wipe out the microbial communities that normally keep it at bay. Infections often happen in hospitals, where antibiotics are becoming more common. Additional antibiotic treatments target-



ing C. diff don't always work, and the infection recurs in as many as 20 percent of patients.

"The downside of antibiotics is they are a sledgehammer that depletes and destroys the gut microbial community," says van Pijkeren, an assistant professor of food science. "You want to instead use a scalpel to specifically eradicate the microbe of interest."

Van Pijkeren thinks that *L. reuteri*, a probiotic bacterium found in many foods and the intestines of most animals, could be that scalpel. His team was able to amplify by 100-fold the natural ability of their strain of the bacterium to survive its trip through the harsh environment of the gut, making it a good candidate to deliver antibiotic-free treatments to the intestines where C. diff resides.

Van Pijkeren's idea, in collaboration with Rodolphe Barrangou of North Carolina State University, is to use one of C. diff's own defense mechanisms, called CRISPR, against it. CRISPR is a genetic surveillance system that bacteria use to protect themselves from invading viruses, which inject DNA into bacterial cells to attempt to replicate. If a bacterium has the right sequence of DNA to match an invading virus, it can use the CRISPR system to cut the viral DNA, thereby inactivating it and preventing infection.

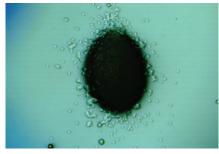
Scientists have used this ability to cut

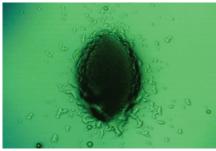
specific sequences of DNA to genetically engineer a wide range of organisms for research aimed at developing new therapeutics. The van Pijkeren lab, which has been developing CRISPR to genetically engineer L. reuteri, now wants to co-opt the system by delivering DNA that targets C. diffs own chromosome. That DNA will be injected by *C. diff-*specific viruses, which will hitch a ride with *L*. reuteri into the intestines.

If it works, *C. diff* will unwittingly cut and degrade its own DNA, preventing the pathogen from multiplying and doing more damage. Because both the viruses and the genetic instructions are targeted at C. diff, Pijkeren believes no helpful bacteria should be harmed.

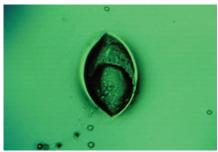
Working with Barrangou and funding from the National Institutes of Health, van Pijkeren has engineered L. reuteri to produce viruses that target lactic acid bacteria, an initial step toward getting the probiotic to produce C. diff-specific viruses. They are also developing ways to induce the probiotic to release these viruses at the right time inside the gut. If these lab tests go well, van Pijkeren's goal is to start testing the system in a mouse model of *C. diff* infection soon.

"I think it's pretty fascinating that an organism like *Lactobacillus* in such low numbers and small amounts can









actually have a health benefit," van Pijkeren says. "To then exploit these microbes to deliver therapeutics is very appealing because we know humans have been safely consuming them for thousands of years."

"Grazing" Amoeba

Bacteria have developed an uncountable number of chemistries, lifestyles, attacks, and defenses through 2.5 billion years of evolution. One of the most impressive defenses is biofilm — a community of bacteria enmeshed in a matrix that protects against single-celled predators and antibiotics. But there's a way through every suit of armor, and professor of bacteriology Marcin Filutowicz has found one.

Still frames from a 48-hour time-lapse, microscopic movie showing the voracious appetite of dictys. From top to bottom: A colony of MRSA (methicillin-resistant staph aureus) in an agar plate (Petri dish with a growth medium); the amoeba begin to graze on the bacteria; after consuming the bacteria, the single-cell amoeba form a multicellular "slug" that moves on in search of another food source; and a bacteriafree space in the growth medium is left behind by the amoeba. A portion of the time-lapse video can be viewed at go.wisc.edu/hungry-amoeba.

Along with Dean Sanders, presently at the Wisconsin Institute for Discovery, and patent co-inventor Katarzyna Borys, Filutowicz has shown the first proof that a certain group of amoeba called dictyostelids ("dicty") can penetrate biofilms and eat the bacteria within. In a recent study, the researchers pitted four types of dicty against biofilm-forming bacteria that harm humans or plants. For example, they targeted Pseudomonas aeruginosa, a common, multidrug-resistant bacteria that afflicts people with burn wounds or cystic fibrosis, and Erwinia amylovora, the cause of a devastating disease known as fire blight in apple and pear trees.

As expected, the results depended on the strain of dicty and the bacterial species. In several cases, the dicty completely obliterated thriving biofilms containing millions of bacteria, all of it captured in time-lapse, microscopic movies, the first of their kind. In addition to the cinematic evidence, other indicators of successful attacks against all four species of bacteria include spore germination and the subsequent union of single-celled dicty into a multicellular "slug" (a striking trait that has earned dicty the label "social amoeba").

Filutowicz became interested in dictyostelids after discovering a neglected archive of about 1,800 strains amassed by Kenneth Raper, a UW-Madison bacteriology professor who discovered the soil-dwelling microbes and started collecting them in the 1930s. He found that Raper and his team were feeding and growing dictys in the lab using bacterial prey, but nobody had pursued their commercial potential as microbe hunters.

"They grow on *E. coli* [a common resident of the human intestine], and I quickly realized that, because dicty are not pathogenic, we might use them as a biological weapon against bacteria."

Since 2010, Filutowicz has learned a good deal about how dicty "graze"

upon bacteria, and which ones they prefer. "We looked at how these cells dismantle biofilms, trying to understand what physical, chemical, and mechanical forces deconstruct the biofilms, and how the dicty move in 3-D space," he says. "These are phagocytes, and they behave much like our own immune cells, except our immune cells do not break down biofilms."

His collaborator, Curtis Brandt, a professor of ophthalmology and visual science at UW-Madison, has produced promising results suggesting that the organisms are harmless to rodents. Now, the National Institutes of Health have given them and AmebaGone a \$1.5 million grant to support their research on using dictys to fight bacterial keratitis, an eye infection, first in rodents and then in rabbits and humans.

"This medical application has a lot of promise," Filutowicz says.

More near-term use for dicty are found in agriculture. In 2010, Filutowicz formed AmebaGone. With funding from the National Science Foundation, the firm has been advancing dicty products toward commercializations, including treatments for fire blight and other bacterial infections of crops.

"Our 2017 external field trials for fire blight treatments were very promising," says Chad Hall, a senior scientist and director of AmebaGone's fire blight project. "Several of our dictybased products reduced fire blight disease without harming either trees or fruit. In fact, one of our treatments was as effective as the antibiotic streptomycin, which is the gold standard treatment for fire blight control in conventional apple orchards but is now banned in organic apple production."

Infection Detection

One way to prevent the overuse of antibiotics, and the drug resistance it creates, is to determine when treatment is not needed. And that's one of the benefits

(Right) Isomark's analytical instrument offers earlier detection of bacterial infection by measuring the ratio of carbon isotopes in patients' breath samples.

(Below) Marcin Filutowicz



of a new system developed by Isomark, a UW–Madison spin-off company, and its founder, Mark Cook.

Isomark's system measures carbon isotopes in exhaled breath. Without even touching the patient, it can offer the earliest warning of severe bacterial infection, says Cook, a professor of animal sciences. He founded the company in 2005 along with Warren Porter, a professor of zoology; nutritionist Dan Butz; and others.

Their novel detection device can often spot a bacterial infection before the patient feels symptoms, increasing the potential for faster, better treatment for severe infections. The company is focused on intensive care units (ICUs), which treat about 5 million people in the United States each year.

Antibiotic-resistant bacteria like MRSA (methicillin-resistant staph aureus) are an accelerating problem in hospitals, says Isomark CEO Joe Kremer. "The average hospital stay is five days, but it's 20 days with a hospital-acquired, resistant infection. The health-care industry puts the cost of diagnosis, treatment, and the extended stay at \$35 billion to \$88 billion."

These figures do not account for the



PHOTO BY BEN VINCENT

pain, worry, and deaths associated with these severe infections. About 100,000 Americans die of a hospital-acquired infection each year, Kremer says, and ever-more stringent controls have not brought the problem to heel. But earlier detection may help.

When the immune system responds to an infection, subtle changes in the ratio of the common carbon 12 isotope and the rare carbon 13 can be detected long before a doctor, a blood test, or even the patient knows that an infection is present. (Isotopes are chemically identical versions of an element that can be distinguished by their differing masses.)

After gathering breath samples and medical records from 100 ICU patients, Isomark scientists saw a telltale change in the isotope ratio for each patient who became ill. "Our studies show that we are 18 to 48 hours ahead of when clinicians suspect an infection," Cook says.

Rapid detection offers multiple benefits, he adds. This includes earlier treatment, which can reduce the ill effects that come with a severe infection, and earlier guidance for physicians about the need for tests to determine the location and cause of an infection. It can also lead to less antibiotic use.

Because bacterial infections are a major hazard in ICUs and operating rooms, "Antibiotics may be thrown at every patient after surgery as a preventive, but that is actually breeding resistance," Cook says. "If a breath test comes back negative, antibiotics may be unnecessary."

Since the test measures non-radioactive isotopes in exhaled breath, the procedure is noninvasive and safe. And the testing process could hardly be simpler. The patient breathes into a bag, or a sample is grabbed from a ventilator. The bag is connected to the tester, the patient ID is punched in, and results appear in 10 minutes.

Isomark is seeking FDA approval as a medical device and is gearing up for a final "regulatory trial" that will look at 300 patients in up to six hospitals nationwide. "We can't be sure about the FDA's decision, but the agency has been very positive," Kremer says. A decision could arrive in January 2018.

EDITOR'S NOTE

We are sad to report that Professor Mark Cook passed away in early September due to complications of cancer. He will be deeply missed



by the CALS community and beyond. To read about his life and distinguished career as a teacher, mentor, entrepreneur, and groundbreaking researcher in the realms of food production and animal health, visit **go.wisc.edu/cook-in-memoriam.**



Tom Blackwood

Claire Campbell

Ethan Lee

Jill Peters

Tom Blackwood MS'77

Tom Blackwood enjoys parks so much he decided to live in one. As the superintendent of Door County's Peninsula State Park, Blackwood resided in the park's "state house," with his wife and their two children, fortunate to call Wisconsin's most popular camping destination their backyard for 23 years. Blackwood was drawn to a career in parks by his inherent curiosity in the unexplored. "I was always enamored with 'what was out there,' the roadless patches on the state map — all those beautiful, natural areas," Blackwood says. His time spent at UW-Madison began as an undergraduate majoring in psychology but took a quick and meaningful turn after graduation. Involvement with the Department of Forestry and the Department of Wildlife Ecology (now merged as the Department of Forest and Wildlife Ecology) led him to pursue a master's degree in recreational resources management. Post graduation,

About In the Field

CALS graduates highlighted here represent the depth and breadth of alumni accomplishments. Selections are made by Grow staff and are intended to reflect a sample of alumni stories. It is not a ranking or a comprehensive list. To read more about CALS alumni, visit cals.wisc.edu/alumni.

Blackwood built his resume through seasonal positions at Effigy Mounds National Monument, Apostle Islands National Lakeshore, and Wyalusing State Park, after which he was accepted into the Park Manager Trainee Program with the Wisconsin State Park System. "The rest is history," he says. Blackwood retired from Peninsula State Park in 2010 after celebrating its 100th anniversary. Though officially retired, he still spends much of his time hiking, biking, and skiing the trails of Door County and serving on the board of directors of the Door County Land Trust. During the summer months, he shares his extensive knowledge of the area's land, water, wildlife, and history giving group boat tours on the bay and its islands.

Claire Campbell MS'15

Originally from Oak Ridge, Tennessee, Claire Campbell describes herself as an energetic and outdoorsy child. "I was always the kid that was out playing in the woods," she says. "From bugs and plants to my first summer job flipping rocks in streams and chasing salamanders for a species inventory in East Tennessee, I was fascinated by the big picture — how and why do our natural systems end up the way that they are?" Her love for the outdoors led her to complete her undergraduate degree in earth and environmental sciences at Furman University. In addition to her studies, Campbell interned on a local farm where she studied soil carbon management and volunteered for Grand Canyon National Park. "I came to love the complexities of how soil forms, how we manage it, and what options exist to protect soil systems," Campbell says. She then came to UW-Madison to reinforce her passion with a graduate degree in soil science. She explored the role of nutrient management and agricultural efficiencies in healthy soil, which was integral in helping her realize her desire to work in the public sector. Campbell set her eyes on a job with the U.S. Forest Service and received an offer from Montana's Lolo National Forest the same day she defended her master's thesis. Since moving to Montana, Campbell has enjoyed checking off adventures in her 600-page book of hikes and backpacking trips near Missoula. Her favorite thus far is a bike ride up Going to the Sun Road in Glacier National Park.

Ethan Lee BS'14

Is your tree in need of a checkup? Certified tree doctor and UW-Madison graduate Ethan Lee may be able to help. Born and raised in Wisconsin, Lee attended UW-Rock County, where he spent three years studying mechanical engineering before transferring to UW-Madison and ultimately majoring in forestry. Upon graduating, Lee chose to give back to his childhood community by using his skills to enhance Janesville parks. He accepted a job as the parks and forestry coordinator for the City of Janesville Parks Division. He is also an International Society of Arboriculture (ISA) certified arborist. Lee's day-to-day work schedule is anything but consistent, with tasks ranging from individual tree assessment and forest health to installing new playgrounds and engaging in community outreach. "I feel extremely lucky and honored to go to work every day with a smile on my face and look forward to all the new challenges," Lee says. "I love my job and my community, and for that, I am very grateful."



Alumni making a difference through Parks

Jill Peters BS'14

Communications may not be the first field that comes to mind when you think of careers in Rocky Mountain National Park, but it's reality for Jill Peters. She grew up on Sand Island, a part of the Apostle Islands National Lakeshore, where she was immersed in the outdoors from a young age and gained a deep appreciation for the natural world. When it came time to choose a degree, Peters was stuck between pursuing her knack for writing, photography, and outreach and her passion for science and the outdoors. Thankfully, she found the perfect marriage of her interests through the life sciences communication major at UW-Madison. After graduating, Peters headed straight to Fire Island National Seashore along the coast of Long Island, New York, where she explored both research and communications positions. In May 2017, she applied and was accepted as the new biological science technician at Rocky Mountain National Park. Here, Peters has been able to continue her multifaceted career by participating in and communicating the latest scientific research in one of the planet's most picturesque places. "Getting to be in the mountains, participating in all sorts of science research, and then playing a role in making the complexities of that science accessible to the public is a challenging and rewarding experience," Peters says. "It's truly the best of both of my passions."

David Powell MS'75

Recognizing his interests in nature and recreation, David Powell created his own undergraduate degree program at Carleton College to prepare him to pursue further education in outdoor design. Upon graduation, Powell headed to UW-

Madison to obtain his master's degree in landscape architecture and kick-start his career. With this education to guide his craft, he returned to Canada, settling in Saskatchewan to work as the chief landscape architect for the province's Parks Service and eventually opening his own landscape architecture firm. Powell has worked in private practice for more than 25 years and shows no sign of slowing. The reward of creating living landscapes and watching them grow and change over time keeps Powell energized and inspired. In the midst of his success, he recognizes his time in Madison as his design awakening. "UW-Madison exposed me to ways of understanding and appreciating natural systems, which have forever framed the way I look at the world," Powell says.

Pamela Schuler BS'80

As the Ice Age National Scenic Trail manager for the National Park Service, Pamela Schuler works with public and private partners to oversee and carry out federal requirements to plan, acquire land for, develop, and interpret the 1,200-mile Wisconsin trail. Schuler became involved with the Ice Age Trail as a horticulture major working as an intern through the Department of Landscape Architecture. Upon graduation, she gained recognition for developing the trail through various positions with the Wisconsin Department of Natural Resources, which led to her current position. Though she began as a landscape architect, Schuler stresses how much collaboration and community involvement are required to build and maintain the trail. Her life's work continues to pay off in a beautiful and visible way. "The Ice Age Trail reaches into communities to bring urban

residents and children out into nature, provides an outstanding hiking experience that educates the public about our glacial past, and restores ecosystems along its footpath while connecting public lands across the state," she says.

Jon Adams-Kollitz BS'89

Ion Adams-Kollitz's interest in urban parks has taken him around the world. While pursuing his undergraduate degree in landscape architecture at UW-Madison, he took advantage of every possibility he could. "I was floored by the sheer amount of options and possibilities UW offered," Adams-Kollitz says. He focused his studies on architectural history and cultural geography and later became involved with Madison's sustainability organization, Sustain Dane. Upon graduating with his BSLA, Adams-Kollitz spent the summer in St. Petersburg, Russia, and Washington, D.C., inventorying and documenting historic landscapes for a survey. After launching Formecology, an ecological/ artistic design build firm in Madison, he continued his education at the Royal Institute of Technology in Stockholm, Sweden, where he focused on sustainable urban design. In 2007, Adams-Kollitz settled in Burlington, Vermont, where he works as the parks project coordinator for the Parks, Recreation, and Waterfront Department. He is now focused on designing and implementing an ecofriendly and universally accessible playground and on rehabilitating Burlington's iconic eight-mile waterfront bike path, efforts that earned him the first ever Mayor's Award for Innovation in 2016.

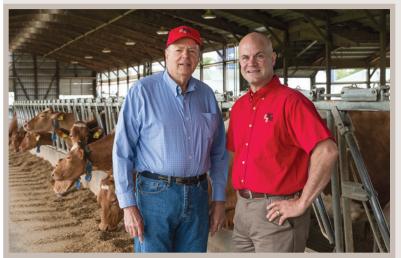
by Gilliane Davison

Catch up with...

Corey Geiger BS'95 Agricultural Economics and Dairy Science Steve Larson MS'70 Dairy Science

With its unmistakable oversized format and bold red masthead, Hoard's Dairyman is perhaps the most influential publication in the dairy industry today.

What began in 1885 as an insert in the Jefferson County Union weekly newspaper has grown into an indispensable print and digital resource for dairy farmers and their advisers in more than 60 countries around the world. Since its beginning, the publication has been linked to the University of Wisconsin's agricultural endeavors through its founder, William Dempster Hoard, a UW regent and passionate supporter of the university's College of Agriculture, which formed in 1889 when he was governor of the state.



Steve Larson and Corey Geiger with members of the herd at the Hoard's Dairyman Farm.

It's fitting, then, that for the last 20 years, CALS alumni have stood at the editorial helm of the magazine. Corey Geiger joined the Hoard's staff in 1995 and took on the managing editor role in 2013. His predecessor, Steve Larson, served as managing editor for almost 15 years, beginning in 1998. Now retired, he still works as a consultant for the magazine and its fully functional dairy farm in Fort Atkinson, Wisconsin. Neither expected to venture into the realm of agricultural journalism, but they have both relished the opportunity to serve the dairy industry.

What makes Hoard's Dairyman so influential and long-lasting?

Corey Geiger: At Hoard's, we operate our own dairy farm, so we're really a part of the industry, not just reporting on it, and there's a big difference. On our editorial page we use words like "we," "us," and "our," which isn't necessarily taught in journalism classes. We're living this every day. We need to know, as editors, what's going on with cows — what are the trends, what are the issues that busy dairy farmers are facing every day, not only in the United States, but around the world.

Steve Larson: Part of our business model, or tradition, is to assume industry leadership positions. That adds to the credibility and the image of the magazine and the ability to know what's going on and how to get things accomplished in the industry.

What role does Hoard's Dairyman play in connecting **UW-Madison and Wisconsin agriculture?**

SL: This connection goes back generations. It started with the lead role W.D. Hoard played in converting Wisconsin from a faltering grain-producing region into America's Dairyland and, later, his efforts to establish agricultural studies at the university.

Researchers and extension specialists from CALS and the School of Veterinary Medicine have made major contributions to the impact Hoard's Dairyman has across Wisconsin as well as the U.S. and the world. Current and past editors have served in advisory roles at the university, and this has created mutually beneficial connections between our company, UW, and industry.

CG: There are more dairy businesses based in Wisconsin than anywhere in this country. It's this flow of jobs that is vital to Wisconsin, and I think, together with UW, we help share with these businesses the great research that the university is doing. We actually partner in these conversations. Probably 60 percent of our stories are written by outside authors. We help put it in a really conversational form that is easy to read but delivers some very deep research at the same time. And that's art to be able to do that.

-NIK HAWKINS

Cultivating Student Success at Allen Centennial Garden

llen Centennial Garden may be one of the most beautiful places on the UW-Madison campus, but it's also becoming one of its most comprehensive classrooms.

Dedicated in 1989, Allen Garden (as it's known informally) replaced the former instructional gardens attached to the Plant Sciences Building, which were removed in 1979 to make room for a facility expansion. Located just one block to the north, Allen Garden has served as a living laboratory ever since its debut. But recently, students have become more involved in its operation through a growing internship program initiated by director Benjamin Futa.

Futa became director of Allen Centennial Garden in 2015 and quickly developed a strategic plan to strengthen engagement between the garden and campus life. He focused on developing a dynamic internship program based on co-ownership, initiative, and responsibility.

"We give our interns the title of student directors to represent how instrumental they are to the garden's success," Futa says. "They're deeply involved with everything we do here."

Just two years later, his vision has come to life. Allen Garden now employs six interns and a growing professional staff. Students' majors range from landscape architecture and horticulture to sociology and art, and how they apply their academics to the garden is limited only by their imaginations.

"If any student approaches me with an interest or idea that is even in the



realm of possibility, we try to make it happen," Futa says.

This inclusive mentality has led to the implementation of art installations, beehives, and public events, including the "Best. Friday. Ever." events in summer 2017. It also assures student directors will graduate with a well-rounded skill set. Peter Hauser, a current student director of horticulture, envisions a career in plant research and appreciates the doors that the garden has opened for him in the last two years.

"It has given me the proper prerequisites to explore vast opportunities not only in horticulture, but also in botany, agriculture, and agronomy," Hauser says.

Regardless of their titles, all students maintain a portion of the garden and take part in incredible field trips that focus on hands-on learning, networking, and professional development.

These internship experiences would be impossible without the generosity of others, Futa notes. "Beyond day-today work in the garden and the salary support it requires, private gifts allow us to support students' pursuit of their own interests through independent

Peter Hauser, student director of horticulture, removes weeds from the rock garden at Allen Centennial Garden.

projects and field trips. These experiences are curated to provide meaningful, authentic, and empowering learning experiences for our students."

-GILLIANE DAVISON

Would you like to help provide internship opportunities for students? You can make a gift to the Allen Centennial Garden Community Fund at supportuw.org/giveto/acgardencommunity.

next**Steps**

SAY POTAYTO, POTAHTO, AND MORE.

Come to the **Potato Variety Harvest Expo** at the Hancock Agricultural Research Station on Thursday, Nov. 2. Mingle with growers and UW researchers while learning about dozens of potato varieties. More info at hancock.ars.wisc.edu.

SEEK OUT SOME SCIENCE. The Wisconsin

Science Festival, which runs Nov. 2-5, features activities for all ages and interests, including hands-on exhibitions, demonstrations, performances, tours, pub nights, workshops, and more, in various venues across the state. Find an event near you at

wisconsinsciencefest.org.



Take the Final Exam!

Fill out your answers online. Ace our quiz and we'll enter you in a drawing for a gift box of Babcock Hall cheese. To participate, go to cals.wisc.edu/grow/ and look for the Final Exam.

Agricultural and Applied Economics

1) The resources that are available to meet society's needs are

- a) plentiful.
- c) human-made and natural. b) scarce.

Community and Environmental Sociology

2) The principal difference between growth machine theory and regime theory is

- a) regime theory assumes that all growth is good while growth machine theory assumes b) growth machine theory asserts that almost all communities are driven to promote growth
 - while regime theory points to the possibility of organizing against growth interests. c) growth machine theory focuses on decisions while regime theory examines nondeci-

 - d) regime theory assumes that government officials have little autonomy while growth machine theory assumes they have some ability to promote progressive policies.

Food Science

- 3) Which statement correctly defines lactose intolerance?
- b) Individuals with lactose intolerance don't have enough bacteria in the large intestine to a) Individuals with lactose intolerance can't absorb lactose.

 - c) Individuals with lactose intolerance have an enzyme deficiency.
 - d) Individuals are given a test at birth for lactose intolerance.

Genetics

- 4) What did Gregor Mendel conclude from his experiments with pea plants? b) An organism that is homozygous for many recessive traits is at a disadvantage. a) Traits are controlled by factors (genes), which come in pairs.
 - c) Recessive genes occur more frequently than do dominant ones.
 - d) There is considerable genetic variation in garden peas.

 - e) Genes are composed of DNA.

Plant Pathology

5) A way of doing things is often termed as "sustainable" if

- a) it requires constant ongoing effort.
- b) it can be kept up indefinitely.
- d) it is a way that things have been done for centuries. c) it does not require extra effort.

Last issue's answers were 1:A; 2:C; 3:C; 4:B; 5:A. Congratulations to Christopher Haber PhD'84, who was randomly selected from among 13 people who correctly answered all five questions. He wins a Babcock Hall cheese box!

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