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Wisconsin's Magazine for the Life Sciences • SUMMER 2018

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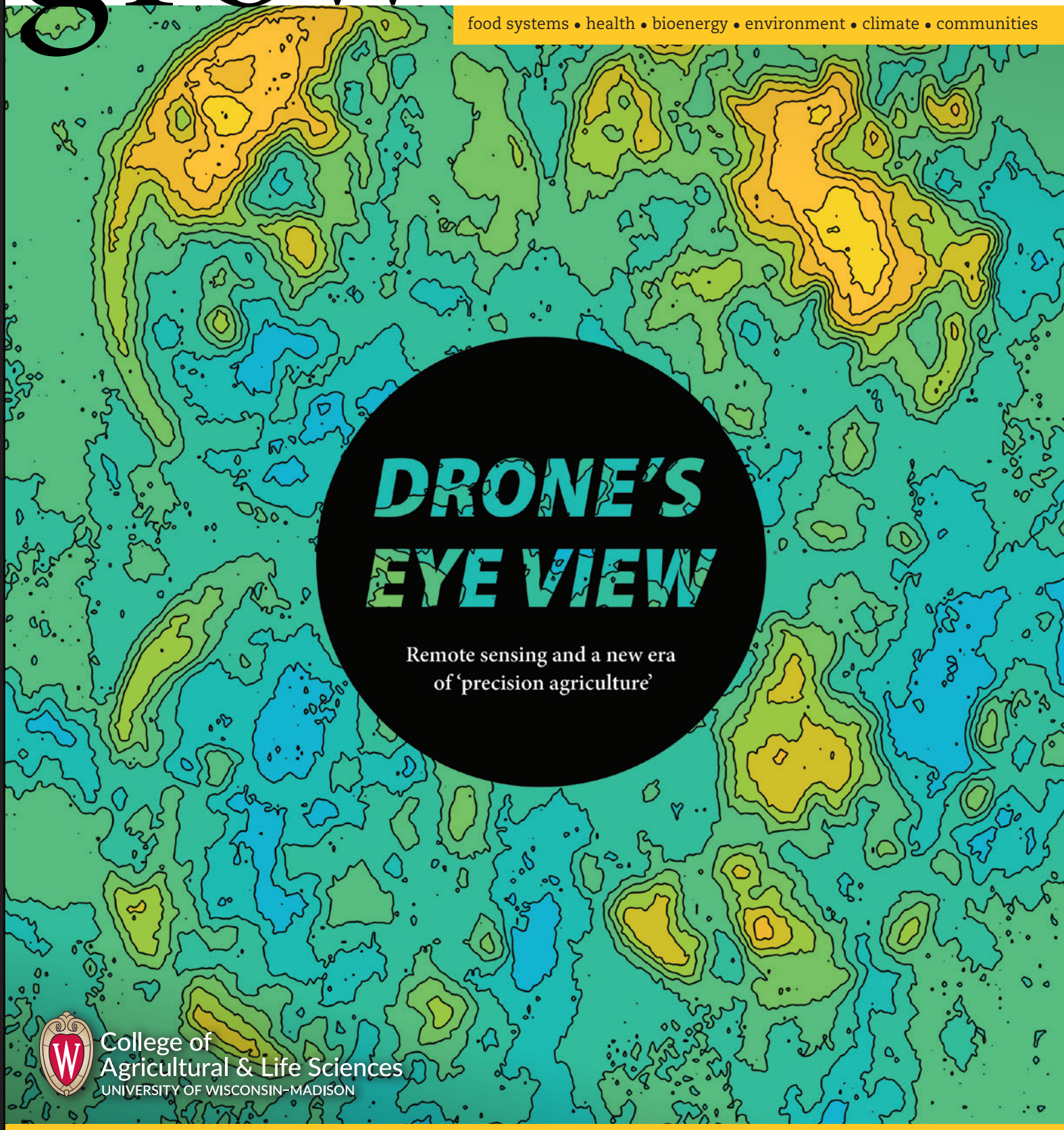

DRONE'S EYE VIEW

Remote sensing and a new era of 'precision agriculture'

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN–MADISON

CENTER FIGHTS BUG-BORNE DISEASE • OLD MOLECULES FIND NEW PURPOSE • SUMMER'S 'LIGHT BEARERS'


Forward

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Students try to beat the heat with Babcock ice cream on the front steps of the Babcock Hall Dairy Store.

Photo by Ben Vincent

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Wisconsin's Magazine for the Life Sciences

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ON THE COVER: This spectral image of several cranberry plants, with "false color" applied to clearly delineate differences in temperature, is part of a research project testing the ability of drone-mounted spectral cameras to identify signs of crop disease and pests from the air. See page 16.

Image by Jessica Drewry PhD'17

Dean Kate VandenBosch

Welcome, Future Problem Solvers

"CALS has developed a new program that helps students create their own road map, and possibly a shorter path, to a degree."

In this issue of *Grow* — as with all issues of the magazine — you'll get a close look at our scholars as they tackle some of today's most vexing issues. In these pages, you'll find food scientists discovering ways to combat disease through diet, wildlife ecologists tracking endangered species, and sociologists engaging with rural communities as they aim to attract more young adults. You'll learn how our engineers are enlisting the latest drone technology to make farming more efficient and how our entomologists are keeping tabs on ticks and mosquitoes to get out in front of the next insect-borne disease outbreak.

Clearly, our experts are working to solve critical problems, and they do this in an astounding range of disciplines. As important as these efforts are, I am even more inspired by how our faculty and staff share their vital knowledge with our exceptional students. They are training the problem solvers of tomorrow — and we have room for more.

However, we understand that the costs of education can create uncertainty for many students and their families. This is why we're working hard to make a CALS education more accessible and more affordable to as many students as possible. We provide a significant amount of financial support for our students, and we're always trying to raise more funds for this purpose. In 2017-18, we awarded 1,013 scholarships for a total of nearly $1.7 million.

We're also leveraging campus-wide efforts to reduce costs for students. One recent example is Bucky's Tuition Promise. Beginning in fall 2018, incoming freshman and transfer students from Wisconsin households with adjusted gross incomes of $56,000 (the state median income) or less will receive free tuition and segregated fees. This commitment extends for eight consecutive semesters for freshmen and four semesters for transfer students.

I am particularly encouraged by Bucky's Tuition Promise because it is structured to help families in smaller towns and rural parts of Wisconsin, where, for the most part, incomes have not kept pace with larger metro areas. And only income — not assets — will be used to determine eligibility, which is important because many small businesses and farms have high reported assets but lower incomes.

Scholarships and targeted tuition waivers are not the only means for cutting the costs of higher education. CALS has developed a new program that helps students create their own road map, and possibly a shorter path, to a degree. It's being offered for the first time this summer. Called CALS QuickStart, it allows incoming first-year students to get a jump on their coursework, engage in early academic and career planning, and join a community of peers and friends.

All of these opportunities can help acclimate students to campus more quickly and reduce their time to degree by as much as a year. And summer tuition support is available for the QuickStart program thanks to a $25,000 gift from the Wisconsin Agricultural and Life Sciences Alumni Association. You can find details at **cals.wisc.edu/quickstart/**.

I am excited about how these efforts will expand opportunities for students at CALS regardless of their financial circumstances. Brilliant minds come from all types of communities and backgrounds, and we want more of those minds here. We want the best and the brightest learning from the best and the brightest — thinking, creating, and innovating for the future. To the problem solvers of tomorrow, we welcome you to CALS.

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Five things everyone should know about . . .

Fireflies

By P.J. Liesch MS'10

1. **Fireflies, or lightning bugs, are a type of winged beetle** known for producing light. There are more than 2,000 species found throughout the world, over 150 scattered across the United States, and around two dozen inhabiting the Great Lakes area, including Wisconsin. Many of Wisconsin's fireflies are most noticeable in June, July, and August, and it's hard to miss the light show after sundown.

2. **Their glow is produced by bioluminescence**, which stems from a biochemical reaction involving a compound known as luciferin and the enzyme luciferase. ("Lucifer" translates from Latin as "light bearer.") The reaction is highly efficient, converting roughly 90 percent of the energy into visible light that is often referred to as "cold light." In contrast, inefficient incandescent light bulbs produce "hot light" because most of their energy is lost as heat. The flash patterns and colors that each firefly species produces through bioluminescence can differ slightly, and some species only produce light in the larval stage, not as adults. Flash colors range from orange to yellow to green and even blue. In most cases, the flash pattern is used for communicating with potential mates, although some deceptive fireflies are known to mimic the flash pattern of another species to lure and then ambush potential prey.

Illustration by Danielle Lamberson Philipp

3. **Fireflies can be a boon for your yard** — at least, their larvae can. The black and pink juvenile fireflies, sometimes called glowworms because they also produce bioluminescent light, have an armor-plated appearance and live in damp areas, where they feed on slugs, snails, worms, and other soft-bodied creatures. Anyone with hostas, marigolds, or other low-growing plants in their yard has likely noticed the feeding damage from slugs in these past few rainy years, but fireflies may help minimize the harm that slugs cause by thinning their ranks.

4. **Fireflies can be distasteful or even poisonous to predators** because they harbor defensive steroids called lucibufagins. These steroids are related to toxic chemicals that certain toads release when injured or threatened. Not all fireflies possess these chemicals, but some species in the Great Lakes region are among those that do, and they wield a potent defense and deterrent against predators such as spiders, bats, mice, and birds.

5. **Scientists have raised concerns that fireflies may be in decline**, and there could be a number of factors involved. Habitat loss and light pollution with changing land-use patterns may be important parts of the puzzle, and pesticides may play a role as well. Anyone interested in helping fireflies in their yard can do so by reducing light pollution, avoiding pesticides, and keeping some "wild" areas on the property as potential firefly habitat. To learn more about fireflies and get involved with a citizen science monitoring project, visit **legacy.mos.org/fireflywatch**.

P.J. Liesch, better known as UW–Madison's "bug guy," is director of the Insect Diagnostic Lab in the Department of Entomology and an entomologist with UW Cooperative Extension. Much of his job involves communicating insect information to the public and acting as a bug identification guru for curious residents and businesses from all over Wisconsin. Learn more at **labs.russell.wisc.edu/insectlab**.

How about Some Granola with That?

The debate over the health benefits of dairy continues with a study showing that yogurt may dampen chronic inflammation

Photo by Michael P. King

Low-fat yogurt with aronia berries.

This study was funded by the National Dairy Council, a nonprofit organization supported by the U.S. Department of Agriculture's national dairy checkoff program. The findings were published in the *British Journal of Nutrition* and the *Journal of Nutrition*.

Yogurt already has a lot going for it. A fermented dairy food, it is rich in calcium, vitamin D, and protein. Its mildly sour taste is a delight to many, and it can be dressed up with healthy, flavorful toppings such as nuts, fruit, and granola. And now there may be another good reason to eat it.

Various studies show that certain dairy products may help dampen chronic inflammation, which is a prolonged, overactive immune response that can be damaging to the body. Chronic inflammation is associated with obesity, metabolic syndrome, cardiovascular disease, and other chronic diseases. This promising research was the impetus behind a new investigation, directed by assistant professor of food science **Brad Bolling** BS'02 PhD'07, into one dairy product's anti-inflammatory properties.

"We wanted to look at the mechanism more closely and look specifically at yogurt," says Bolling, whose research focuses on the role of food in preventing chronic disease.

Evidence suggests that yogurt may help reduce inflammation by improving the integrity of the intestinal lining, thus preventing endotoxins — pro-inflammatory molecules produced by gut microbes — from crossing into the bloodstream. Bolling's yogurt study set out to explore this hypothesis. It involved 120 premenopausal women, half obese and half non-obese. Some were assigned to eat 12 ounces of low-fat yogurt every day for nine weeks; a control group ate non-dairy pudding for nine weeks.

At various points during the study, Bolling and his team took fasting blood samples from participants and evaluated an assortment of biomarkers that scientists use to measure endotoxin exposure and inflammation, such as elevated blood plasma levels of specific proteins and cytokines. The results were very

promising: while some of the biomarkers remained steady over time, the yogurt eaters experienced significant improvements in certain key markers.

"The results indicate that ongoing consumption of yogurt may be having a general anti-inflammatory effect," Bolling says.

Participants in the study were also involved in a high-calorie meal challenge at the beginning and end of their nine-week dietary intervention. The challenge, meant to rev up an individual's metabolism, started with a serving of either yogurt or non-dairy pudding followed by a large high-fat, high-carb breakfast meal.

"It was two sausage muffins and two hash browns, for a total of 900 calories," Bolling explains. "But everybody managed it. They'd been fasting, and they were pretty hungry."

For both challenges, blood work showed that the yogurt "appetizer" helped improve some key biomarkers of endotoxin exposure and inflammation as participants digested the meal over the ensuing hours. It also helped improve glucose metabolism in both obese and non-obese participants.

"Eating eight ounces of low-fat yogurt before a meal is a feasible strategy to improve post-meal metabolism and thus may help reduce the risk of cardiovascular and metabolic diseases," says **Ruisong Pei**, a UW–Madison food science postdoctoral researcher involved in the studies.

The findings contribute new evidence to the ongoing scientific debate about whether dairy reduces or promotes inflammation. "There have been some mixed results over the years, but a recent review shows that things are pointing more toward anti-inflammatory, particularly fermented dairy," Bolling says.

Bolling's study doesn't identify which compound or compounds in yogurt are responsible for the health-promoting effect — or how they act in the body. Solving that piece of the puzzle will require more research, Bolling notes.

"The goal is to identify the components and then get human evidence to support their mechanism of action in the body. That's the direction we are going," he says. "Ultimately, we would like to see these components optimized in foods, particularly for medical situations where it's important to inhibit inflammation through the diet. We think this is a promising approach."

—Nicole Miller MS'06

YOUR THOUGHTS ON THE FUTURE OF

grow

It's been more than a decade since *Grow* first launched. In that time, we've printed more than 30 issues. That's over 1,200 pages filled with more than 400 articles. We hope we've captivated you with compelling stories and stunned you with gorgeous images. We hope we've kept you connected to the college and sustained your CALS pride. And we hope we can keep on going for another decade and more.

But to do this in the best way possible, we need your guidance. After 11 years, *Grow* is due for some changes, and we want you, our readers, to help us decide how it develops and evolves. If you'd like to have a hand in shaping the future of *Grow*, please take a few minutes to respond to our short online survey**.**

Need extra motivation? To show our appreciation for your time and attention, anyone who completes the questionnaire can be entered in a drawing for a **free gift box of Babcock Hall cheese!** We await your responses…

SHARE YOUR THOUGHTS AT

go.wisc.edu/grow-survey

Kind regards,

Nik Hawkins
Editor

Eyes on an American Marten Revival

With funding from an endowed professorship, CALS researchers are using trail cameras to monitor the evasive creatures in the Apostle Islands

The American marten, a small, elusive member of the weasel family, was long thought to be extinct in Wisconsin's Apostle Islands. Now, thanks in part to an endowed gift to CALS, they have been found roaming the area once again.

Evidence of the animal's presence in the national lakeshore resurfaced in 2015 when a research group, led by forest and wildlife ecology professor **Tim Van Deelen**, identified several martens in photos taken by trail cameras. Some of the images came from a dozen cameras that Van Deelen purchased with funds from his appointment as Beers-Bascom Professor in Conservation.

The professorship was established by **William Beers**, former chairman of the board and CEO of Kraft, Inc. It is awarded to a CALS faculty member for outstanding research, teaching, and service in natural and environmental resources conservation and management. Van Deelen has held the appointment since 2015. He says he purchased the trail cameras because they are an invaluable tool for wildlife researchers.

"They can be out there gathering data night and day, in all kinds of weather, with minimal requirements of humans to go service them," he says.

That trail camera technology, which has proven crucial in learning about animal habits and movement, is especially helpful for sighting rare and evasive animals like the marten. Wisconsin was once home to a stable population of martens. However, trapping and loss of habitat led to their complete extinction in the state by the early 20th century. State officials tried in vain to reintroduce them in the 1950s, but later efforts in the Chequamegon-Nicolet National Forest have proven more successful.

According to Van Deelen, there are three prevailing theories that could explain where the Apostle Islands marten population originated. First, it's possible that a small group survived the original extirpation. A second theory suggests that they migrated from a group released into the Chequamegon-Nicolet National Forest between 1987 and 1990. Finally, they may be relatives of a handful reintroduced in the 1950s during what was considered a failed effort.

For the time being, no one has a true sense of how many martens inhabit the Apostle Islands. Researchers have found them on at least seven of the 21 islands, and Van Deelen believes they are fairly well distributed throughout the area.

The marten findings are encouraging, says Van Deelen. This summer, he may purchase and place additional cameras on the islands and also use his professorship funds to support student fieldwork. **Morgan Morales**, a graduate student assisting with the project, plans to return to collect more data. She says the trail cameras provide an "intimate look" into the habits of animals without the obtrusiveness of a human presence.

For Van Deelen, the camaraderie and discoveries of the project are just another reminder of the importance of professorship funds. "There's a big value in having graduate students who are working on the same thing together. It's an esprit de corps thing," he says. "Purchasing the cameras enabled me to do that for the grad students."

—BEN VINCENT

Forest and wildlife ecology professor Tim Van Deelen used funds from his appointment as Beers-Bascom Professor in Conservation to purchase trail cameras, which have captured images of the American marten in Wisconsin's Apostle Islands, an area where they were long thought to be extinct.

Photos courtesy Tim Van Deelen and Morgan Morales

classAct

Leah Johnson
Sustainability as the New Standard

Leah Johnson BSx'19 didn't have cable TV until her freshman year of high school. Even after the box arrived, her parents enforced a daily one-hour rule for screen time. So she spent much of her childhood exploring the natural landscape around the Twin Cities suburb where she grew up.

Photo by Michael P. King

"Our version of forced family fun was to go hiking or to tromp up and down a muddy river," Leah recalls. Apparently, her parents' approach worked: Leah quickly decided that she wanted to make the environment part of her career. "I realized it wasn't enough to just care about the environment," she says. "I wanted to do something."

Now entering her senior year as a biochemistry and environmental studies major, Leah is a fearless doer who complements her environmental ethics with concrete action. As a first-year student, Johnson discovered the ASM Sustainability Committee, a subgroup of the Associated Students of Madison (ASM) that focuses on identifying and addressing ways for the university to advance its sustainability practices. She moved up the ranks quickly, serving most recently as chair.

In this leadership role, she sought to infuse sustainability into the everyday fabric of campus, making green living an easy choice — and perhaps not a conscious choice at all. For instance, she argues, "No one cares about the tiny delay in automated lights in bathrooms and common areas. No one says, 'this split second of darkness is terrible.' And yet the energy-saving benefits of installing them are enormous."

But Johnson quickly realized that achieving large-scale operational change means building coalitions. She cofounded CLEAN (Campus Leaders for Environmental Action Now), a group of student leaders who want UW–Madison to commit to using solely renewable energy by 2030. The group has taken off, says Johnson, and campus leaders are taking notice: members of CLEAN recently presented their case to administrators in the Office of the Vice Chancellor for Finance and Administration and the Office of Sustainability.

Johnson has gone from tracing muddy waterways in Minnesota to making waves in sustainability at the UW. It's a safe assumption that she'll keep expanding her green horizons through her last year of college and beyond.

—Nathan Jandl

I'D LIKE TO THANK THE ACADEMY

The bacteriology and biochemistry departments keep adding to their list of accolades. **Katherine "Trina" McMahon** and **Jue "Jade" Wang**, both professors of bacteriology, were elected Fellows of the American Academy of Microbiology, and **Robert C. Landick**, the Charles Yanofsky Professor of Biochemistry and Bacteriology, was elected to the American Academy of Arts and Sciences.

DAIRY DOMINANCE

Dairy-minded folks with CALS connections gathered a herd of awards and honors in recent months. In April, a team of now recently graduated dairy science students, including **Charles Hamilton** BS'18, **Anthony Schmitz** BS'18, **Logan Voigts** BS'18, and **Connor Willems** BS'18, took first place at the National Intercollegiate Dairy Challenge. They were coached by faculty associate **Ted Halbach** and professor **David Combs** PhD'85.

Students weren't the only ones to be recognized. Dairy science alumnus **Pete Kappelman** BS'85 of Reedsville, Wisconsin, was named the 2018 Dairyman of the Year by the World Dairy Expo, and dairy science assistant professor **Heather White** was honored as AgSource Friend of the Cooperative. In the world of cheese, **John Lucey**, director of the UW Center for Dairy Research, was inducted into La Guilde Internationale des Fromagers, and Babcock Hall Dairy Plant cheesemaker **Gary Grossen** received the Vanguard Award from the Wisconsin Cheese Makers Association. Holy cow!

Number Crunching | 1

THE UW MICROBIOLOGY DOCTORAL TRAINING PROGRAM IS NUMBER ONE, according to the most recent graduate school rankings released by *U.S. News & World Report*. Other programs affiliated with CALS also fared well in the rankings. The biochemistry specialty ranked eighth and the biological/agricultural specialty ranked 14th.

Rural Brain Gain

As Wisconsin tries to lure young adults, how do certain communities succeed?

Early this year, Wisconsin's economic development agency launched an ad campaign to persuade young professionals to ditch Chicago and head north to pursue their careers. The campaign was pegged as one way to address an ongoing shortage of young, talented workers in the state. Answers for the growing problem haven't come easy, but it turns out we might not have to look very far to find them.

Illustration by Danielle Lamberson Philipp

A recent study by researchers at CALS and UW-Extension explored rural communities in Wisconsin that are already maintaining or increasing their number of young adult residents aged 20 to 39. Their goal was to find out what factors accounted for success in these unique cities and villages.

Although statistics are abundant for counties, the researchers chose a smaller unit of analysis. "People don't move to counties, people move to communities," says **Randy Stoecker**, professor of community and environmental sociology and the study's lead investigator. "If we're going to answer the questions, the data had to be at the community level."

The 12 case study communities — Delavan, West Bend, Omro, De Pere, Black Creek, Plover, Hayward, Somerset, New Richmond, Onalaska, Brooklyn, and Evansville — were chosen for their diversity in terms of location, income, and economic structure. With advice from local UW-Extension educators, the team identified a "core group" of leaders in each community that helped guide the research.

The researchers conducted extensive qualitative analysis and interviews in each community. What they discovered were subtle variations on one consistent message. "It was always about proximity to cities, and about housing, schools, and outdoor amenities," says Stoecker, who has a joint appointment at UW Cooperative Extension's Center for Community and Economic Development.

More specifically, the young adults included in the study were attracted to rural communities with high-quality schools that also serve as community and cultural centers; affordable housing with a mix of housing types suitable for the different life stages of residents; outdoor recreational opportunities, including "silent sports" such as skiing and hiking; and local gathering spots and family spaces such as coffee shops, swimming pools, and restaurants.

They also looked for convenient access to larger cities, leading Stoecker and colleagues to conclude that communities must be seen in the context of their regional centers. In particular, proximity to a city or an interstate highway was critical. "We found that people are looking for a nearby employment center that includes high-end, professional employment," he says. "They look for amenities in these regional centers: entertainment, movies, art, theater, high-end restaurants, and spectator sports."

To move forward, communities around the state might adapt the lessons of these case studies, Stoecker says. "Do a dozen or two dozen interviews to learn about young people in the community, what keeps them, what attracts them," he says. "It's not expensive or super time-consuming. Then start thinking about how you might leverage that knowledge."

—David Tenenbaum

This study was funded by a Hatch Act grant from the USDA National Institute of Food and Agriculture. Co-principal investigators include (from UW–Madison) Katherine Curtis, associate professor of community and environmental sociology, and (from UW Cooperative Extension) Matt Calvert, professor of youth development, and Allyson Watson, communities extension educator for Outagamie County. To read a full report of the study, visit **apl.wisc.edu/youngadults**.

CENTRAL AMERICA

Ancient Method Helps Feed Present-Day Communities

Photos by Brenda Dawson, UC Davis

Erick Gutiérrez teaches grafting to farmers in the small Guatemalan village of San José Sigüila.

Seedlings of Hope is supported by the Horticulture Innovation Lab, with funding from the U.S. Agency for International Development, as part of the U.S. government's global hunger and food security initiative called Feed the Future.

In remote villages and rural towns from Guatemala to Costa Rica, horticulture professor **James Nienhuis** and his former grad student **Erick Gutiérrez** MS'17 are improving countless lives, one tomato seedling at a time. Their goal is to combat the region's agricultural afflictions (viruses and soil pathogens) to ease the hardships of growing food and earning a living. They're doing this with a technique older than the ruins of Tikal.

The roots of the initiative go back about eight years when Nienhuis established Seeds of Hope with a USAID grant. His goal was to combat the whitefly-transmitted geminivirus in Central America by developing genetically resistant cultivars that are still beautiful and flavorful.

Nienhuis produced the cultivars he needed to withstand the virus, but other soil pathogens — fungal, bacterial, and parasitic — continued to spoil tomato crops, slashing yields and decreasing the income and nutrition levels among the rural poor.

"*Ralstonia* (a bacterial wilt) kills the plant once symptoms develop. It causes serious yield losses," says Gutiérrez, a native of Honduras. "It is very hard to eradicate."

Matthew Kleinhenz PhD '96, Nienhuis' former student, asked if he had tried grafting as a possible solution. Seeing merit in the idea, Nienhuis shifted focus and launched a new program called Seedlings of Hope. The idea was to unite the upper portions (scions) of his virus-resistant cultivars with soil pathogen-resistant rootstocks. *Solanum habrochaites*, a wild tomato plant that thrives in diseased soil, was a prime candidate to serve as the rootstock.

The grafting process works like this: In the late-seedling stage, a cleft is cut into the stem of the rootstock; then the scion (shaved to a point) is inserted. They are held with a plastic clip or rubber tube. It sounds tedious, but dozens can be done in an hour by a pair of practiced hands. The most critical step is the plants' recovery period as they meld their vascular structures at the graft junction.

"If you don't give the plants high relative humidity and keep the temperature constant and reduce light, the grafting won't be successful," says Gutiérrez. Part of the challenge is teaching growers how to make affordable "healing chambers" with local materials.

The strategy has proven to be a game-changer. With grafted tomato plants, growers are seeing 100 percent increases in their yields, and selling the fruit is no longer the only profitable endeavor. Women's cooperatives, for example, can do the grafting and sell a resistant plant to a grower at three times the price.

Despite the higher cost, Nienhuis hears from growers — some buying as many as 10,000 grafted seedlings a month — that they are saving money by not using pesticides. Better yet, their families and farmworkers aren't exposed.

As word spread of the benefits, training became more in demand. Gutiérrez continued to teach grafting to farmers and womens' cooperatives. Eight students from Nicaragua's Universidad Nacional Agraria fundraised for months to afford travel to Madison to learn about grafting and agriculture for nine days in August 2017. They are now partners in ongoing grafting experiments.

Gutiérrez now teaches soil conservation and agricultural practices in steep lands at Universidad Zamorano outside Tegucigalpa, Honduras. He also once assisted in the development of a biofortified bean with increased iron and zinc content — two common areas of nutritional deficiency in the developing world. He says he has been changed by seeing the fruits of his labor:

"It is really amazing to see how the adoption of a small technique, something simple like grafting, can mean a lot to poor families and improve the lifestyles of a lot of people."

—Michael P. King

PERU

The Poverty-Biodiversity Link in Western Amazonia

In examining the loss of plant and animal life in the Amazon, scientists and the media often focus on the effects of deforestation. But a different set of causes may be at work in one part of the massive rain forest.

To uncover the true culprits behind this biodiversity loss, two UW–Madison alumni, **Yoshito Takasaki** MA'96, PhD'00 and **Oliver Coomes**, are drawing on a new, massive data set — and some help from their former mentor, agricultural and applied economics professor **Brad Barham**. Their conclusions could inform public policy in the Amazon for decades.

Coomes, who earned a minor in agricultural and applied economics with his geography Ph.D., and Takasaki — both Barham's former students and long-time collaborators — recently completed the largest census ever attempted to study the connection between poverty and biodiversity conservation in western Amazonia. They targeted the Loreto and Ucayali regions in eastern Peru, an area slightly larger than Sweden that encompasses more than 85 percent of the Peruvian Amazon. Their research teams completed a four-year field project covering thousands of miles of Amazonian tributaries, including a census of 919 rural communities followed by 4,000 household surveys in 235 of those same communities.

Coomes and Takasaki view biodiversity loss in the Peruvian Amazon as a developmental problem linked with rural poverty. Local residents overharvest certain species, causing the species' populations to crash and forcing the rest of the ecosystem to adapt. By surveying the local residents and studying what resources they extract from the forest — and how they do so — Coomes and Takasaki hope to create policy solutions to best preserve biodiversity.

Specifically, they examined the economic drivers and resources of different communities as well as important social aspects that spark population and economic growth. They are in the early stages of analyzing the combined survey and census data but have already discovered some notable relationships.

One surprising finding is that soccer is critically important to expanding labor and marriage networks in the Peruvian Amazon. Communities in the Amazon are small and separated by dense forest, but Coomes and Takasaki observed how the ubiquitous game can connect these communities through tournaments and help form bonds between people who would not normally meet.

"People find mates or partners at tournaments," says Takasaki. "You can get marriage across villages and diversify a community."

Coomes and Takasaki have also created an index with their census data to examine biodiversity changes in different communities. They examined fish, game, and timber populations, noting important and rare species. This helps them to track when different species were abundant and demonstrate how the forest has changed over time.

"The index allows us to see how biodiversity has changed from the start of the community to the present," says Coomes. "It tells us what can be done to help communities in earlier developmental stages and to find ways to support development with reduced impacts on the animal, fish, and plants surrounding them."

Barham, who assisted with some of the initial analysis, calls the dataset Coomes and Takasaki have assembled "beyond imagination" in its depth and representation of people in western Amazonia. "Previously, the problem with understanding what's going on in these vast areas of the Amazon is there was just no data at this level or scale or with this kind of systematic approach," he says. "Now we can use this data set to make statements about what's happening across the entire region."

Takasaki believes it will take researchers several years to finish analyzing the data, but he is excited about its possibilities. "There are so many potential topics and projects we can do using this data," he says. "Hopefully, we can find some creative solutions to slow biodiversity loss in the Amazon."

—Michael Warren

Photo by Oliver Coomes

A trail leads to several homes near the Marañón River, a mainstem source of the Amazon River, in Peru. The largest census ever attempted to study the connection between poverty and biodiversity conservation in western Amazonia included 919 rural Peruvian communities.

Private Lands, Public Good

Land trusts and governments are protecting private lands — and the vital natural resources they contain — with conservation easements, tax incentives, and other tools. **Adena Rissman** examines how well they are working.

Interview by Nik Hawkins

WITH THE WARMER MONTHS UPON US, the outdoor season is in full swing. There are hikes to take and birds to watch, fish to catch and shade to savor beneath the trees. And the fine weather doesn't only bring play. Workers are hitting the fields and woods, planting and harvesting crops and trees. We see their bounty in farmer's markets and crackling campfires.

All of these endeavors rely on one common element — good land. Parks, preserves, and other public lands are part of the picture, but private lands are critical too. Consider that, in Wisconsin, individuals and families own 57 percent of the state's forests, which hundreds of companies rely on for the majority of their raw materials. And the state is home to 68,500 privately owned farms. When properly managed, private lands help keep our water clean and our plants and wildlife abundant; they provide a sustainable wood supply for books and hardwood floors, rich soil for growing food, and so much more. But parcelization, invasive pests and diseases, and unsustainable land use continue to threaten these vital natural resources, a trend that's closely tied to the outcomes of public policy.

At this intersection of society and environment is where you will find Adena Rissman, associate professor in the Department of Forest and Wildlife Ecology. Much of her work focuses on natural resource policies and conservation strategies — their design, implementation, evaluation, and outcomes. A former forest planner for the Wisconsin Department of Natural Resources, she also examines how society and its laws adapt to environmental change.

One of her team's recent projects delves into digital mapping of private lands, which is critical for many stages of conservation, including planning, monitoring, evaluation, and accountability. Specifically, they looked closely at the public availability of geospatial data (locations on a global coordinate system) for conserved private lands. Based on their findings, they made recommendations for how to make this information more accessible. The study only scratches the surface of a broad research platform that covers conservation, adaptive ecosystem management, and sustainable resource use and their impact on forests, wildlife, rangelands, agriculture, and water resources across Wisconsin and the United States.

WHAT ARE SOME OF THE BIGGEST ISSUES SURROUNDING PRIVATE LAND CONSERVATION RIGHT NOW?

Private lands are critically important for producing food, fiber, and fuel and for providing wildlife habitat, water quality, floodplain protection, and sometimes public recreation. We're losing forests, farms, and wetlands while our conservation organizations have fewer resources to manage what remains. As housing is increasingly interspersed with forests and natural lands, fires become more life-threatening and expensive, and fragmentation is impacting wildlife habitat and forest and agricultural economies.

My research examines the design and effectiveness of private land conservation strategies. For instance, in Wisconsin, paper companies sold their land fairly rapidly, and we're looking at the patterns in which lands were divided into smaller parcels or became part of public lands and conservation easements. Conservation easements are agreements between private landowners and conservation organizations, such as government agencies and nonprofit land trusts. The idea behind conservation easements is to provide permanent protection of lands and their conservation values.

CAN YOU SHARE SOME INTERESTING FINDINGS FROM YOUR RESEARCH ON LAND TRUSTS AND THEIR PARTICIPATION IN DIGITAL MAPPING?

We found that just about half of land trusts contributed maps of their conservation easements to regional or national databases. These maps help organizations coordinate their efforts and tell the story of conservation to decision makers and the public. But participation in mapping is growing, and we found that land trusts were more likely to have contributed maps if they had larger budgets, were involved in regional collaborations, had a strategic plan, found the maps useful, and had fewer privacy concerns. Land trusts were also more likely to share their maps if peer organizations in their states were also sharing them.

WHAT WERE SOME OF THE RECOMMENDATIONS THAT CAME OUT OF THIS STUDY?

To have useful geospatial data for planning, evaluation, and tracking what happens with conservation dollars spent, it would be helpful to have complete maps of conservation easements, which are public documents. Additional funds for compiling and mapping parcels are needed to complete the maps. As more organizations join in, they bring others along with them.

Adena Rissman

Photo by Michael P. King

HOW MIGHT CONSERVATION EASEMENTS AND LAND TRUSTS BE AFFECTED BY ENVIRONMENTAL DISRUPTION LIKE CLIMATE CHANGE?

Environmental changes from floods, fires, invasive species, and heat waves, which have been exacerbated by climate change, are impacting private lands, including lands under conservation easement. So organizations are now having to adapt their management to ensure that conservation protections can continue under climate change. In a 2011 survey of conservation professionals from nonprofit land trusts and government agencies, the majority were concerned about the effects of climate change on conservation easements, but very few conservation easements mention climate. So we have to look to other parts of the agreement to help us understand how to adapt land management to climate change.

HOW ARE WATER QUALITY LAWS BEING CHANGED IN THE FACE OF INCREASING URBAN DEVELOPMENT AND AGRICULTURAL PRODUCTION?

We're studying innovative ways of bringing urban and agricultural interests together to improve water quality. One challenge is that urban and agricultural sources of water pollutants are regulated differently, with more specific rules for sewerage districts and urban areas than for agriculture and other rural lands. Locally, in the Yahara Watershed around Madison, organizations are looking for ways that urban households can help pay farmers upstream to improve their practices. Our work has explored the role of urban-rural networks and the negotiations over how water quality models and measurements should matter for policy design, payments, and compliance.

WHAT ARE THE BENEFITS AND DRAWBACKS OF INCENTIVE-BASED POLICIES AND REGULATION-BASED POLICIES RELATED TO WATER POLLUTION?

Incentives and regulations are two important tools in the water quality toolbox that can help us all enjoy clean water for drinking, swimming, fishing, and beautiful days outside. One drawback is that incentives can be too expensive to make available for everyone at the levels required to actually improve water quality. One drawback of regulation is that one-size-fits-all rules don't account for variation among people, firms, and places. They also may not keep up with emerging threats to water quality. We mapped dozens of incentive, regulatory, and other policies to look at their spatial patterns and found differences in how they target lands for improvement. For instance, some rely on the participants who are most likely to walk through the door, which helps landowners most interested in conservation, while other tools target areas with bigger pollution problems.

WHY ARE VOLUNTARY PROGRAMS SUCH AS WISCONSIN'S MANAGED FOREST LAW SO VITAL IN SHAPING LAND USE?

The Managed Forest Law is an incentive program through which landowners pay reduced taxes if they follow sound forest management practices. It's important for sustainable forestry because it helps landowners keep forests as forests that supply wood, recreation opportunities, and wildlife habitat, among other benefits. Tax policy like the Managed Forest Law reaches more forests than conservation easements. The Managed Forest Law has a 25-year minimum enrollment period; we found that this longer enrollment period helps the program be more effective in conserving forests and preventing parcelization. This finding was from before the most recent round of legal changes to the program, which made it easier to withdraw and parcelize land.

WHAT'S THE NEXT STEP IN YOUR RESEARCH?

We're working on a longitudinal study of conservation easements in Wisconsin and elsewhere and their land cover effects and social relationships as landowners and conservation staff change. We aim to evaluate conservation easement effectiveness and provide resources to conservation organizations to help them manage changing social and ecological conditions.

DRONES, JOYSTICKS, AND DATA-DRIVEN FARMING

BY RON SEELY

PHOTOS BY MICHAEL P. KING

The use of drone-assisted remote sensing is ushering in an era of 'precision agriculture'

Elissa Chasen PhD'14, left, and Jessica Drewry PhD'17 work with a drone fitted with spectral imaging cameras to study the effects of pests and disease on cranberry plants at UW–Madison's Walnut Street Greenhouse.

Brian Luck grew up on an 800-acre corn and soybean farm in western Kentucky, so he knows well the look of a planted field from the exact height of a tractor seat.

But these days, Luck is more familiar with a much loftier view of farm fields. It's a bird's-eye perspective afforded by the "unmanned aircraft vehicles," or drones, that have captured Luck's imagination as an assistant professor of biological systems engineering and extension specialist in machinery systems at UW–Madison.

From a workshop in the Agricultural Engineering Laboratory, Luck has been working to wed the programmable flight of drones with the evolving science of remote sensing — imaging farm fields with spectroscopes and infrared cameras to reveal what the naked eye cannot see.

This summer, he and **Shawn Steffan** MS'97, an assistant professor of entomology will test knowledge gained from months of sweaty greenhouse studies by piloting their disease- and pest-seeking drone above cranberry bogs in northern Wisconsin. The work is being financed through a two-year grant from the Wisconsin Department of Agriculture, Trade and Consumer Protection and funding from the Wisconsin Cranberry Growers Association.

A better understanding of the data and images gathered by the drone-borne instruments could lead to new ways for cranberry growers to detect insects and disease weeks sooner than traditional scouting forays on the ground. Such foreknowledge would allow them to treat threatened plants earlier and avert more widespread damage and crop loss, according to Luck. And because farmers would know more precisely where to spray, they could reduce pesticide use, which would be a major cost saver and a boon to ecosystems already overburdened by chemicals.

It's called "precision agriculture," according to Luck and Steffan, who is also a research entomologist with the USDA Agricultural Research Service. And with all the work going on in their labs, greenhouses, and fields, drone-based precision ag is on the near horizon.

"The savings on inputs alone makes this work justifiable," Luck says. "But until we show a farmer he or she is getting a dollars-and-cents benefit, until you show value, they're not going to invest."

THIS PUSH TO PROVE THE NEW TECHNOLOGY explains why labs such as Luck's, along with other labs across the CALS campus, frequently look like the droid junkyards out of a Star Wars movie. Drones of every description and size perch on lab benches. Spare parts and controllers and snarls of coiled wiring crowd shelves and benches in the best mad scientist tradition.

With two fast-changing technologies at their fingertips — drones and remote sensing — it is sometimes difficult to tell which excites researchers the most.

Phil Townsend, a UW–Madison professor of forest and wildlife ecology, specializes in studying remote sensing. He is director of the UW–Madison Environmental Spectroscopy Laboratory, where research is pushing the science of remote sensing forward by finding new ways to incorporate spectroscopy and interpret data.

The science has come a long way, Townsend says. In the 1800s, scientists were strapping cameras to the legs of pigeons; and in the 1920s and 1930s, researchers used aerial photography to create the earliest maps of soil types.

Townsend's lab specializes in reflectance spectroscopy, the study of how light interacts with objects. The instruments measure the intensity of light reflected by an object at wavelengths from 350 to 2,500 nanometers. This extends the reach of researchers far beyond the range of human eyes, which can only detect light across a meager 390 to 700 nanometers.

Using a type of spectroscopy called imaging spectroscopy, researchers are able to determine the chemical and physical composition of vegetation and other material based on the shape of the reflectance profile. These chemical signatures are what give researchers the ability to determine the health of crops over large areas. Simply put, a healthy plant is going to have a different chemical profile than a plant being devoured by caterpillars or destroyed by a fungus.

"We're pretty good at knowing what we're seeing," Townsend says. "We take the spectral data and figure out what different molecules in the plant absorb light at different wavelengths. So we can say, for example, that an effect we're seeing is because of a nitrogen deficiency."

WHILE TOWNSEND CAN TALK nonstop about spectroscopy and its promise, Luck brings a similar energy to the subject of drones. Big and jovial and sporting red hair and beard, he roamed his lab one recent spring day, enthusing about piloting drones and the advancements that have put the technology at the fingertips of experts and non-experts alike.

Luck is enamored with all things mechanical. In fact, it's nearly certain he would not object to being labeled somewhat of a geek about the subject. He's spent a good part of his research career thinking about and studying how to improve the efficiency of all things mechanical on a farm. His publications deal with fine-tuning everything from agricultural sprayers to ventilation in chicken broiler houses. A favorite subject is autonomous farming, or, in plain English, robot tractors.

But few things cause Luck to light up as much as drones. Luck understood their potential value in agriculture a number of years ago and started toying with their inferior forerunners.

"I crashed a lot of cheap, remote-controlled airplanes," Luck says.

Today, however, flying a drone is a lot less harrowing thanks to sophisticated onboard navigation systems and software that allow a pilot to program a flight plan and let the drone guide itself. Some software, for example, allows an operator to draw a line around the part of the field that needs inspection, and the software creates an automated flight path. The drones, especially those with horizontal, helicopter-like propellers, can hover over a specific location or fly low and slow, depending on the imaging task.

"I can tell the thing to fly 10 feet off the ground," Luck says.

The drones used by Luck and others who are adapting them to agricultural uses are feather-light, made from carbon fiber. Black, four-legged, and bristling with antennae and other instruments, they look almost menacing, like crouching spiders. They're controlled using an iPad that's loaded with navigation software and linked to a controller equipped with dual joysticks.

Part of the confidence that Luck and Steffan have in the drones' capabilities stems from a project initiated by Steffan a couple of years ago.

Moths are a particularly pesky problem for cranberry growers, and Steffan came up with an idea for dealing with them that could reduce pest populations while applying less insecticide. Instead of the standard insecticide regimen, Steffan used a sex pheromone that, when broadcast within a marsh, confused the male moths and kept them from mating.

A cranberry plant at UW–Madison's Walnut Street Greenhouse.

"Reduced mating means fewer caterpillars chewing on cranberries," Steffan says. "It's moth birth control."

The unique part of the plan involved deploying the pheromone with a drone. Steffan worked with a private company that mixed the pheromone into a "wax soup." Then, using a novel contraption mounted to the drone, they dropped dollops of the cocktail (a trademarked substance known as SPLAT) into the cranberry bog. It worked. And the programmable, highly maneuverable drone made it possible.

"We basically showed it could be done," Steffan says. "It's a new form of precision ag for Wisconsin cranberries."

The experiment was a perfect example of why drones are becoming a go-to alternative to planes and satellites for carrying remote-sensing instruments and other scientific payloads. They're cheaper and more versatile, and they give the researcher more control over how and when to fly.

These attributes also bode well for getting the technology to farmers for their personal use in the near future, Luck says.

"I'm trying to investigate things farmers can get their hands on now," Luck says. "This is something a farmer could buy tomorrow."

Luck has no end of ideas when it comes to envisioning how drones can be incorporated into the routine operation of a farm. Farmers, he said, could use drone imaging to make management decisions about everything from fertilizer application to irrigation. Or, he mused, leaning against a lab bench, what about the potential advantages for farmers with disabilities?

"Say you have a broken motor on top of a grain bin," Luck says. "You could avoid climbing up a 100-foot grain bin by flying a drone up to check on the problem instead of having to climb up a ladder.

"Or what about flying a fencerow? You could fly a drone close enough to a fence to see if the insulators are working."

It's not too far-fetched, Luck says, to think that, someday, having a drone on the farm will be little different than having a tractor parked in the machine shed. He envisions drones ensconced in boxes on the edges of fields, their batteries being recharged by the sun via solar arrays, waiting for the farmer to bring them to life and pilot them up and down their crop rows with the same nonchalance they bring to deploying something as prosaic as a manure spreader.

Brian Luck, assistant professor of biological systems engineering and extension specialist, and assistant faculty associate Jeff Nelson MS'95 take a DJI Matrice drone out for a test flight at UW–Madison's West Madison Agricultural Research Station.

OF COURSE, LUCK ISN'T THE ONLY researcher out there with such an imagination. Drones are hot. Researchers in fields ranging from meteorology to wildlife ecology are finding ways to bring the drone's unique advantages to bear on their work.

Drones have become so ubiquitous, and the technology has advanced so rapidly, that UW–Madison has rushed to firm up regulation of the devices to meet Federal Aviation Administration standards and to make sure that researchers and others don't run afoul of the rules in their work. Last year, the university adopted a new drone-use policy that replaced a set of more restrictive rules. The policy includes an approval process and allows drone use for research and teaching.

Restrictions were necessary because of Madison's urban setting, nearby airports, and the location of UW Health's Med Flight base at University Hospital. The new regulations followed an unsettling 2014 incident in which a mysterious drone appeared and hovered above the Camp Randall Stadium student section during a football game. The pilot was never discovered, though the incident was heavily investigated due to the fear of a heavy drone dropping into a crowd of unsuspecting people.

Today, federal rules exist for both recreational and commercial use of drones. Farmers who use drones would have to abide by the commercial rules. A drone pilot certification is required, for example. Flights are restricted to daytime hours, altitudes limited to 400 feet and speeds to 100 mph, and pilots must maintain visual line of sight with their drone.

Also, as part of its larger response to the heightened interest in and use of drones, UW–Madison now offers a course on piloting the devices. **Chris Johnson**, director of the UW Flight Lab in the Department of Industrial and Systems Engineering, started the class last year. He said the class is aimed at not only teaching students to pilot drones but also introducing them to practical applications of the technology. The course includes a certification exam.

The list of commercial uses for drones is long and growing, Johnson says. Their use is being explored in construction, real estate, and utilities management. For example, Johnson says, utility companies could use drones to inspect thousands of miles of power lines, seeking hot spots or corrosion. But farmers especially are paying close attention to the adaptation of drones, he says.

"Agriculture is perhaps the single most mature market sector for drone-based technology," Johnson says. He cites the cost savings for farmers and the greater ease and safety of flying drones in rural rather than urban areas as the major reasons for agriculture's embrace of the technology.

"A lot of growers know about it," says

Joe Paul, a former farmer who runs a drone-based agriculture imaging and data service in New Lisbon, Wisconsin. "Although they're not quite sure how they want to use it in their operations. It's mostly the younger farmers, the sons or daughters who are taking over management and want to try new things. Drones will be able to help bring farming into a more technological age."

One problem, Paul says, is that some farmers choose not to tackle the complexities of the software that is necessary for compiling and interpreting images and data gleaned from the drone flights. "A lot of growers don't want to sit at the computer," Paul says.

And that is where the evolving field of remote sensing technology becomes a crucial part of the story. As drones increase in sophistication, UW–Madison researchers are also developing a better understanding of how to read and interpret the images being captured by the drone-borne spectrometers and cameras. Equally important, they are finding ways to make that knowledge more accessible and usable for farmers.

"It's basically automating the process," says Townsend. "We're out there figuring out how to manage this and turn it into data people can use."

WORKING ALONGSIDE LUCK

and Steffan on the cranberry project, postdoctoral research associate **Jessica Drewry** PhD'17 and lab technician **Elissa Chasen** PhD'14 have spent long months in the Walnut Street Greenhouse on the UW–Madison campus. They have carefully tended and grown cranberry plants before infesting them with an army of hungry caterpillars that munch away on the leaves.

Now Drewry and Chasen are meticulously documenting the damage the caterpillars have wrought using images taken with a multispectral camera, an infrared camera, and a regular camera. Like most such research, it has been a slow and tedious process — from building the wooden and mesh-covered frames that cover the plants to growing the cranberries to collecting hundreds of images week after week.

And, of course, there have been challenges. The researchers struggled to figure out a way to water the plants. At first they had the plants resting in trays while they watered them.

"But the caterpillars were falling off the plants and drowning in the trays," Drewry says. They got rid of the trays and built a special contraption to water the plants without disturbing the caterpillars.

This is the hard, workaday part of science that most people don't see. Entomologist Steffan calls it "ground truthing."

Drewry and Chasen feed the data they collect from the images into a software program that helps them correlate the data from the pictures with the extent of the caterpillar damage. They do everything they can to take into account variables that would harm the accuracy of their findings. In the bright, steamy greenhouse room, for example, they noted temperature and light variations from enclosure to enclosure.

"That's why we have a clipboard," Drewry says. "And why there are two of us."

At one point, the women bent over one of the plants, worried as parents hovering over a baby's crib.

"We should note that fungus," Drewry says. Down went a scribble on the clipboard.

To keep their experiment as realistic as possible, they use the drone itself, outfitted with the cameras, to capture the images. Drewry holds the drone above the enclosures, and Chasen uses the drone controller to trigger the cameras.

This is the painstaking process that Luck and Steffan hope will eventually lead to a system that allows a farmer to easily analyze images of a field on a computer and understand immediately what's revealed, whether it's an early-stage caterpillar infestation or perhaps a fungus or other disease.

The brilliance of such a system is that the time-strapped farmer won't need to learn a thing about the complicated science that powers the new technology. The farmer will sit down at a computer and load the images, and powerful algorithms — basically sequences of instructions built by the researchers using their collected data — will do the hard work of matching images with the specific nature of the crop damage.

"It's basically automating it," says Townsend. "We're working underneath the hood, making all of this invisible to users."

This invisible science of algorithms powers much of the technological innovation we rely on today, from weather maps to navigation devices to Google searches.

OTHER SCIENTISTS IN CALS ARE

also working to expand our remote sensing capabilities.

In the environmental spectroscopy laboratory, researchers **Clayton Kingdon** and **Erin Hokanson Wagner** work with Townsend to create new uses for spectrometers as well as a more refined understanding of the data collected by the instruments. And they are compiling a database, basically a library, of spectral data called the Ecological Spectral Information System, or EcoSIS.

Spectrometers of every stripe sit on the lab benches in various stages of assembly. On one countertop is a tube-shaped spectrometer mounted on what looks like a trailer hitch. It's designed to be mounted on a tractor.

Open just about any drawer in the lab and you'll find a spectrometer. The whiteboards in the lab are covered with dozens of scientific scribbles, various versions of the distinctive squiggly lines that represent light at different wavelengths, all created as the researchers hash out the data they are continually compiling and interpreting.

Kingdon is particularly enthralled with dreaming up different ways to deploy the spectrometers, including on

airplanes and on two different kinds of drones that are at rest on a counter in another room.

In March 2018, Townsend spent time at the NASA Jet Propulsion Laboratory in California, working with researchers there to adapt the newer, cutting-edge hyperspectral imagers to use aboard satellites. Surprisingly, he says, few, if any, satellites are equipped with the newer versions of imaging spectrometers now being pioneered.

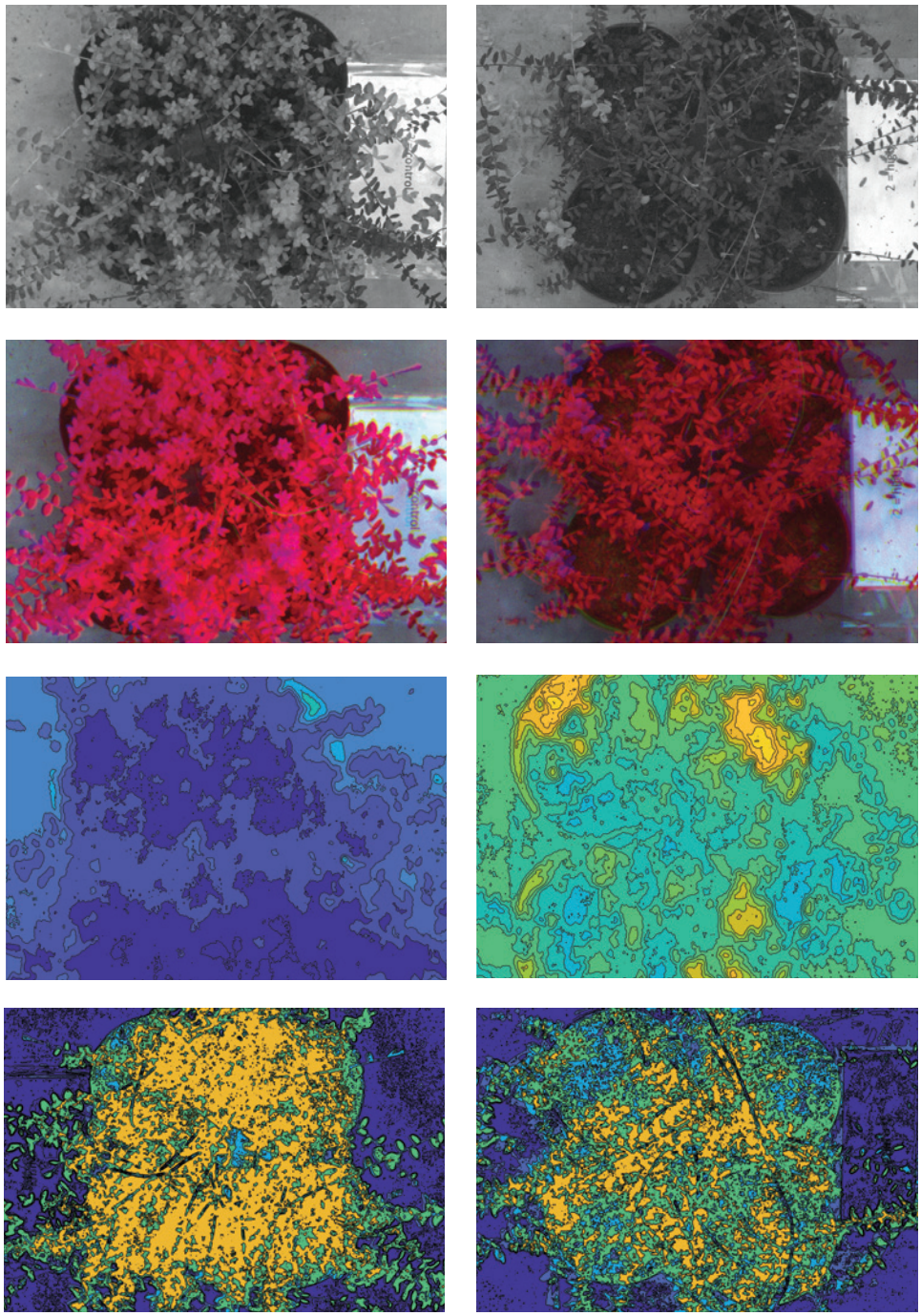
For Townsend and the others in the spectroscopy lab, the most exciting work involves the development and use of hyperspectral remote sensing, an amped-up version of traditional spectroscopy. It provides much more detailed data, offering the promise of detecting problems with a crop even earlier.

Like Luck and his crew, Kingdon and Wagner are working with farmers to compile additional data from field studies to bring more precision to the use of spectroscopy. They're working with cranberry and potato growers and others. But the work in the lab goes beyond agriculture to studies, for example, of forest canopies in northern Wisconsin looking to better understand the impacts of climate change.

Wagner has been working on a project in which she is using spectroscopy to better predict yield — crucial for growers who are trying to market a crop even as it grows in their fields.

All of this science has moved agriculture far from the days when a farmer walked out in a field and cupped a handful of soil to make management decisions. And it has propelled Luck into a much different domain than those rural Kentucky corn and soybean fields. He still honors that past. He still feels happy and at home in the seat of a tractor. But when Luck starts talking about drones and the promise of remarkable machines that can peer into worlds invisible to our eyes, it's the future one hears.

"There are uses out there for this technology that we don't even know about yet," Luck says.



Images by Jessica Drewry PhD'17

These images of cranberry plants growing in greenhouse enclosures were taken by drones outfitted with multispectral cameras. They are part of a research project aimed at creating a spectral imaging-based diagnostic system for crop damage.

The plants in the left column are experimental controls, meaning they have not been subjected to pests or pathogens. The plants in the right column have been infested with insects, and the damage they cause affects how the plants reflect light at different wavelenghts. All of the images have been processed with software to determine certain characteristics, such as temperature. The images in the bottom row are mapped with the normalized difference vegetation index, a simple graphical indicator of plant health based on the spectral measurements.

Laurens "Andy" Anderson, emeritus professor of biochemistry, left, and another researcher study large-scale diagrams of sugars, which was once a common way to ascertain how chemicals look at the molecular level and to decide on the best approach for synthesizing them.

Forgotten Molecules

By Kaine Korzekwa MS'16 and Sarah Perdue

THE FRUITS OF AN EMERITUS PROFESSOR'S 40-YEAR CAREER IN BIOCHEMISTRY ARE CONTRIBUTING TO THE MODERN SEARCH FOR NEW MEDICATIONS

On a rainy day last fall, chemist **Scott Wildman** left his office on the UW–Madison campus and drove to a retirement community on the city's west side to bring 40 years of scientific work out of the dark.

His trip brought him to the home of **Laurens "Andy" Anderson** MS'47 PhD'50, emeritus professor of biochemistry. There, packed away in a closet, Wildman found a cache of dark green boxes holding nearly 800 meticulously organized vials of purified chemicals, each one stoppered with real cork and labeled with intricate handwriting. Many of the vials boasted a tiny drawing of a structural chemical formula for identifying the white or sometimes colored powders inside. Wildman wrapped the glass treasures in protective plastic and chaperoned them to their new home — and new purpose — at the UW Carbone Cancer Center's Drug Development Core (DCC).

Department of Biochemistry file photo

The so-called "green box collection" contains the physical legacy of Anderson's career with the Department of Biochemistry. While cleaning his house one day, it occurred to him that the molecules could be useful for carbohydrate chemistry researchers, so he approached the department about donating the collection. In the end, it was decided they would have the biggest impact at the DDC, where they can serve as a resource for the next generation of scientists looking to discover new drugs for treating diseases.

In the complicated process of drug discovery, scientists screen large collections of molecules — called libraries — in search of a range of properties that indicate they could be used as antibiotic, antifungal, or anticancer agents, or even neurological drugs. A molecule with one or more of these properties is called a "hit" and can be further investigated as a possible drug. A hit gives researchers an important starting point for deeper research in drug design. But when compared to the types of molecules synthesized for drug discovery today, the old-school way in which Anderson's molecules were made gives them some unique properties, so they are taking on new significance in their present home.

"Learning about him and what he

'There is a second life for some of these compounds, which may harbor untapped biological relevance.'

Photo by Robin O. Davies

did while he was here 20 years before I was born has been very interesting, especially because I am now one of the keepers of the fruits of that labor," says Wildman, who is an associate scientist at the DDC. "As scientists, we have a finite period of time in which to make an impact. But in this case, we just gave his impact a whole new lease on life. In a way, he can start over, even without being in the lab."

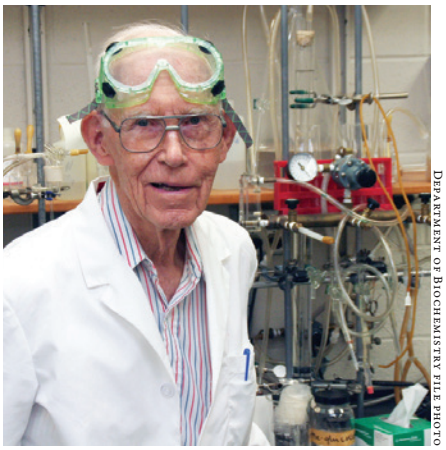
THE MAKING OF THE 800

Anderson, now 98, was born in South Dakota, and he earned his undergraduate degree from the University of Wyoming in 1942. After college, he joined the Air Force and served as a bomber pilot in missions over southern Europe. In 1946, he began his graduate studies in biochemistry at UW–Madison, where he worked with esteemed biochemist **Henry Lardy** MS'41 PhD'43, an expert in metabolism and sugars. After earning his Ph.D., and following a yearlong postdoctoral position in Switzerland, Anderson returned to UW–Madison to join the biochemistry faculty.

One of Anderson's first major scientific contributions was determining the molecular structure of several cyclitols, which are a group of compounds closely related to sugars. Around the time Anderson joined the UW faculty, antibiotics were just starting to see widespread clinical use. The second one to be introduced, streptomycin, included a cyclitol in its chemical structure.

"And so I began thinking about how to synthesize analogues of streptomycin," Anderson says. "I thought, 'Well, if I could change the cyclitol part and put more sugars on it, maybe I'd have an antibiotic.'"

Each purified chemical in the "green box collection" is contained in a vial, which in turn is housed in a larger glass tube and sealed with a cork stopper. The number and letter combination on the outside denotes the location of the tube in the collection.



DEPARTMENT OF BIOCHEMISTRY FILE PHOTO

After his retirement in 1986, Anderson couldn't stay away from science. He became a visiting scientist in the UW Department of Chemistry, where he was involved in science outreach and work with undergraduates.

Although Anderson's work did not lead to a new antibiotic (at least, not yet), it did start him down the path of completing complicated organic syntheses of sugars. He began reading about the importance of sugar molecules on the surface of cells and how they contribute to crucial functions such as cell-to-cell communication and immunity. These cell-surface sugar molecules are oligosaccharides, or combinations of a few individual sugars into a larger, multiunit sugar. Anderson expected he could use his organic chemistry expertise to synthesize a variety of oligosaccharides with potential biological applications.

The problem is that the chemistry of making substitutions in sugars is extraordinarily complex. Unlike the other "big player" molecules in biochemistry (DNA, RNA, and proteins), sugars have multiple chemically reactive parts to them, any of which is difficult to differentiate. With specific end products in mind, Anderson realized he needed to selectively block certain reactive parts in order to synthesize the intended product.

"The result, then, is that I've spent a great deal of effort on thinking how to attach protecting groups to the reactive groups of the sugar molecules," says Anderson, who retired from the biochemistry department in 1986. "This turned out not to be the best strategy for making oligosaccharides."

It did, however, turn out to be a strategy that yielded more than 800 cyclitol and sugar derivatives, most of which are the intermediates to becoming the desired end product. Along the way, Anderson and his research group purified each of the derivatives and meticulously documented and saved them, which led to the green box collection.

A LEGACY OF SCIENTIFIC RIGOR

The diligent labeling and organizing of his sugar collection reflects Anderson's approach to all of science, explains biochemistry professor **John Ralph** PhD'82. Ralph, also a researcher with the Great Lakes Bioenergy Research Center based at the Wisconsin Energy Institute, collaborated with Anderson in the 1990s and 2000s.

Ralph describes Anderson as extremely rigorous in his scientific work, particularly when it comes to naming carbohydrates. A system for naming scientific compounds is extremely important; proper nomenclature allows scientists from around the world to understand one another's work. Ideally, carbohydrates are named based on their structure so that a scientist can tell the exact structure from the name. There was no good system for naming new carbohydrates until Anderson changed the field. His naming rules are still in use today.

"He is really a world authority on carbohydrate nomenclature and helped devise many of the rules during his career," Ralph says. "His interest and expertise in the fine details advanced the field immensely. He was also an editor at the *Journal of Carbohydrate Research* for a long period and ensured everything that went in that journal was absolutely correct. He never minded being contacted, and we'd run new compounds by him to make sure they were accurately named. He was always happy

to lend his expertise without a hint of arrogance or condescension."

Anderson and Ralph worked on two papers together when Anderson was still mentoring some young scientists in his retirement. One paper dealt with the cross-linking of plant cell walls and required Anderson's selective protection strategies; and the other, which was a particularly successful paper, was about a popular dietary supplement called psyllium. Anderson was working with collaborators in the Department of Food Science to investigate a specific polysaccharide in psyllium thought to be responsible for lowering cholesterol. Ralph was invited onboard to use a technique called nuclear magnetic resonance (NMR) spectroscopy to determine the structure of the complex polysaccharide.

"We made a big advance in that paper, and it actually got a top citation award in 2007," Ralph says. "It's also an example of how Andy always wanted to stay relevant. He had an interest in being meticulous in his synthesis and nomenclature but also saw the big picture and the impact his work could have in an area like health and cholesterol lowering."

Ralph's current research focuses on lignin, a chemical polymer that binds plant fibers together and makes stems hard, durable, and difficult to break down. His lab is investigating how lignin can be engineered so it's easier to break down plant biomass for purposes such as biofuel. Although his current work focuses outside the field of carbohydrate chemistry, Ralph says Anderson's rigorous scientific approach still inspires him today.

"In the lignin literature, there can be a lot of discrepancies in the structures presented, but we try to ensure we are always correct," Ralph says. "It's important for us because, when you don't make those silly mistakes, we become known as experts, and now people know they can come to us for advice. That is something I attribute in large measure to Andy."

Ralph adds that Anderson's collection of molecules will have great value for a long time because not many people are still doing the same kind of difficult synthesis. "Andy is one of those wonderful human beings and an unbelievably good mentor to many people," he says. "A collection like this one he's donated is just invaluable."

A NEW PURPOSE: DRUG SCREENS

Jennifer Golden, associate director of the DDC's Medicinal Chemistry Center, knows that there are many unique chemical collections from UW's scientific past. Which is why her center reaches out to local investigators who have synthesized novel molecules and helps funnel their compounds into diverse biological screens.

"Academic careers have been built on training students to construct structurally unique molecules," says Golden, who is also an assistant professor in the School of Pharmacy. "Once synthesized, these agents can often end up in a freezer vial, never to see the light of day. There is a second life for some of these compounds, which may harbor untapped biological relevance. We want to harvest these potential gems from the freezer — or the closet, in the case of Andy's collection."

'A collection like this one [Andy has] donated is just invaluable.'

Wildman, the DDC chemist who procured the green box collection, is now working with his team to confirm the chemical structure of each molecule and enter it into the database. When the process is complete, Anderson's sugar molecules will be ready to screen, along with the hundreds of thousands of other molecules available at the DDC.

To reap the benefits of these molecules, scientists can incorporate them into their current experiments. The DDC works with researchers to screen the molecules and narrow the search for compounds that can be developed into new drugs. **James Keck**, professor of biomolecular chemistry in the UW School of Medicine and Public Health (SMPH), is using this screening process to look for possible new antibiotics.

"Essentially, these experiments are like huge sieves," explains Keck, who is also the SMPH's associate dean for basic sciences. "You start out with this giant library of roughly half a million compounds they have at the screening facility, where Andy's will soon be included, and you devise a way of rapidly going through and checking each compound individually to see if any appear to do what you want."

Using different methods, the screens continue to narrow the pool of molecules finer and finer. From half a million, to fifty thousand, to maybe 500, and then finally a number that individuals in a lab can actually work with. Keck's search for possible antibiotics just finished its first screen.

Keck's lab studies protein complexes that are uniquely found in bacteria, not humans, and that are essential for the bacteria to survive. If they can find a chemical that binds to one of those protein complexes and then stops an essential process, they've got a potential drug to investigate.

"You're sorting the wheat from the chaff, and each step in the process is a screen that gets rid of more of the chaff," he says. "Then, the small number of molecules we end up with almost certainly aren't the drugs one could use. They must undergo further research after that."

DEPARTMENT OF BIOCHEMISTRY FILE PHOTO

Anderson working in his lab during his tenure in the Department of Biochemistry.

OLD MOLECULES MEET NEW

This efficient screening of candidate drugs is not a new innovation. It was picked up in earnest by pharmaceutical companies in the 1990s. And the number of molecules in the green box collection, synthesized by fairly conventional methods, pales in comparison to the hundreds of thousands of molecules now available through commercial libraries. The significance of Anderson's molecules lies in their uniqueness, complexity, and close relationship to molecules that occur naturally.

Back when Wildman worked for a pharmaceutical company as a drug library designer, he says he made them as simple as possible. The reasoning was twofold. One, each step requires purification that can be laborious, so the fewer the steps, the less purification. Two, researchers thought drugs should not be so chemically complex that they react with everything — they should only react with the intended target.

"From a development standpoint, structural simplicity offers many advantages," Golden says. "However, it is more widely appreciated now that surveying compounds that are architecturally differentiated from those in commercial libraries is likely to offer new opportunities in drug discovery. We need structural diversity, and an academic environment is uniquely suited to deliver on that front."

Golden is principal investigator on a recently awarded UW2020 grant that seeks to make spatially complex molecules like Anderson's, but to do so with biological significance and drug-likeness in mind. Once completed, the UW2020 library, like Anderson's, will be a resource for the entire UW community.

With the donation of Anderson's collection, the science is coming full circle. Anderson's storied career, which includes earning the American Chemical Society's prestigious Hudson Award for Carbohydrate Chemistry in 1984, can now carry on even though he's no longer in the lab.

Today's researchers are happy to include his molecules in their libraries and develop new methods to make libraries with the same chemical diversity, albeit much faster thanks to modern technology. Among the hundreds of thousands of molecules in these screens, the researchers say these 800 will always stick out for their uniqueness and fascinating connection to UW–Madison.

"An enormous amount of man and woman hours went into these things, and I had a policy from the beginning that if we made some kind of intermediate we would save a little bit and put it in a vial and label it," Anderson says. "That's how we ended up with those green boxes. I'm glad they are back at UW–Madison."

VECTOR VIGILANCE

A new CDC-funded center at UW–Madison looks to stay a step ahead of the Upper Midwest's ticks and mosquitoes — and the diseases they carry

By Caroline Schneider MS'11

When you visit the UW Arboretum, you go to take a stroll through the woodlands, prairies, and flowering trees. You go to navigate the boardwalks that wind through wetlands to views of a shimmering Lake Wingra. You go to breathe in the heady scent of the world-famous lilac collection. What you don't go to do is serve as a taxi for ticks and their pathogens. But if you spend time outside in the summer, odds are you're acting as an unwitting tick transport — and the odds are increasing.

Home to robust populations of ticks and their hosts (namely, mice and deer), Wisconsin — the Arboretum included — has become a hot spot for tick-borne diseases. Over the past 25 years, deer ticks have trekked from the northern parts of the state to the south and east. They are now found nearly everywhere, lurking in the backcountry, in the wooded areas of neighborhoods, and even in well-manicured lawns.

"There's an idea that people in Wisconsin only get ticks when they go hiking in remote places. I don't think that's true," says **Susan Paskewitz**, professor and chair of entomology. "I think there are many people picking them up in their backyards."

Wisconsin residents are also encountering more of another well-known pest — mosquitoes. Last summer, Paskewitz and her colleagues trapped 80,000 mosquitoes in Dane County. That's eight times more than ever observed previously, a sign that their numbers are growing.

The Asian tiger mosquito, a species capable of spreading the Zika virus, was found in Wisconsin last year. In humans, Zika infection often causes mild or no symptoms, but it can lead to pregnancy complications, such as brain malformations in infants. In 2015, an epidemic of Zika broke out, starting in Brazil, where around 1.5 million people became infected. Although the number of cases throughout the Americas has dropped dramatically since 2016, and Zika transmission has not been detected in Wisconsin, the disease has made its way into other parts of the Midwest.

As mosquitoes and ticks travel into new territory, exposure to the diseases they carry increases. In 2016, more than 640,000 cases of vector-borne disease were reported nationwide, which is triple the number of cases in 2004. In roughly that same time period, nine new germs spread by bites from mosquitoes and ticks have been discovered or introduced in the United States.

In this new reality, scientists, public health officials, industry representatives, and the public are asking how they can be better prepared to respond to ongoing cases and stop epidemics before they start. A new consortium led by Paskewitz and **Lyric Bartholomay** PhD'04, associate professor in the UW School of Veterinary Medicine, aims to provide answers.

The Midwest Center of Excellence for Vector-Borne Disease was established last year with a $10 million grant from the Centers for Disease Control and Prevention to research illnesses transmitted by ticks and mosquitoes (the vectors, in this case) and train new professionals who can stop

Photos by Michael P. King (2)

Susan Paskewitz, professor and chair in the Department of Entomology, is pictured here in the UW Arboretum, the site of ongoing research on control strategies for two common vectors — ticks and mosquitoes.

the diseases from spreading. The center is a direct response to the struggle the U.S. faced when Zika arrived and is part of a system of regional consortia tasked with studying and preparing for vector-borne diseases. These consortia form the basis of a federal plan to build a barricade against what is seen as a rising threat.

"There was broad recognition that we were underprepared when Zika came in, so the CDC put out a call for proposals asking for Centers of Excellence to represent specific geographic regions," Bartholomay explains. "The goal is to provide public health and public health entomology expertise in these regional areas. This is really unprecedented investment in this kind of work."

The investment will allow researchers and public health officials to keep a close watch on a number of pathogens transmitted by ticks and mosquitoes. Lyme disease is the most prevalent tick-borne disease in Wisconsin, with almost 1,500 confirmed cases in 2016 (and many cases go unreported). Spread by deer ticks, the disease causes fatigue, aches, and fevers, which are sometimes — but not always — accompanied by the hallmark bull's-eye rash. If left untreated, Lyme disease can lead to facial paralysis, nerve pain, short-term memory issues, and a host of other debilitating symptoms.

Other tick-borne diseases in the area include Powassan virus infection, ehrlichiosis, and anaplasmosis. Reported cases of anaplasmosis, which is also spread by deer ticks, have increased drastically in the last several years. The disease typically causes flu-like symptoms, but it can lead to dire complications, such as renal failure, neurological problems, and hemorrhaging, if not treated correctly. Severe cases can cause prolonged hospitalization and even death.

Mosquitoes, likewise, carry a number of different diseases. West Nile virus, which often causes no symptoms but can sometimes lead to fever, headaches, and vomiting, is the most recognized mosquito-borne pathogen in Wisconsin. The state saw 47 confirmed cases in 2017. Other diseases reported in Wisconsin include the Jamestown Canyon virus and the La Crosse virus, which was discovered by researchers at UW–Madison in the 1960s and is a major cause of pediatric encephalitis.

One main objective of the new center is to spur collaboration among various sectors — academia,

Lyric Bartholomay, professor of pathobiological sciences at the UW School of Veterinary Medicine, stands in her office near an old, elaborate diagram depicting how a mosquito transmits the parasites that cause malaria in humans.

industry, and public health — to improve vector surveillance, outbreak responses, and prevention efforts. "We want to assemble experts and organizations who can put a plan in place to respond to ongoing problems and when we have outbreaks," Paskewitz says. "Everything we do in the center leads to being ready for and responsive to current and emerging vector-borne diseases."

ONE CENTER, MANY PARTNERS

Although the Midwest center is headquartered at UW–Madison, its many partners, including universities, public health departments, clinics, and mosquito control districts, can be found in Illinois, Iowa, Michigan, and Minnesota. The collaborators work together closely, communicating and consulting regularly.

"There is so much interaction and cross talk in the center," says **Bieneke Bron**, a UW–Madison postdoc who joined the center last October. "It's a synergy. It's not one plus one equals two; it's really one plus one equals three. Everyone has so much knowledge, and it's mind-blowing how much information is shared. The building of ideas and projects is astounding."

The regional focus and collaborative spirit of the center promises to provide mutual benefits to partners across the Midwest. For example, Illinois has seen its fair share of mosquitoes that can spread the West Nile and Zika viruses. If conditions become favorable for an outbreak of either disease in Wisconsin, Illinois could offer a lot of help in responding to those issues.

"We're hearing about things that are happening in neighboring states, so that puts us on alert," Bartholomay says. "We can then have conversations about how we might respond much more quickly than if we had to wait for data to be reported at the end of the mosquito and tick seasons."

UW–Madison holds a wealth of knowledge as well. As ticks move into Illinois and Michigan, researchers and public health officials in Wisconsin will be able to share their experiences and research findings with others in the region. The UW Arboretum is a microcosm for the state and the Midwest, serving as an ideal place for observing vector, rodent, and human behavior and testing new control strategies. The expertise and structure of a regional center ensures that information gleaned from areas like the Arboretum reaches all collaborators. For instance, UW–Madison researchers held a workshop on mosquito and tick surveillance, just one of several short courses that the center and its partners have hosted.

Photo by Michael P. King

Postdoc Bieneke Bron prepares capillary tubes for insertion into a PCR machine. PCR, or polymerase chain reaction, is a technique that allows researchers to identify DNA belonging to a known pathogen or even uncover hints of new pathogens.

Postdoc Scott Larson and Colin Sinott BS'13 (an undergraduate at the time), "drag" for ticks in the Kettle Moraine State Forest - Southern Unit. The drags, large pieces of fabric with strips or tails cut into the end, help researchers collect ticks and bring them back to the lab for identification and pathogen analysis.

The wide variety of expertise is especially important given the complexity of vector-borne diseases and their transmission. The tick life cycle provides many opportunities for diseases to be passed on because they must eat at every stage to survive. Larvae may feed on mice, birds, or chipmunks from which they can catch a disease. Nymphs might eat blood from larger animals, even coyotes and raccoons, giving them a second chance to become infected. Nymph and adult ticks can subject humans to any disease they may have picked up along the way.

"There are so many players in vector-borne diseases," explains **Scott Larson** PhD'17, a UW–Madison postdoc. "It's not the flu, where I give it to you and you pass it to someone else. You have intermediate steps and all sorts of different hosts for the pathogens. The fact that some tiny organism can pick up something from a wildlife host that can then end up in people is fascinating. It's so complex."

This complexity necessitates not only the center's varied expertise but also an approach that blends different players and interests. To make sure that all the people needed to address emerging diseases have a seat at the table, the center approaches its work through three avenues: training, research, and developing networks with communities and public health officials.

RESPONSIVE EXPERTS IN TRAINING

To be certain that the right personnel will be available when the next disease or outbreak arises, the Midwest center trains new experts in public

health entomology, an essential part of their focus on readiness.

"We're training people who could mobilize in a very short time in the event of an emergency," says Paskewitz. "And the Public Health Entomology Certificate that we offer is a major piece of that effort."

The certificate program is non-transcriptable (students don't receive academic credits), but participants achieve various milestones that mark their ability to respond to the threat of a vector-borne disease. They achieve state certification as pest control applicators, take online or in-person classes, conduct fieldwork, and complete training in vector identification and diagnostics. The certificate was awarded to seven people last year.

The center's investment in training has already yielded benefits. Last fall, the floodwaters that Hurricane Harvey left behind in southeastern Texas provided habitat for millions of mosquitoes to emerge in the area, thwarting recovery and raising concerns about disease. Two UW students working with the center traveled to Texas to help with mosquito control efforts. **Melissa Farquhar**, a veterinary medicine student, and **Erin McGlynn**, a medical student, were made temporary employees of a mosquito control company and spent many hours identifying the mosquitoes brought in from traps set up around the area.

"We were so proud to be able to send people who could help and who could, in turn, get some hands-on learning experience," Paskewitz says. "That's what we want — enough expertise so that, when a situation arises, we have people who can respond."

A STEP AHEAD THROUGH RESEARCH

Along with sending public health entomologists to the front lines of outbreaks and disease threats, the Midwest center is educating new researchers to augment the information and ammunition available for combating vector-borne diseases. Undergraduates, graduate students, and postdocs participate in many different research projects as they work to identify, understand, and fight diseases and vectors.

With access to its large insectary, many in Bartholomay's lab study mosquitoes. They're working to find new ways to control the insects. Some are studying the effectiveness of larval-stage controls while others are looking for new active ingredients for insecticides or trying to understand the effectiveness of spraying for adult mosquitoes.

"We want to make approaches to controlling mosquitoes more economical and more environmentally friendly," Bartholomay says. "We're also interested in how the public perceives insecticide applications for mosquito control and how that can factor into the approaches we use."

Just across a small outdoor courtyard from Bartholomay's lab, Paskewitz and her team focus on ticks. They capture the insects through tried-

Photo by Xia Lee

TICK-TRACKING TECH

The Tick App

You can help report tick activity. Download The Tick App for your mobile device (iOS and Android), complete the enrollment questions, and write in your "tick diary" for 14 days during peak time for nymphal ticks (June) and later in the summer. You can also report a tick at any time. The data you provide will help scientists understand where people are encountering ticks and what behavior increases the risk of tick encounters and possibly tick-borne diseases.

Wisconsin Tick ID

You found a tick — now what do you do? You could submit a report through The Tick App or send a photo to the Wisconsin Tick ID service, launched this year by the Department of Entomology. It will identify the life stage and species of the tick (based on your images and geographical location) and provide guidance on any steps you should take following your encounter. Visit the site at **go.wisc.edu/tickID**.

Postdoc Scott Larson looks for a place to set a tick tube, and a trail camera for monitoring its use by wildlife, in an area designated for research in the UW Arboretum.

and-true fieldwork using "drags," large pieces of fabric with strips or tails cut into the end that they pull through forested areas. They then collect the ticks, sometimes using a simple lint roller to get them off the drags, and bring them back to the lab for identification and pathogen analysis.

In the past, variations in tick collection methods made it difficult for scientists to compare data from different labs. Some may use a drag with or without tails. They may count steps or keep track of time spent using the drag. Or they may cover the area of an entire plot. Because collection looked so different, it was hard for researchers to say that the outcome at one plot was comparable to the outcome at another. But the Midwest center is changing that.

"We're really trying to standardize tick collection here so we can directly compare data from different researchers," Larson says. "We're all using the new drags with tails that float better as we pull them through the woods, and we have a specific protocol to use while collecting ticks."

Another tool aiding the researchers is the sophisticated technology they use to identify pathogens and uncover new diseases as they arise. Called PCR, or polymerase chain reaction, the technique allows researchers to identify DNA belonging to a known pathogen or even uncover hints of new pathogens. Using PCR, scientists can reveal the pathogens that are present and possible diseases that may be on the horizon.

As researchers get an idea of where the ticks live and what pathogens they harbor, they can come up with ways to reduce tick exposure and disease prevalence. Larson, who has a master's degree in geography, hopes to develop new maps that show how the risks of diseases differ across Wisconsin.

Photos by Michael P. King (2)

Tick tubes like this one in the UW Arboretum are being studied for their effectiveness in controlling tick populations.

Larson and other researchers in the lab are also looking for ways to help homeowners take tick control into their own hands — and their own backyards. Studies conducted in the UW Arboretum show that tick numbers could be reduced through the use of "tick tubes," short stretches of pipe stuffed with cotton balls coated with an insecticide called permethrin. The tubes are placed near fallen trees or logs that serve as small animal highways. When animals happen upon the tubes, they nab the cotton balls for their

Following page: A magnified image of a deer tick, a species that is known to transmit Lyme disease and other illnesses.

nests, and the permethrin transfers to their coats, where it repels and kills ticks.

A LITTLE HELP FROM THE PUBLIC

Tick tubes and other control strategies will become tools for public engagement as experts work to inform and involve more people in the center's work. Larson has held training sessions and meetings with public health departments and homeowners' associations in various parts of the state. He builds relationships with communities and finds opportunities to include them in the research process. Larson is applying these principles to an ongoing survey of homeowners' properties in three areas in Wisconsin: Bearskin Lake near Minocqua, the Baraboo hills, and the UW Arboretum.

"I've been focusing on homes that are embedded in woods and are good places for tick habitat," Larson says. "I set up plots half in the woods and half in the yards and look for ticks. I was really surprised to find ticks crawling through people's manicured lawns. One of the prevention methods out there is to mow your grass very short, but we're finding that's not effective in these cases."

Findings like this get homeowners interested and invested in the research. Then they can test prevention methods on their own properties and share the information with their neighbors and the center. This summer, Larson will be visiting backyards to test the tick tubes that showed promise in the UW Arboretum.

"The goal of these prevention methods is to have them work at people's homes. Now we'll test this with the help of the homeowners to see if we can present them with a new way to avoid ticks in their everyday lives," Larson says.

A new app, launched in May, will amplify the public's role in gathering data and developing prevention methods. Bron, the Midwest center postdoc, developed The Tick App in collaboration with the Northeast Center of Excellence and the UW–Madison Center for Health Enhancement Systems Studies. It asks users questions about their possible exposure to ticks. After a baseline survey, the app does what's called ecological momentary assessments by prompting users to write an entry in their "tick diary" each day for 14 days.

"We want to know if the user had any ticks that day and what [the user] did," Bron says. "We want to see if we can associate ticks with certain activities. There's also an option to use GPS capabilities to track activities so that we'll know not just that they went for a run but that they went for an hour-and-a-half run in the woods."

Bron wants to use this data to determine where people are encountering ticks, which tick species they are running into, and how often tick bites result in disease transmission. She plans to integrate a feature that will allow users to send a photo of a tick they've come across so that researchers can determine the species and tie that back to what the user was doing when it was found.

In addition to data collection, Bron and her colleagues want the app to become a prevention tool. It can educate users about safe practices during tick season, remind them to use their bug spray, and send out alerts when tick numbers are peaking.

And the ability to identify ticks through the app could lead to a better understanding of which ticks are harmless and which are cause for a precautionary trip to the doctor's office.

Other public outreach methods in the works include new flyers and a center website that will host up-to-date information about vectors and disease prevention. The Department of Entomology has also developed a site that can accept photos and information from users and provide recommendations based on science. Partnerships with public health officials will help get the recommendations and data out to communities and residents throughout the state.

"Evidence-based information about the prevention of vector-borne diseases is a vital piece of the outreach package we want to provide," Paskewitz says. "We really want to find and develop tools like these that communities and homeowners can use to reduce their risk now and in the future."

In the end, the center's varied approach to vector-borne disease management means that residents of Wisconsin and the Upper Midwest will be more informed and prepared for vector-borne diseases and any future outbreaks. It means the next time you explore the UW Arboretum or enjoy a summer evening in the backyard, you can better understand the ticks and mosquitoes around you and how you can protect yourself and your neighborhood.

Photo by Scott Larson

REMEMBERING ROBIN

The directors and staff of the Midwest Center of Excellence for Vector-Borne Disease wish to recognize and remember **Robin Mittenthal**, who passed away in December following a tragic accident on his farm. As the center coordinator, Mittenthal was critical to maintaining connections among partner organizations across five states. He also had a rare gift for connections on a personal level. He touched the lives of countless colleagues in CALS and the Department of Entomology and hundreds of undergraduates when he was the advisor for the UW global health certificate program. He is dearly missed.

in the field

by Gilliane Davison BS'18

HEIDI BAILEY BS'16

When **Heidi Bailey** discovered the Department of Life Sciences Communication (LSC), she knew it was the perfect fit for her. After graduation, she was able to apply what she learned in LSC at Boulder Brands in Colorado, where she found her passion for an active, outdoor lifestyle. Now Bailey seeks to share her passion with the world through Wander Outdoor LLC, an adventure guide service. As the cofounder and CEO of Wander Outdoor, every aspect of her communication degree was put to the test. "When starting your own business, you have to do it all," Bailey says. "I have had to design our logo, create a color scheme, write and rewrite several business plans, perform market research, prepare sales plans and goals, execute financial analyses, etc." But she says it was all worth it. Bailey enjoys inspiring people to get outside and appreciate nature in an increasingly digital world. Her active lifestyle of rock climbing, mountain biking, surfing, and trail running supports her career goals and keeps her in touch with Wander Outdoor's mission. Bailey credits CALS for giving her a multifaceted skill set and a network of LSC advisors that helped her succeed.

JOHN BURD MS'70, PhD'75

John Burd has dedicated his career to improving diabetes treatment and medical products. "I continue to be interested in developing products for people with diabetes, including several family members," Burd says. "I love being busy and helping people who are suffering from a terrible disease." Through the years, he has founded more than 15 health care companies, authored numerous papers, enhanced existing technology, and created his own medical products resulting in 23 separate patents. Burd's current company, Lysulin, markets a new over-the-counter nutritional supplement for lowering blood sugar and preventing glucose toxicity. Prior to Lysulin, Burd founded DexCom, Inc., a prominent medical company where he developed the first long-term implantable glucose monitoring system. This innovation landed him in the American Association of Clinical Chemistry Hall of Fame. All of this success was the result of years of education, hard work, and personal drive. Burd earned his master's and Ph.D. degrees from the Department of Biochemistry.

GREGORY GOOD BS'79, MS'82

Gregory Good's interest in forestry began at a young age. In high school, he spent two summers working in the woods of Mels, Switzerland, his father's hometown. Good's higher education began in mechanical engineering, but he eventually earned bachelor's and master's degrees in forestry from UW–Madison, where **Ray Guries**, now a professor emeritus, steered him toward arboriculture. During his graduate studies, Good gained more hands-on experience working for **R. Bruce Allison** MS'82 at Allison Tree Care, Inc., in Verona, Wisconsin, which gave him a nudge toward commercial arboriculture. "I keep in touch with both Ray and Bruce to this day," says Good. In 1983, Good opened his own tree care business, Good Tree Care Co., in Hartland, Wisconsin, where he has practiced ever since. In 1997, Good received a particularly difficult isolated tree removal job. To tackle this project, he combined his engineering mind with his forestry experience and invented a new tree rigging device. And it worked well. Good went on to patent the product, now known as the Good Rigging Control System (GRCS). It is used today by arborists worldwide. When Good takes a break from the trees, he enjoys spending time raising sheep with his wife, Barbara, an alumna of UW–Madison's School of Veterinary Medicine, and helping his nephews keep their race cars on track.

ENTERPRISING ALUMNI

Many CALS graduates go on to launch small businesses, patent new products, and found successful companies, among other entrepreneurial endeavors. This special "In the Field" series tells their stories. Look for more profiles of innovative alumni in the next issue.

About *In the Field*

The 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. For more about CALS alumni, visit ***cals.wisc.edu/alumni****.*

Alumni making their mark as ENTREPRENEURS

NINO RIDGWAY MS'83, PhD'86

Nino Ridgway earned her master's degree and Ph.D. in entomology with a focus on pest control in apple orchards. After working a variety of positions alongside farmers, Ridgway took an interest in agriculture. In 1986, Ridgway spent a year working on organic, sustainable, and indigenous farms in New Zealand, Australia, Papua New Guinea, Germany, and England. After circling the globe, she relocated at Barthel Fruit Farm in Mequon, Wisconsin, where she started her retail nursery, Herbs & Everlastings. She grows and sells a large selection of herbs, perennials, vegetables, plants, and succulents without using chemical pesticides. Ridgway handles sales, management, customer relations, and scouting for pest problems, and she still manages to get her hands dirty in the gardens. "I love watching seeds sprout and cuttings take root," Ridgway says. "Plant propagation fascinates me." Although an entomology degree is not a typical pathway to farming, Ridgway incorporates her CALS education in many aspects of her work. "I love to help my customers become better gardeners by educating them about the biology and ecology of gardening," she says. "We talk about the importance of native species, pollinator plants, insect and disease life cycles, soil health, water conservation, and the ripple effect of changes we make in our yards."

CHRISTIAN SCHAUF BS'03

Christian Schauf graduated with a bachelor's degree in life sciences communication and agricultural business management — and little idea of where his career was headed. Just 15 years later he seems to have done it all. Schauf's diverse career path has taken him around the world, working for advertising and marketing agencies, touring as a professional musician, and launching several start-up companies. His latest endeavor, Uncharted Supply Co., is an outdoor safety and survival brand that combines his love for outdoor adventure and passion for making the world a safer place. "I've always been most successful when I've followed my passions, and Uncharted is simply a culmination of all of my past experiences coming together," Schauf says. "It's a very true representation of who I am as a person." In October 2017, Schauf and his business partner introduced Uncharted Supply Co.'s emergency survival kit, The Seventy2, on the television show Shark Tank, garnering a $200,000 investment from businessman **Robert Herjavec**. In its first year of operation, the company has sold to more than 100 countries. Schauf points out that Uncharted Supply Co. takes constant focus and commitment; to stay fresh and motivated, he spends his free time climbing, skiing, and cycling around his home in Park City, Utah, and beyond.

CHERI STOKA BS'96

As a former professional soccer player, **Cheri Stoka** knows a thing or two about exercise and nutrition. Stoka was a scholarship player for the UW–Madison women's soccer team and logically supported her love for health and fitness with a degree in dietetics. "Food and staying healthy were just part of my life," Stoka says. As she became more involved in nutrition, she realized the disconnect and confusion that surround weight loss and healthy eating. Weighless MD was her solution. As the founder and president, Stoka has grown Weighless MD into an entity that addresses all aspects of health. "We specialize in weight loss, but we address other chronic and root cause illnesses as well," she says. Weighless MD offers a variety of services, including personalized meal plans, nutritional supplementation, specialty testing, and nutrition education — all of which stem from Stoka's passion for health and desire to help others. "I love learning about the science behind nutrition," she says. "Knowing how nutrients affect the body allows us to incorporate strategic ways to be healthier. When we see people transform, it's pretty amazing." Stoka works constantly to grow her business but still manages to have a rewarding life outside of the office. She enjoys spending time with her husband and two sons as well as reading, running, meditating, and, of course, playing soccer.

Catch up with…

Ellen Morgan BS'95, MS'97 Food Science

As a UW–Madison undergrad, **Ellen (Shumaker) Morgan** was eagerly hopping through an array of science electives, undecided on a specific major. Her curiosity was piqued when she learned that a food science degree could be her ticket into the brewing industry. After an introductory course in the field, she was hooked.

Morgan declared her food science major and soon began homebrewing, well before today's craft beer boom and the now-formalized fermentation sciences program at UW. Her new hobby was the beginning of her track record of staying ahead of food and beverage trends.

Morgan later joined the student Dairy Product Judging Team and worked at the Center for Dairy Research. If homebrewing was her spark, cheese was fuel on the fire. She earned her master's degree with a thesis on pinking discoloration, a common defect in orange-colored varieties of processed cheese, with emeritus professor of food science **Bill Wendorff** BS'64 MS'66 PhD'69 as her advisor.

Photo by Michael P. King

Ellen Morgan, research and development director for wet dairy and culinary systems, in the culinary kitchen at Kerry in Beloit, Wis.

It all prepared the Watertown, Wisconsin, native for a career with Kerry, a major food ingredient company based in Ireland. The company's global success has benefited CALS through investment in the Food Research Institute and new Babcock Hall and Meat Science Lab construction projects, and other partnerships are in the works. Since 1998, Morgan has worked at Kerry's North American headquarters in Beloit, Wisconsin, where she is now research and development director for wet dairy and culinary systems.

WHAT IS A WET DAIRY OR CULINARY SYSTEM, AND WHAT PROBLEMS ARE YOU SOLVING IN THIS AREA AT KERRY?

It could be cheese, cheese sauce, or a dairy snack like a yogurt bite or an ice cream bite. Maybe you're trying for bake stability, or emulsion stability — things that natural cheese can't do. You want to control the melting properties of cheese, or you don't want it to blow out of a pastry. Or you need a sauce that has a certain viscosity and has certain cling properties. We would develop a system that could meet your needs.

Kerry has over 15,000 products that we supply to customers in over 140 countries — dairy ingredients and sauces, batters and breading used on coated meat, cereal inclusions, sweet variegates and inclusions that you see in ice cream. Those all have Kerry technology or ingredients in them.

WHAT IS CHANGING ABOUT YOUR FIELD, AND WHAT ARE YOU WORKING ON NOW?

What I think is really cool is that Kerry has evolved our focus to stay ahead of consumer demand. Back 20 years ago it was about convenience foods. Now, people want products that taste good but they can feel better about. They want real food. They want to know where their food comes from. And they're looking at labels.

There's a lot of on-the-go snacking. We need to tie into that convenience trend, but tie into the "clean label" trend for general health and wellness. We're developing products that might be a healthier snacking option that keeps people satiated longer — higher protein, lower sugar — all while still meeting the experience the consumers are looking for, and tasting great.

—Michael P. King

Photo by Wolfgang Hoffmann

Agronomy professor Bill Tracy and Adrienne Shelton MS'12, a former graduate student in the Plant Breeding and Plant Genetics program, sample their organic sweet corn in the field at the West Madison Agricultural Research Station.

A Half-century of the PBPG Program

The Plant Breeding and Plant Genetics (PBPG) program is marking an impressive milestone this year. In June, faculty, staff, students, and alumni gathered for a two-day mini-symposium in honor of the graduate training program's 50th anniversary.

There are a lot of reasons to celebrate. PBPG has trained more graduate students than any similar program in the nation — awarding more than 330 doctorates and 120 terminal master's degrees.

"Our graduates are in leadership positions in every aspect of private companies, public institutions, and academia," says program director **Michael Havey** MS'83 PhD'84, professor in the Department of Horticulture and research geneticist with the USDA Agricultural Research Service. "We have outstanding representation of Wisconsin at all levels of plant breeding around the world."

PBPG was founded in 1968 to combine the long-standing graduate education offerings of a large handful of departments. Today, participating departments in CALS and across the UW campus include agronomy, biochemistry, biostatistics and medical informatics, botany, entomology, genetics, horticulture, plant pathology, and statistics. From the start, it's been considered a premier program, underpinned by the university's strong plant sciences research enterprise and cultivar development efforts, which make for a rich learning environment for graduate students.

That has certainly been the case for **Chris D'Angelo** PhD'18. He joined the program in 2013 and took a research assistantship position in the lab of **Irwin Goldman** PhD'91, professor and chair of the horticulture department. D'Angelo's research project involved developing a way to fit the entire life cycle of an onion, traditionally a biennial crop, into a single year, with the goal of helping plant breeders speed the pace of their onion improvement efforts.

According to D'Angelo, the experience has prepared him to be successful in a highly multidisciplinary field, one that requires knowledge in computer coding, statistical analysis, molecular biology, plant physiology, horticulture, and greenhouse design and management. "I started graduate school with some of these skills, but the PBPG program has made me confident in all of them," he says.

The program's graduate student cohort, with more than 50 members at any given time, is large and vibrant — and it's an important part of the overall experience. D'Angelo has maintained a strong connection with this community through scientific conferences and research talks as well as professional development, leadership, and community outreach opportunities.

"There's such a diversity of what our grad students are doing — the crops they are working on, their research problems," Goldman says. "There's a real mixing of ideas that happens. It's like a cross-pollination, if you will. The students really get to know each other as they go through this intensive training together, and they will be connected for their whole careers."

D'Angelo graduates this summer, and he has a job lined up as a sweet corn breeder with Illinois Foundation Seeds in Plover, Wisconsin. He's excited to be staying in the state, where he'll be able to work with UW–Madison extension specialists and stay connected to the PBPG program.

Havey says it's always exciting to see what PBPG graduates go on to do and the roles they play in tackling some of society's most important issues.

"Growers around the world are facing economic and environmental challenges due to climate change, increased disease and pest pressures, and consumer preferences," Havey says. "There's also the need to increase production to feed 9 billion people by 2050. All of these require the development of new cultivars — and that's what our students do. Our students are an integral part of addressing these challenges."

—Nicole Miller MS'06

INTERESTED IN SUPPORTING THE PBPG GRADUATE PROGRAM?
Visit **supportuw.org/giveto/GraduateEducationPlantBreeding** to make a gift to the Wisconsin Fund for Research Assistantships in Plant Breeding.

ALL WAYS FORWARD®

GROWING KNOWLEDGE AND GROWING SOLUTIONS

It's what we do at CALS — from improved agricultural practices and technology to new medications and treatments. Our students help us with this vital work, but they need the guidance of our professors, UW-Extension specialists, and other researchers — and the support of donors like you. Please contribute to the CALS Fund and turn student dreams into real-world improvements.

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Thanks to a generous match from an anonymous donor, your 2018 gift will go twice as far!

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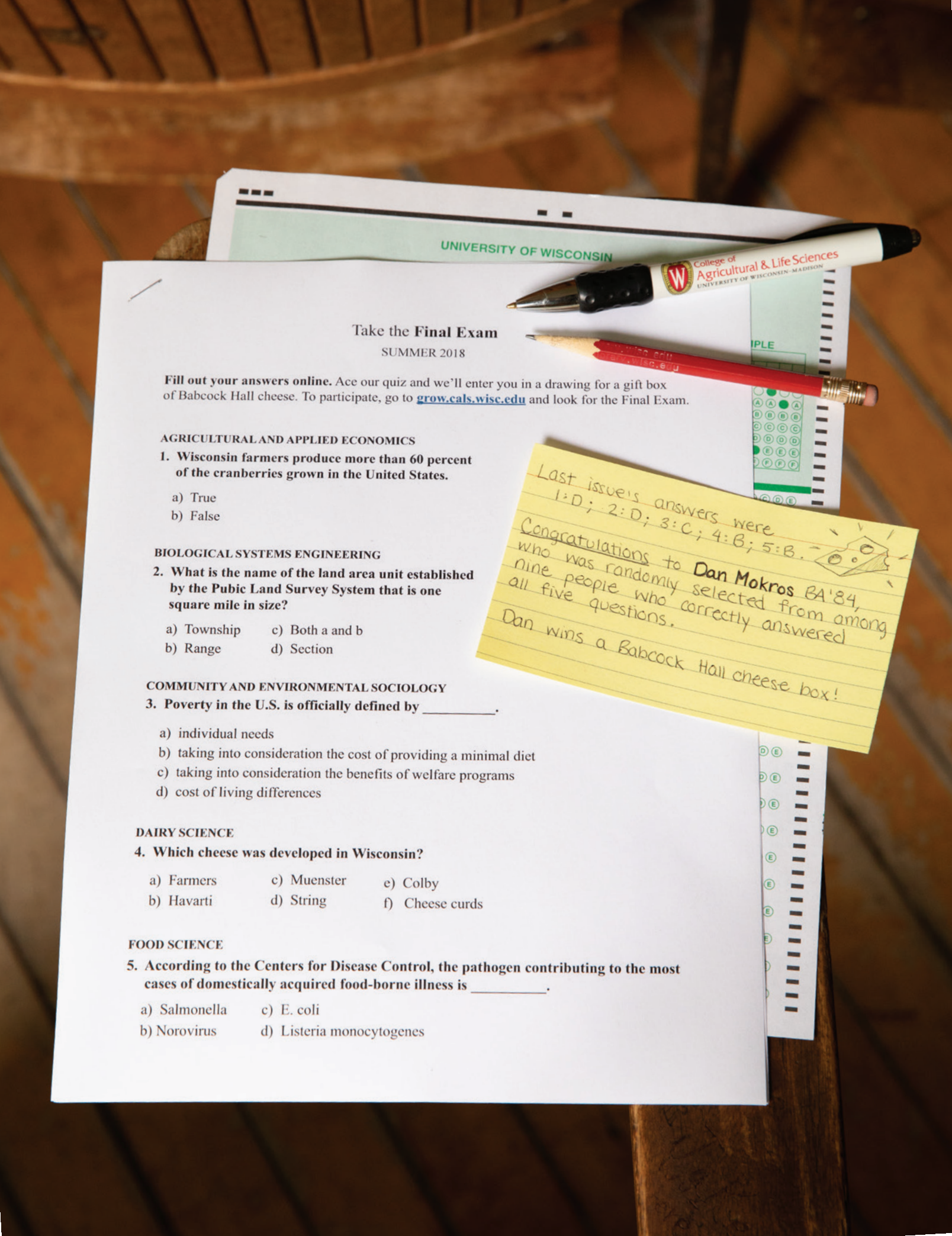
Photo by Sevie Kenyon BS'80 MS'06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Take the Final Exam
SUMMER 2018
Fill out your answers online. Ace our quiz and we'll enter you in a drawing for a gift box of Babcock Hall cheese. To participate, go to grow.cals.wisc.edu and look for the Final Exam.
AGRICULTURAL AND APPLIED ECONOMICS
1. Wisconsin farmers produce more than 60 percent of the cranberries grown in the United States.
a) True
b) False
BIOLOGICAL SYSTEMS ENGINEERING
2. What is the name of the land area unit established by the Pubic Land Survey System that is one square mile in size?
a) Township
b) Range
c) Both a and b
d) Section
COMMUNITY AND ENVIRONMENTAL SOCIOLOGY
3. Poverty in the U.S. is officially defined by _____.
a) individual needs
b) taking into consideration the cost of providing a minimal diet
c) taking into consideration the benefits of welfare programs
d) cost of living differences
DAIRY SCIENCE
4. Which cheese was developed in Wisconsin?
a) Farmers
b) Havarti
c) Muenster
d) String
e) Colby
f) Cheese curds
FOOD SCIENCE
5. According to the Centers for Disease Control, the pathogen contributing to the most cases of domestically acquired food-borne illness is _____.
a) Salmonella
b) Norovirus
c) E. coli
d) Listeria monocytogenes
Last issue's answers were 1:D; 2:D; 3:C; 4:B; 5:B.
Congratulations to Dan Mokros BA'84, who was randomly selected from among nine people who correctly answered all five questions.
Dan wins a Babcock Hall cheese box!

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GENETIC REFLECTIONS

Artist Angela Johnson, right, and student Doug Powell inspect a laser-etched glass panel depicting a section of genetic code from a clawed frog, part of a Biotechnology Center art installation coordinated by genetics professor Ahna Skop.

Photo by Michael P. King