grow

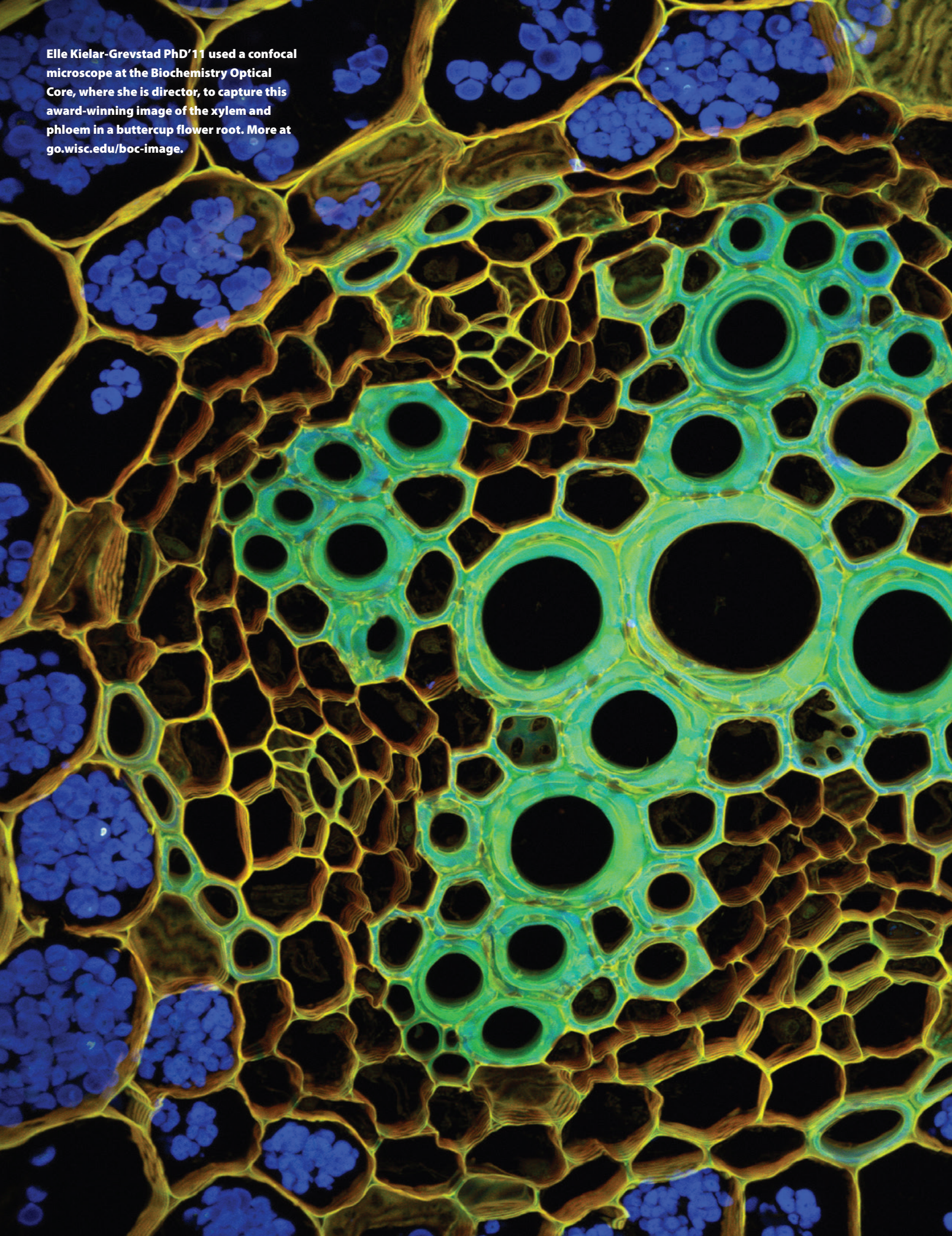
Wisconsin's Magazine for the Life Sciences • SPRING 2019

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

A DIFFERENT Beet

There's more to these loved and loathed root vegetables than meets the mouth

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN–MADISON



Elle Kielar-Grevstad PhD'11 used a confocal microscope at the Biochemistry Optical Core, where she is director, to capture this award-winning image of the xylem and phloem in a buttercup flower root. More at go.wisc.edu/boc-image.

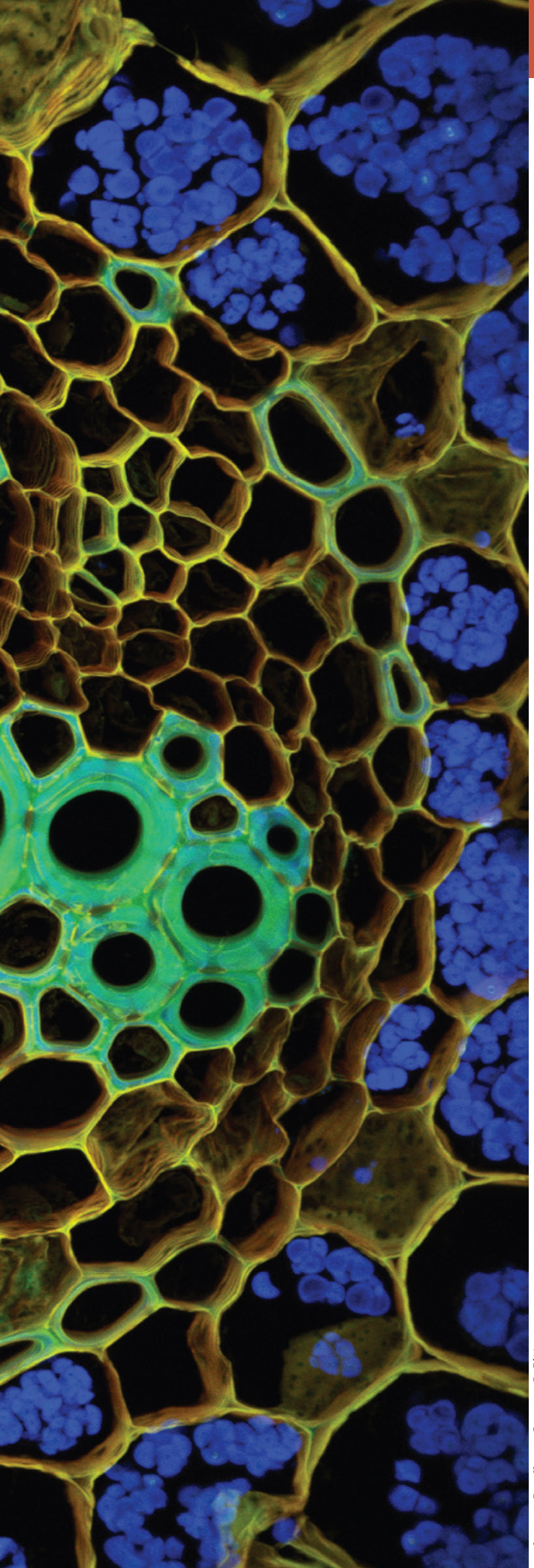


Image by Elle Kielar-Grevstad PhD'11

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Wisconsin's Magazine for the Life Sciences

FEATURES

DEPARTMENTS

ON THE COVER: Slices of multiple varieties of beets, developed through breeding research at the UW Carrot and Beet Lab, are arranged around a whole, uncut example of the root vegetable.

Photo by Michael P. King

Dean Kate VandenBosch

Cooperative Extension Comes Home

"Strong Extension programs and a forward focus will continue to be central to [our work]."

By now the news has probably reached you that Cooperative Extension has returned to UW–Madison, and I would like to discuss why this is a positive development for CALS. First, though, some background.

In November 2017, the UW System Board of Regents voted to close the central administrative organization called UW Colleges and UW–Extension and redistribute its two-year campuses and Extension units to the four-year campuses. This statewide restructuring was initiated in response to declines in state funding and student enrollments.

As a result, four UW–Extension units transferred to UW–Madison effective July 1, 2018. Cooperative Extension and Wisconsin Public Media (Wisconsin Public Radio and Wisconsin Public Television) now comprise the UW–Madison Division of Extension and Public Media. The new division reports to the Office of the Provost.

Cooperative Extension's move to UW–Madison represents a homecoming: Extension began at UW–Madison in 1907 and continued until 1965 when several UW–Madison programs combined to create University Extension as a separate UW System "campus" in 1971.

Since the earliest days, our college has had a strong partnership with Extension. While several colleges at UW–Madison, UW–River Falls, and UW–Stevens Point have active partnerships with Extension, we have always had the highest number of statewide specialists — and that includes 48 faculty and 38 academic staff with Extension responsibilities today. Their research is at the core of several of Extension's evidence-based educational programs. In fact, you can read about one fine example of this work, the Applied Population Laboratory, on page 16. We expect these partnerships to continue to be a cornerstone of UW's work, and I believe that the transition will improve opportunities for faculty in other schools and colleges to partner with Extension educators around the state.

As public funding models have changed, overall funding for Extension has decreased. As a result, CALS has lost 45 percent of its Extension faculty positions over the last two decades. **Doug Reinemann**, associate dean for extension and outreach, and other college leaders will continue to work with Extension leaders to grow the number of Extension-funded faculty positions so that we can keep pace with changing needs of agriculture and rural communities. This includes staying on top of trends like changing rural demographics that impact the available workforce and create a need for more automation and technology. The increased availability of data is generating potential for more effective livestock and landscape management (as long as the necessary expertise in analytical tools is available).

Consumer preferences also continue to change — whether in dietary trends or concerns about animal welfare and environmental quality — and we want our agricultural industries to be able to rely on a strong research base when making decisions about their futures. As we have opportunities to hire Extension faculty, we aim to add expertise that will serve needs such as these for Wisconsin's tomorrow.

It has always been a CALS priority to serve the state's agricultural industries and local communities with applied research expertise and continuing education. Strong Extension programs and a forward focus will continue to be central to that effort. In a recent op-ed, Chancellor Rebecca Blank wrote, "I am confident that this transition will be win-win. Both entities are better together, and this merger will allow us to do even more in service to Wisconsin residents." I agree completely.

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Five things everyone should know about . . .

Mycotoxins

By Ahmad Alshannaq PhD'18 and Jae-Hyuk Yu MS'91 PhD'95

1. **Mycotoxins are small, poisonous molecules, produced by certain species of molds, that can cause disease or death in animals and humans.** Mycotoxin-producing fungi can invade and grow on many agricultural crops, particularly in hot, humid climates or as a result of poor agricultural practices. These fungi can also colonize foods and feeds during processing, distribution, and storage. More than 300 different mycotoxins have been identified, but only seven of them are commonly responsible for contamination in foods that humans consume.

2. **Even at exceedingly low levels, mycotoxins are major health hazards.** They can cause cancer, reproductive problems, liver and kidney damage, and reduced immune system response in both humans and animals. Most mycotoxins are chemically stable and can survive food processing and even cooking. Human exposure to mycotoxins occurs mainly through the consumption of contaminated plant-based foods, but animal products, such as milk, meat, and eggs, can also be indirect sources of exposure for humans. Infants can be exposed if a nursing mother has consumed contaminated food. Mycotoxin-contaminated food also causes significant revenue losses for the agricultural industry and contributes significantly to food insecurity and waste.

3. **Mycotoxins can contaminate a wide variety of foods and feeds**, and contamination with multiple toxins, which is common, exacerbates food safety concerns. Almost all grain and food crops — including maize, rice, wheat, barley, oats, rye, soybeans, sorghum, peanuts, and coffee — are at risk of contamination by one or more species of mycotoxin. Certain fruits, including figs, apples, pears, peaches, grapes (and thus wine and grape juice), and dried vine fruits are vulnerable, as are a variety of nuts, such as groundnuts, pistachios, almonds, and walnuts. Even asparagus spears, black tea, cottonseeds, spices, and herbs (including the medicinal variety) are not immune.

4. **Aflatoxins (AFs), a kind of mycotoxin, are the most significant threat to food safety and security**, contaminating around 25 percent of the global food supply. And due to lack of regulatory systems, more than 4.5 billion people worldwide are exposed to high, unmonitored levels of AFs. In humans, AFs can suppress immune response, disrupt in utero development, induce genetic mutations, and cause serious illnesses, including cancer. Among AFs, aflatoxin B1 is the most potent carcinogen found in nature, 200 times more potent than the well-known carcinogen benzo[a]pyrene, a compound found in cigarette smoke, diesel exhaust fumes, coal tar, and charbroiled food.

5. **Many mycotoxins, including AFs, are monitored and regulated.** About 120 countries, including the U.S., set maximum limits for AFs in foods and feeds. Monitoring these levels, however, is an extraordinary undertaking. One complicating factor is that, while mold spores can be seen on the surface of food with the naked eye, most mold growth is found in the hidden food interior. Also, mycotoxins are invisible. Although numerous strategies for detecting and controlling AFs have been developed since their discovery in the 1960s, they remain a serious and increasing problem worldwide.

Illustration by Danielle Lamberson Philipp

Jae-Hyuk Yu is a professor of bacteriology and genetics, and **Ahmad Alshannaq** is a postdoctoral researcher in Yu's lab. They have been developing safe, novel technologies for eradicating aflatoxins in foods and feeds, one of which they will disclose publicly in the near future.

On Henry Mall

News from around the college

Photos by Howard-Yana Shapiro (2)

The dripping gel from this corn plant harbors bacteria that convert atmospheric nitrogen into a form usable by the plant. Scientists have long sought corn with this ability to reduce the crop's high demand for artificial fertilizers, which are energy intensive, expensive, and polluting.

Hold the Fertilizer

Researchers identify corn that acquires its own nitrogen, a rare advantage among crop plants

The term is "nitrogen fixation." No, it doesn't refer to an unhealthy obsession with one of the most common chemical elements on Earth. Rather, it's a process in which atmospheric nitrogen is converted into a form usable by a plant.

Nitrogen is essential for plants to function, but very few crops can "fix" it on their own. Scientists have long sought corn with this ability, their goal being to reduce the crop's high demand for artificial fertilizers. Fertilizers are expensive, and excess can run off the soil, impacting water used for swimming, fishing, and drinking. Reducing corn's need for fertilizer would be a boon for farmers and water quality alike. And now the search for nitrogen-fixing corn may be over.

A team of researchers from CALS; the University

of California, Davis; and Mars Inc. has identified varieties of tropical corn from Oaxaca, Mexico, that can acquire a significant amount of the nitrogen they need from the air by cooperating with bacteria. To do so, the corn secretes copious globs of mucus-like gel from arrays of aerial roots along its stalk. This gel harbors bacteria that facilitate nitrogen fixation. The corn can acquire 30 to 80 percent of its nitrogen this way, but the effectiveness depends on environmental factors like humidity and rain.

The team reported its findings in the journal *PLOS Biology*. It's a positive development in this area of study, but further research is required to determine whether the trait can be bred into commercial cultivars of corn, the world's most productive cereal crop.

"It has been a long-term dream to transfer the ability to associate with nitrogen-fixing bacteria from legumes to cereals," says **Jean-Michel Ané**, a professor of bacteriology and agronomy at CALS and a co-author of the new study.

Legumes, such as beans, are the only group of crop plants previously known to acquire a significant amount of nitrogen through fixation, which they perform in specialized tissues called root nodules.

Howard-Yana Shapiro, the chief agricultural officer at Mars, a senior fellow in the Department of Plant Sciences at UC Davis, and a co-author of the report, identified the indigenous varieties of corn in a search for cultivars that might be able to host nitrogen-fixing bacteria.

The corn is grown in the Sierra Mixe region of Oaxaca in southern Mexico, part of the region where corn was first domesticated by Native Americans thousands of years ago. Farmers in the area grow the corn in nitrogen-depleted soils using traditional practices with little or no fertilizer, conditions that have selected for a novel ability to acquire nitrogen. The biological materials for this investigation were accessed and utilized under an Access and Benefit Sharing Agreement with the Sierra Mixe community and with the permission of the Mexican government.

The corn is striking. Most corn varieties grow to about 12 feet and have just one or two groups of aerial roots that support the plant near its base. But the nitrogen-fixing varieties stand more than 16 feet tall and develop up to 10 sets of thick aerial roots that never reach the ground. Under the right conditions, these roots secrete large amounts of sugar-rich gel that provide the energy and oxygen-free conditions needed for nitrogen-fixing bacteria to thrive.

Establishing that plants are incorporating nitrogen from the air is technically challenging.

"It took us eight years of work to convince ourselves that this was not an artifact," says Ané, whose lab specializes in studying and quantifying nitrogen fixation. "Technique after technique, they're all giving the same result showing high levels of nitrogen fixation in this corn."

The group used five different techniques across experiments in Mexico and Madison to confirm that the Sierra Mixe corn's gel was indeed fixing nitrogen from the air and that the plant could incorporate this nitrogen into its tissues.

"What I think is cool about this project is it completely turns upside down the way we think about engineering nitrogen fixation," says Ané.

The gel secreted by the corn's aerial roots appears to work primarily by excluding oxygen and directing sugars to the right bacteria, sidestepping complex biological interactions. The research team was even able to simulate the natural gel's effects with a similar gel created in the lab and seeded with bacteria. The simplicity of the system provides inspiration to researchers looking to identify or create more crop plants with this trait.

Breeding the trait into commercial cultivars of corn could reduce the need for artificial nitrogen fertilizers, which have a host of disadvantages. More than 1 percent of the world's total energy production goes toward producing nitrogen fertilizer. Developed countries contend with waterways polluted by leaching nitrogen, while adequate fertilizer is often inaccessible or too expensive for farmers in developing countries. Corn that fixes some of its own nitrogen could mitigate these issues, but more research will be required.

"Engineering corn to fix nitrogen and form root nodules like legumes has been a dream and struggle of scientists for decades," says Ané. "It turns out that this corn developed a totally different way to solve this nitrogen-fixation problem. The scientific community probably underestimated nitrogen fixation in other crops because of its obsession with root nodules.

"This corn showed us that nature can find solutions to some problems far beyond what scientists could ever imagine."

—Eric Hamilton

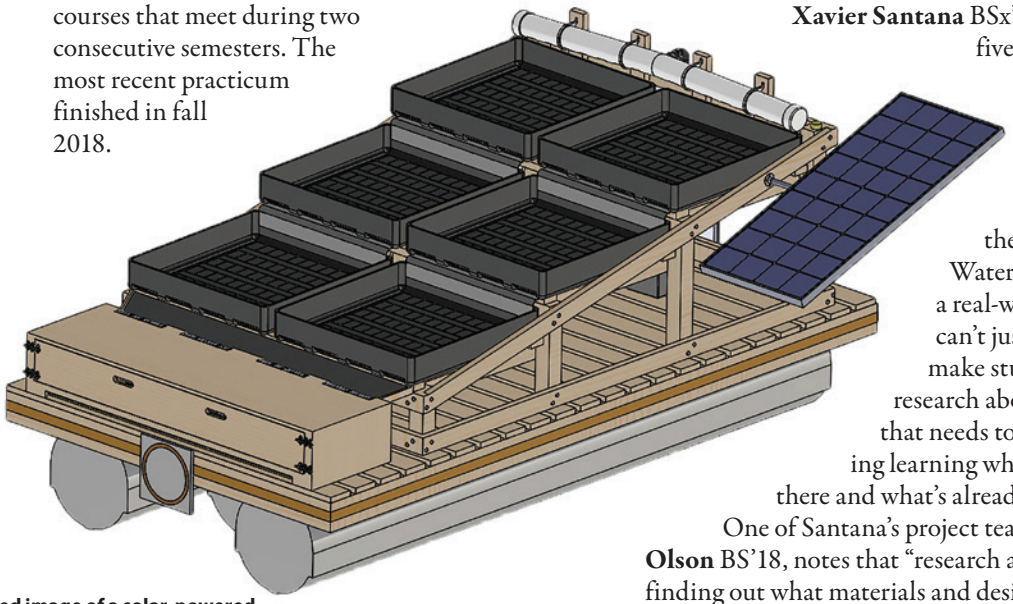
Newly identified nitrogen-fixing varieties of corn like these develop multiple sets of thick aerial roots that never reach the ground.

Engineers of Ingenuities

In their capstone practicum, biological systems engineering students offer solutions to real-world problems

A bioreactor that removes phosphorus from lakes, an easy-to-use harness system designed to prevent falls from dangerous heights, and an early detection sensor for toxic nitrogen dioxide gas in vertical silos. Three very different design projects, three potential responses to real-world issues. And all of them were developed by CALS students as part of their capstone practicum in biological systems engineering (BSE).

A requirement for all BSE majors, the design practicum is comprised of two courses that meet during two consecutive semesters. The most recent practicum finished in fall 2018.



A digitally rendered image of a solar-powered bioreactor designed to remove phosphorus from lakes. The 7-by-12-foot system takes in water as it floats on the surface of the lake. The water is pumped to the top of the bioreactor and then flows through a series of containers filled with switchgrass, alfalfa, and duckweed. The plants strip some of the phosphorus from the water before it is further filtered through a series of alum-filled trays and then released back into the lake.

In the first semester of each practicum, students form teams focused on a particular problem. Together, they study the problem, review past efforts to solve it (including any existing patents), and improve their understanding of safety standards. During the second semester, the teams put their research to use designing products that provide practical solutions.

"Businesses, faculty, and [Division of] Extension colleagues submit suggestions for problems that are in need of an engineering-based solution," says **John Shutske**, professor of biological systems engineering and an agricultural safety extension specialist. "The solutions are developed by BSE students. The work they do in these courses mirrors what they would do in an engineering design business."

Design teams are self-directed but meet regularly throughout the practicum with a faculty advisor. The teams set their schedules and assign tasks as they would in a typical workplace.

"This class is the closest you're going to get to a real-world experience while still in school," says **Xavier Santana** BSx'19. He's part of a five-person team that developed a phosphorous-removing bioreactor to help clean up the Yahara River Watershed. "Just like a real-world project, we can't just go out and make stuff — there's research about the project that needs to be done, including learning what's already out there and what's already been tried."

One of Santana's project teammates, **Jacob Olson** BS'18, notes that "research also includes finding out what materials and design elements are readily available so parts don't have to be custom-made, which helps to keep costs down." He also emphasizes the importance of reviewing safety standards in designing a product to ensure that "everything is up to code and even overdesigned to withstand whatever comes its way."

Santana and Olson's team knew they needed to create a system that is both easy to maintain and more cost effective than a water treatment plant. Faculty advisor **Rebecca Larson**, associate professor of biological systems engineering and extension biowaste specialist, says this project also provides students with opportunities to learn how to engage others in science-based conversations about a policy topic.

"Improving surface water quality includes discussing issues related to excess nutrients, how those enter the water system, and how to design technologies that are cost effective and sustainable," says Larson. "These discussions can include a multitude

of people, including elected officials, farmers, landowners, lake association representatives, and county extension agents. Listening to these stakeholders and getting buy-in is important in learning the context of the issue and applying the design."

Another important aspect of the course is creating and maintaining engineering design notebooks that document the team's research and design process. This protocol not only keeps the project organized but also provides documentation if the students choose to patent their project.

"Unless there is a prior agreement with the stakeholder who suggested the project, students own the intellectual property rights to their designs," Shutske says.

For some design projects, rather than reinventing the wheel, teams modify existing designs to improve results. "Our design teams may be that fresh set of eyes that provides a better solution," Shutske says.

"[The practicum] pulls everything together that we've been studying over the years," says **Parker Williams** BS'18, part of the design team that worked on a safety harness system. "We can pick out bits and pieces from other classes and put it to practical use."

While students use knowledge from previous courses and input from their faculty advisors, feedback from team members is also key. "Even though we're all at the same level of experience, we're all each other's teachers," says **Sarah Nagel** BSx'19.

As part of the design process, students meet with the stakeholders who originally submitted the problem they are trying to solve. The stakeholders offer feedback in the initial project stages and attend a student presentation of the final product design.

"While the focus of the practicum is to interweave the knowledge gained in courses throughout their college years, we also want to include elements of professional development to prepare students for their next steps after graduation," Shutske says. "Throughout the capstone practicum, students learn about working together and building relationships, which are transferrable life skills for whatever they do post-graduation."

—Lorre Kolb

Awards and Honors

TO KNOW OURSELVES

Dominique Brossard, professor and chair of life sciences communication, has been appointed to the advisory committee for the Social, Behavioral and Economic (SBE) Science Directorate at the National Science Foundation. The SBE supports basic research on people and society to better understand human behavior and use that knowledge to advance science as well as national health, prosperity, and welfare.

SCHOLARLY ACHIEVEMENT

Steven Deller, professor of agricultural and applied economics, has received the Walter Isard Award for Scholarly Achievement from the North American Regional Science Council for his significant theoretical and methodological contributions to the field. Regional science is the study of social problems within spatial dimensions.

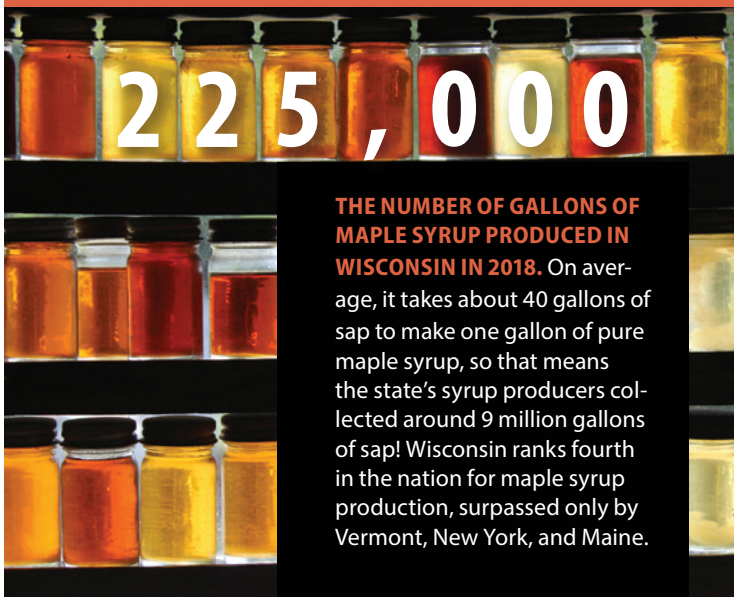
A LIFETIME AT THE PLANT-BUG NEXUS

The Entomological Society of America selected professor emeritus of entomology **Kenneth Raffa** as the 2018 recipient of the Plant-Insect Ecosystems Lifetime Achievement Award in Entomology. The award recognizes the career of an entomologist who has greatly advanced the field and has been an inspiration to others.

INAUGURAL PRIZE

Professor of genetics **Ahna Skop** is the inaugural recipient of the American Society for Cell Biology Prize for Excellence in Inclusivity for her advocacy and mentorship on behalf of underrepresented STEM students.

Number Crunching



THE NUMBER OF GALLONS OF MAPLE SYRUP PRODUCED IN WISCONSIN IN 2018. On average, it takes about 40 gallons of sap to make one gallon of pure maple syrup, so that means the state's syrup producers collected around 9 million gallons of sap! Wisconsin ranks fourth in the nation for maple syrup production, surpassed only by Vermont, New York, and Maine.

FreeImages.com/Martin E. Jones

classAct

Chloe Green

A Step Toward More Inclusive Farmers Markets

Photo by Michael P. King

Chloe Green, who is pursuing a dual degree in dietetics and community and environmental sociology, has conducted surveys at multiple locations for a project on farmers market accessibility, including the Eastside Farmers Market in Madison, Wis., shown here.

Chloe Green BSx'19 came to UW–Madison from Culver City, California, with a desire to study sports nutrition. She was motivated by her high school involvement in sports medicine. But all of that changed with her experience in a first-year interest group focused on the sociology of ethnic minorities.

"I realized it wasn't the aspect of sports that I really liked in sports medicine, it was the part of helping people in a unique way by using the skills I accrue," says Green, a senior dual-degree student majoring in dietetics and community and environmental sociology. "I decided I wanted to use my knowledge from dietetics and apply it to communities that needed it most."

To turn her realization into action, Green applied for and received a Wisconsin Idea Fellowship for the summer and fall of 2018. Awarded by the Morgridge Center for Public Service and funded by American Family Insurance, the fellowship supports her project called A Farmers Market for All? A Look into the True Accessibility of Farmers Markets. She is working with the UW Kaufman Lab for the Study and Design of Food Systems and Marketplaces, led by urban and regional planning professor **Alfonso Morales**, to evaluate how accessible farmers markets are for people with lower income and for individuals who do not fit the stereotypical image of the white, middle-class shopper. The project is exploring factors such as location, hours of operation, and transportation.

Green is interested in capturing the opinions of people already attending markets and discovering what would convince them to come more often. To find that audience, she conducted surveys at the markets themselves. Last summer, she completed more than 100 surveys at 16 markets in six counties throughout the state.

Although she is still in the process of analyzing her results, Green already sees clear trends and is formulating ideas from her data. "One initial suggestion for targeting patrons who are lower income, or members of other minority groups, is to host markets in atypical spaces," she says. "For example, instead of placing a market in a park in an affluent neighborhood, a market could be successful in residential areas that are more densely populated, even small markets on street corners."

Another notable finding is that markets with larger consumer bases, mostly in Madison and Milwaukee, are more likely to have incentive programs or allow use of Supplemental Nutrition Assistance Program (SNAP) benefits.

In a separate project funded by American Family Insurance, Green is developing a set of protocols that farmers markets can use to increase access to lower-income community members. The project will be piloted at Brown Deer Farmers Market in 2019.

"I am really hoping that, if anything, these projects bring about awareness of concepts such as incentive programs at markets and the fact that markets really can serve as a community space rather than simply a place to get groceries," says Green.

—Caroline Schneider MS'11

Controversy to Consensus to Civility

National Academy reports show potential for informing and shifting the tone of public discourse on hot-button science topics

Somewhere in the discouraging maze of fake news and widespread disinformation campaigns aimed at confusing and polarizing public discourse, there lies a road map for fostering honest public debate — at least around issues of science and technology. And **Dominique Brossard** may have found it.

The search for this glimmer of hope led Brossard, a professor of life sciences communication, into the contentious realm of genetically engineered crops. She teamed up with **Kathleen Hall Jamieson** of the Annenberg Public Policy Center of the University of Pennsylvania for an extensive study that sought to answer one question: Are consensus reports published by the National Academies of Sciences, Engineering, and Medicine (NASEM) useful for fostering informed public conversation on a divisive technology?

NASEM consensus reports are produced by panels of people with broad expertise and are aimed at achieving scientific agreement on the state of a technology and its varied impacts. Brossard contributed her expertise on communicating science in new media environments to a recent consensus report titled "Genetically Engineered Crops: Experiences and Prospects."

"The goal of a consensus report is to start a public conversation," she says. "It has to be used."

To explore the extent to which the crops report was being used, Brossard, Jamieson, and their colleagues employed national survey data and large-scale social media content analysis to explore public conversations on genetically modified crops both before and after the report's May 2016 release. The results of their analysis, published in the journal *Politics and the Life Sciences*, were encouraging.

One of the primary conclusions of the crops report is that there is no evidence that eating foods stemming from genetically modified organisms (GMOs) is harmful to human health. It also reasons that the technology is increasingly important to modern agriculture (but context-dependent); is powerful but not a magic bullet that can "feed the world"; is changing rapidly (and regulations need to keep pace); and has environmental trade-offs with both risks and benefits.

Seizing an opportunity to measure the effect of an independent, credible report from the nation's leading scientific academy on a polarizing issue, Brossard and Jamieson mapped out a strategy to systematically assess the reach and impact of the report as it was publicized and disseminated through social media. Their goals were to capture English-language coverage of the report in both traditional and social media, peg the report's release to broader patterns of discussions of GMOs on Twitter, and measure fluctuations of negative and positive sentiment in conversations about GMOs in both social and traditional media.

The analysis found that the publicly available report was downloaded nearly 44,000 times and earned widespread news coverage and social media exposure. It also noted a sharp increase in Twitter conversations when the NASEM report was released in May 2016. That, says Brossard, suggests that the report gained currency with the public and had the desired effect of fostering informed public conversation.

And the report's expert conclusions, say Jamieson and Brossard, not only percolated through traditional and social media, fueling conversations on Twitter and elsewhere, but also changed the tenor of the debate.

"We observed spikes of conversation. We observed spikes in opinion," says Brossard. It shows that authoritative reports like those produced by NASEM "can influence the conversation if the communication is well done."

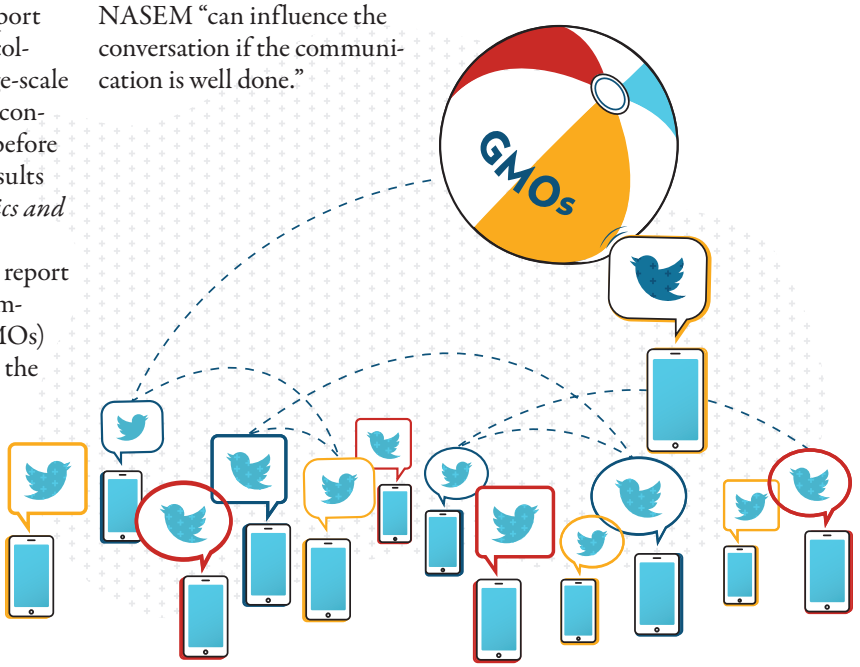


Illustration by Danielle Lamberson Philipp

Minty Fresh

A new extraction innovation for mint oil production could save farmers time, money, and energy

As you approach a basic steel structure at the West Madison Agricultural Research Station, your nose informs you before your eyes do that you've found the outdoor laboratory of CALS agricultural engineer **Scott Sanford**. Here, the sharp, fresh aroma of mint leaves permeates the air.

For three years, Sanford has been honing an energy-saving, continuous flow method to remove mint oil from tons of mint plants. Today, the standard extraction procedure involves injecting steam through a tub of chopped mint — a two-hour process with somewhat unpredictable results.

Mint oil — an essential flavoring for gum, toothpaste, mouthwash, and tea — is grown by a dozen Wisconsin farmers on about 3,000 acres, usually on lowland "muck" soils in the south-central part of the state. Nationally, 82,700 acres of peppermint and spearmint were grown in 2017, mainly in the Northwest.

In Sanford's tests, mint hay is unloaded from a wagon and metered into a 13-foot-long, steam-heated steel cylinder where an 18-inch auger moves and mixes the hay. At the far end, the steam and oil are condensed, and then, in a separate tank, the oil floats to the top of the water and is drained off.

Trapped under the roof of the lab's temporary shelter, the pleasant, familiar scent of mint can be concentrated into a cloying odor; but to a mint farmer, it's the smell of money.

The experiments are not without complications. As Sanford describes his search for a low-energy, continuous extraction process, an auger gets plugged up. Instantly, the afternoon program shifts from taking samples and analyzing productivity to disassembling and unplugging the auger, the centerpiece of Sanford's invention.

As **Jack Kotte**, a UW–Madison senior majoring in biological systems engineering, opens the machine and wrestles with the jam, Sanford says he's shown that oil can be extracted in only five or six minutes versus a couple of hours with the conventional method.

A second benefit of the new process is greater control, says Sanford, who is an extension specialist in the Department of Biological Systems Engineering. "All the motors are variable speed, so we can control the residence time, feed rate, and steam pressure."

Current methods only control steam pressure and time. "The material sits in a tub as the steam is forced through," Sanford says, "but if the tub is not loaded evenly, you can get dry pockets, or the steam may exit too quickly through an unwanted escape channel. With the new method, the mint hay is continuously being mixed to ensure good steam contact."

Richard Gumz, who grows 1,000 acres of mint (mostly peppermint) near Endeavor, in central Wisconsin, says energy eats a big part of his farm budget. "The steam distillation process that we use now for extracting oil is time-consuming and energy-consuming."

A third advantage of the new process is potentially equal to the other two: it can handle wetter mint, which reduces the time needed to dry leaves in the field.

That could be a compelling reason to adopt the new process, adds Gumz, who is president of the Wisconsin Mint Board, Inc. "Now, after cutting, we have to wait 48 to 72 hours for drying to remove hay from the field," he says. "If Scott's process allows us to get it out in 24 to 36 hours, that would reduce our risk. Any time mint is cut and laying in the field in Wisconsin, rainfall can remove oil from the leaf or knock leaves off the plants."

At worst, mint that's plastered to the ground by heavy rain can "rot to the point where it's not even salvageable," Gumz adds.

Because the continuous extraction process, like the existing one, will use steam to disperse the oil as vapor, it can utilize the steam boiler found on all mint farms. Spent hay from the new process could even be dried with waste heat and then burned to fuel the steam generator, allowing the process to run on renewable energy.

If Sanford can prove that the process will actually save energy — and work reliably — he says it will be up to private industry to make and sell the equipment. "I'm not trying to invent a product. I'm trying to prove a process."

—David Tenenbaum

Photos by David Tenenbaum • Photo 3 courtesy Gumz Farms

These studies are funded by a specialty crop research grant from the U.S. Department of Agriculture National Institute of Food and Agriculture.

1 Like his great-grandfather, Richard Gumz raises mint — along with carrots, onions, and potatoes — at his farm near Endeavor, Wis. One acre of Wisconsin mint supplies enough mint flavoring for 50,000 to 80,000 tubes of toothpaste.

2 Scott Sanford, an extension specialist in the Department of Biological Systems Engineering, holds a jug of fresh mint oil. Sanford has been honing an energy-saving, continuous flow method to remove mint oil from tons of mint plants.

3 In Wisconsin, mint hay is harvested in wagons that, when full, are connected to the farm's steam supply for extraction of the oil.

4 Gumz checks the level of mint oil at his distillery. Of Sanford's new mint oil extraction process, he says, "If there is a means of doing it in a more timely manner, or a cost savings, that would help us be competitive with other growing areas and improve both sustainability and profitability."

5 Jack Kotte, a senior majoring in biological systems engineering, works to unplug the auger in a mint processing machine.

What Would a Cow Prefer?

Jennifer Van Os studies the biology and behavior of dairy cows to help make the animals more comfortable, farms more efficient, and consumers less wary

Interview and photo by Michael P. King

AS A PSYCHOLOGY STUDENT AT HARVARD University, Jennifer Van Os studied people with Alzheimer's disease. Animals and agriculture were far from her mind. But she realized that, while the research for her honor's thesis could improve understanding of the human brain, it wouldn't directly help patients. She longed to do something that would have more immediate, real-world impacts.

Van Os pivoted toward business after graduation and moved to Los Angeles to gain management experience. Then the 2008 election season arrived, and with it came a battle over a ballot initiative that gripped her: Proposition 2.

"It wasn't the first piece of state legislation that promoted farm animal welfare, but it was a landmark one," Van Os remembers. "It painted the story of agriculture as very profit-driven and not doing right by the animals. The opposition didn't refute that in a clean way. They talked around the animal, about food safety, economics, and 'this is going to drive ag out of the state.' They didn't address treating animals right or wrong. It got me thinking: Is there a way to evaluate, scientifically, what is the right thing for the animal?"

It inspired Van Os to challenge her perceptions of animal welfare by returning to research.

She enrolled in the animal behavior graduate program at the University of California, Davis, where she studied heat stress on dairy cows and methods for cooling them. After postdoctoral research at the University of British Columbia, she came to UW–Madison, where she is an assistant professor of dairy science and an extension specialist. She has been meeting with farmers across the state to better understand and anticipate their concerns and needs.

"It's a dream come true to be in the Dairy State working on this topic," Van Os says. "Wisconsin is a dairy researcher's paradise because there are such strong ties between alumni and others who support the university."

WHAT EXACTLY IS ANIMAL WELFARE?

One really important distinction is that "animal welfare" is not "animal rights." At the most extreme end, people who believe in animal rights think we shouldn't be managing animals for any purpose — biomedical research, food production, pets. The foundation of what I do is accepting there are systems where we keep animals for our uses. So, how do we make sure they have the best lives possible? Animals should be treated responsibly. They do experience pain and emotions. We need to be aware of that, try to promote good welfare, and minimize poor welfare within the context of human uses.

A common framework uses three overlapping areas to represent different concerns people have about animal welfare: the animal's physical health; affective state, or the animal's emotional or psychological experience; and naturalness, the animal's ability to express important, species-specific behaviors.

WHY IS ANIMAL WELFARE IMPORTANT FOR WISCONSIN'S DAIRY INDUSTRY?

Animal welfare isn't a trend. It's really integral to the sustainability of food animal production, especially dairy. You need public buy-in to continue to operate. It's not just about being economically viable today. Do you have a bank of public trust to make sure you can continue to sell your product in the future, that people will find your product palatable not just in the literal sense? Do they feel good about what they're buying?

Consumers place a lot of value on an animal's ability to move around, interact, and not be restricted. It's important to listen to public concerns and understand the values behind those concerns, but we need science to understand what's important to the animal. Solutions require a biological understanding of what's appropriate for the species.

As an extension specialist, it is very important to me that the questions I work on are bringing value to dairy stakeholders. This can be challenging because production is sometimes welfare-neutral: If you have conditions leading to poor animal welfare, you can see decreases in production, but not always. If you improve animal welfare, it doesn't always lead to a boost in production. It's a great win-win when those two things go together. But I also think it's often just the right thing to do.

WHAT ARE SOME COMMON MISCONCEPTIONS ABOUT DAIRY COW WELFARE, AND HOW CAN GREATER BIOLOGICAL UNDERSTANDING HELP ADDRESS THEM?

In North America, we've selectively bred dairy cows to produce the greatest outputs for the least inputs because that's better economically and for environmental impact. They are like endurance athletes. They're working so hard to pro-

Assistant professor of dairy science Jennifer Van Os takes notes while conducting an airflow study in a cross-ventilated barn at Rosy-Lane Holsteins in Watertown, Wis.

duce milk, and that also produces a lot of body heat. People have this idea that cows should be outside frolicking in the sunshine. But they gain heat from solar radiation, and they're already feeling really hot even in conditions we find pleasant. When we give high-producing cows the choice, they prefer the barn if conditions are extreme. At the same time, they like to go outside at night, not necessarily to graze but to lie down.

Lying down is super important to cows. Research out of Denmark gave cows a trade-off between lying down and accessing food after deprivation from both. Even when they're hungry, they would rather lie down — 12 to 13 hours a day. This gets at the naturalness aspect of animal welfare, but it also overlaps into the other two aspects. If cows are prevented from lying down enough, it can lead to negative affective states, such as frustration and pain, but also lameness, a serious physical health issue.

It's not about what we would enjoy but understanding what state that animal is in and how their environment affects them. Animals can't answer us in words, but if we ask the question in the right way we can give them a voice.

WHAT ARE YOU RESEARCHING AT ROSY-LANE HOLSTEINS IN WATERTOWN, WISCONSIN?

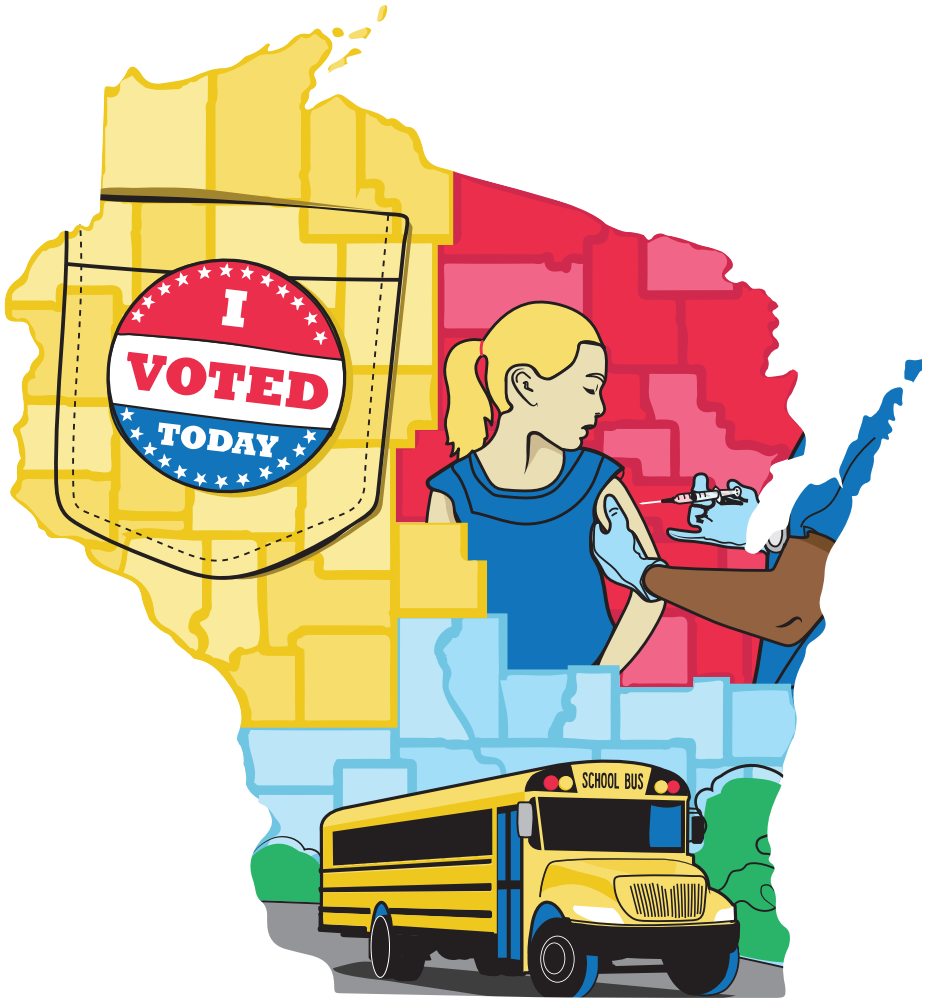
Soaking cows with water in the summer is a pretty common technique. It lowers body temperature and increases milk production and feed intake. But there's potential for water waste, and cows avoid being sprayed on their heads. At Rosy-Lane, instead of nozzles running on a timer over a feed bunk or holding pen, they have a shower mounted over each stall in the milking parlor, angled so that it just sprays their body. I really liked that it was an idea Rosy-Lane came up with themselves and spent years troubleshooting. They put it into practice inside a very successful operation. I really wanted to test and quantify how effective it is.

Also, they have two barn types — naturally and mechanically ventilated — so I wanted to compare cows from both barns milked in the same parlor. The study also allows me to integrate extension with research and give feedback to the farm that could help them learn more about how their cows are responding.

WHAT ARE YOU GOING TO RESEARCH NEXT?

I'm really interested in social housing — groups or pairs — for calves. Decades ago, the idea was to separate calves to reduce calf-to-calf disease transmission. But recent studies have shown there are other ways to mitigate that risk and lots of benefits to social housing. It helps their cognitive development, making them less fearful of new things. It's good for future productivity and their development and welfare. Cows experience a lot of new things in their lives: larger groups, new pens, and new feed items. You want weaning to be as low stress as possible for calves because otherwise their growth and weight gains can go backward.

I'm interested in how producers can do this without large infrastructure investments. You could simply put hutches side by side and a fence around them. We have research questions about how feed should be delivered and how social housing impacts bedding costs. We'd like to try to quantify that because that could lead to economic benefits. We'll be taking a look at all of this through studies based at the Emmons Blaine Dairy Cattle Research Center at Arlington Agricultural Research Station.



KNOWLEDGE APPLIED

The team at the Applied Population Laboratory uses a unique skill set to help decision-makers understand complex social trends and plan for the future

By Nicole Sweeney Etter

Illustration by Danielle Lamberson Philipp

Should a school district close an elementary school with shrinking enrollment, or will student numbers rebound in the coming years? What's the outlook for a rural town with a rapidly aging workforce? Can a funeral home expect to be more or less busy over the next decade? How might climate change affect migration?

On the third floor of Agricultural Hall, the researchers in the Applied Population Laboratory (APL) puzzle over these questions and much more. As skilled forecasters, problem solvers, and data facilitators, they deftly wield numbers, graphs, and maps to help the public better understand the shifting sands of people and place.

Then there's that word: applied. This knowledge is used to make vital decisions in communities across Wisconsin and the nation. APL's nine researchers and outreach professionals field hundreds of requests each year from diverse sources: concerned citizens searching for information to share with their county boards; local and state government officials hoping to predict community needs; staffers from nonprofits looking to hone their programs; and journalists who want objective analysis of the latest population trends.

"Those connections set us apart," says **David Long**, APL's associate director. "We're trying to help people answer questions and solve problems that have a real, tangible impact."

APL is nationally known for its population estimates and projections program — what director **Katherine Curtis** refers to as the "meat and potatoes of applied research" — as well as other areas ranging from health geography to spatial analysis.

"What makes me excited to get up and come to work every day is that we have this history of fundamental, building-block demography, which is foundational and continues to be very necessary and important to our stakeholders," notes Curtis, a professor of community and environmental sociology at CALS and a demographic

specialist with the UW–Madison Division of Extension. "Then we have this complex spatial overlay, we have emerging areas in health, and we have our institutional relationship as a partner with the U.S. Census Bureau — we're one of only two Census partners in the state. It's this valuable combination of area expertise that makes the APL a unique place to be."

The lab's team includes experts in demography, geography, statistics, epidemiology, community development, and web design. Despite the wide variety of its projects, there's a common theme: APL turns social and economic data into information that nonacademics can use to make decisions.

"I think it's the hope and dream of most researchers to have a very high quality product that can be used for public good, and that's what we do here," Curtis says. "I'm proud of our long-standing ability to generate cutting-edge, advanced research and then translate it so that it's usable by anyone."

INSPIRED BY THE WISCONSIN IDEA

APL began in the 1960s as a small unit in the Department of Rural Sociology, now known as the Department of Community and Environmental Sociology. The lab initially grew out of the university's desire to get a better sense of human elements in agricultural landscapes, and it eventually expanded its study to less rural parts of the state as well.

Dan Veroff, an extension demographic specialist with CALS, joined APL more than two decades ago. In Veroff's early days on campus, the lab was more focused on providing access to demographic data sets that weren't readily available to people without expertise in statistics or databases. Most data had to be shared via floppy disk or CD-ROM or even via printed volumes.

"Over the time I've been here, that has changed enormously because so much data is now available online," he says. "With web-based data, almost anyone can get the information, and so now our role is to be data facilitators and to do outreach and education on how to use data well and how to understand the strengths and limitations of data from an ever-increasing variety of sources. We've also gotten much more sophisticated with how we provide access to information, so instead of just serving up data tables, now we have websites where people can make maps and other visualizations of data in graphic form."

Decades ago, staff used to color-code paper maps with markers. Now web developer **Caitlin Bourbeau** designs slick, interactive graphics for the web. "She's one of our team who makes our data very interactive, engaging, and accessible," Curtis says.

APL's focus has also broadened over the years, from its early focus on how national trends affect rural communities to its work today, which spans everything from community development to school enrollment projections. But through the years, APL's connection to the Wisconsin Idea has remained constant.

"We partner with a lot of people, and what it all has in common is doing work that will improve and enhance people's well-being," Curtis says. "How quickly it hits the ground and influences decision-makers varies, but it all has an impact for the populations that we study and serve."

Curtis thinks of it as "data democracy." "Part of what we're trying to do is generate and share knowledge," she says. "We don't have a political affiliation or agenda; we're about the data and packaging the data in a way that it can be used by anyone. It supports the idea of democracy, not in a partisan way but in the true meaning of the word."

That mission constantly inspires the staff. **Malia Jones**, a social epidemiologist, moved from the Los Angeles area to join the APL team in 2015.

"I don't think there's anything else like it anywhere," says Jones. "There are other top demography research centers, but they have a more academic focus. What the APL does that's unique is it connects to the people of Wisconsin and really acts on the Wisconsin Idea through our ties with Extension and the media."

SOCIAL SCIENCE FOR THE PUBLIC

APL's work is getting an even wider audience thanks to Jones's partnership with WisContext, an online multimedia service of Wisconsin Public Radio and Wisconsin Public Television that presents social science to the public in an accessible way. The project, which is funded by a three-year grant from UW–Madison's Baldwin Wisconsin Idea Endowment, includes 48 short pieces on demographic issues affecting Wisconsin, including health, rural life, the electorate, jobs, and aging. The stories are first published on the WisContext website and are often picked up by other news sites.

Leaders at WisContext first approached APL staff about a potential partnership, and Jones jumped at the chance. "A lot of academics don't interact with the general public, and I think that's a real missed opportunity," she says. "I'd like to show people that it's not hard, it's not risky — it's actually fun. And I think it can help break down barriers between the university and the view people have of us as an ivory tower. So I'm really excited about where that work can take us. It has tremendous potential."

One of the most popular pieces so far is Jones's series on gerrymandering and the political geography of the state. Her work was cited as part of an amicus brief in the Wisconsin gerrymandering case that recently went before the U.S. Supreme Court. The Supreme Court ultimately decided to return the case to the lower courts.

"Gerrymandering wouldn't be possible if voters were evenly distributed across the landscape like so many rainbow sprinkles," Jones notes. "I really got interested in gerrymandering because of the close ties to segregation

and historical processes that have led to the suburbs of Milwaukee being very Republican places and the city being a very Democratic-leaning place."

A WINDOW INTO A SHIFTING WISCONSIN

Wisconsin's population continues to change. Aging and increasing racial and ethnic diversity are two factors that have affected many communities statewide.

"One of the things I find fascinating about Wisconsin is that our state is an example of what's going on in the rest of America," Curtis says. "Aging and the workforce challenges that come with it, distressed communities, opportunities for growth, opportunities for integration — all of these national conversations are very much a part of what's unfolding in Wisconsin communities. Our work focuses on these trends, including at the local level."

APL stays busy with requests from people around the state who want to better understand local population trends. In his role with Extension, Veroff frequently works with communities, local governments, and nonprofits throughout the state to make sure they have the data they need. He fields as many as 500 requests for data every year.

"A lot of communities want to know what's going to happen with the age structure of the population, and it's really important on a number of different levels," Veroff says. "It helps school districts plan for enrollment and facilities, and it helps communities from an economic development perspective plan for the potential labor force.

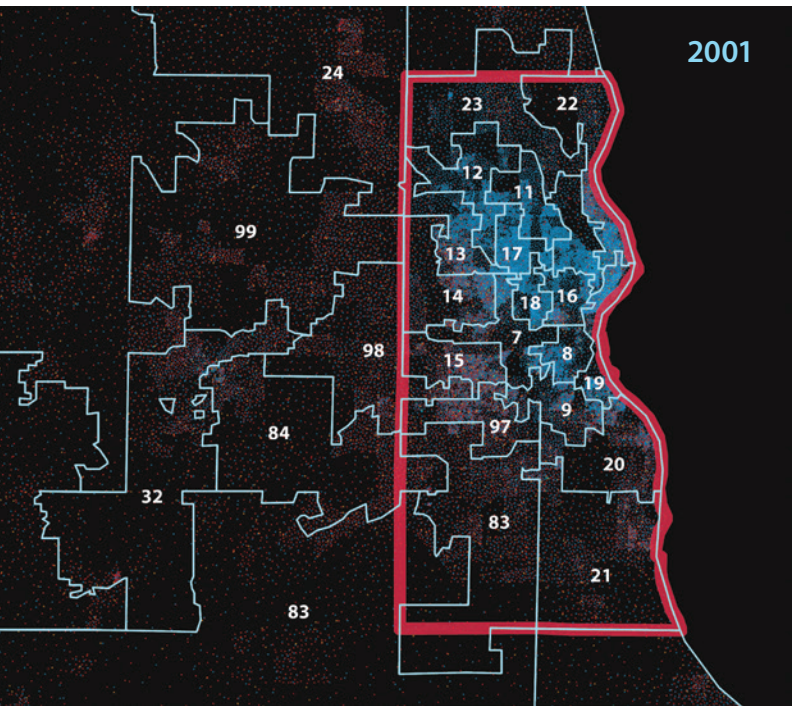
"The most profound changes are in areas where the population is graying rather rapidly. We're looking at the impact of that on economic status and well-being, prevailing wages, kinds of employment (and in what industries), income, poverty, and socioeconomic conditions. We're telling the story of population change and growth in a way that helps communities understand and get a handle on those issues."

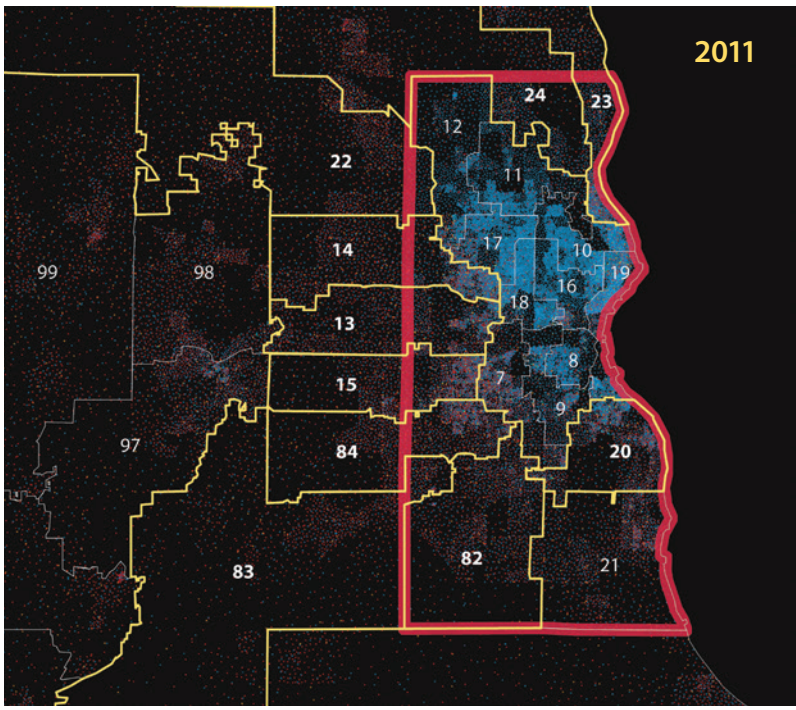
Communities often use the data to bolster grant applications and comprehensive plans, make decisions about resources, and develop new strategies for reaching underserved or underrepresented areas. School districts rely on the data for everything from hiring decisions to facilities planning. This becomes especially important in rural areas, where steady enrollment declines raise questions about the feasibility of keeping schools open, Veroff says.

Sometimes the work is on a neighborhood level. "We can tabulate a lot of administrative data, including police incidents and building inspection data, to identify hot spots that need some attention in terms of resources or programming to get a neighborhood back on its feet," Long explains.

And some of the data requests or projects are more unusual. Veroff remembers when someone from the Wisconsin Department of Natural Resources asked for a projection of the deer hunter population. "A lot of it makes me feel like I'm a reference librarian. I get to learn something new every day," he says.

The Applied Population Laboratory's work with WisContext includes an analysis of gerrymandering in Wisconsin. The 2001 Wisconsin Assembly districts (left) in the Milwaukee metro area mostly followed the Milwaukee County boundary. The 2011 Wisconsin Assembly districts surrounding Milwaukee show evidence of cracking, one method of electoral gerrymandering.





Graphics by Caitlin McKown/UW Applied Population Lab

Photos by Michael P. King

Caitlin Bourbeau, web developer at the Applied Population Laboratory (APL), works on an interactive graphic in her office in Agricultural Hall at UW–Madison.

APL staff, from left, Katherine Curtis, David Long, and David Egan-Robertson, talk during a staff meeting in Agricultural Hall at UW–Madison.

APL is also gearing up for Census 2020. That means educating people on why it's important to be counted, defining the boundaries and structures that make sure the Census is hitting all the right places, and preparing for the slew of reports that will be generated after the Census is complete.

Veroff travels to Wisconsin communities to champion the Census. "There are billions of dollars of federal and state funding that are attached to Census counts that will come out after 2020, and new election districts will also be drawn on the basis of population counts," Veroff explains. "If you have a better count for a community and know where you've been and where you're heading, that's really important for thinking about growth and decline and how to plan for services."

A DEEPER LOOK AT PUBLIC HEALTH

APL's work could also shape the future of public health in Wisconsin. Jones recently won a large, five-year grant from the National Institutes of Health to use simulation modeling to study the social dimensions of vaccine refusal, which has led to spikes in preventable childhood diseases, such as measles and pertussis.

"We know that people who don't want to vaccinate their kids are clustered in certain schools and neighborhoods," she explains. "We know it matters for outbreak risk because we see outbreaks happening in those places, but there is no good measure of how much that matters."

Current policy proposals aimed at reversing the public health effects of vaccine refusals don't take into account clustering. The average vaccine exemption rate in California is 3 percent, but some schools have rates as high as 98 percent. Those schools may need different policies to curb potential outbreaks, Jones notes.

Jones is initially focusing on California, which has the best data on vaccine refusal, but she plans to share her work with Wisconsin policymakers. "Wisconsin is well above the national median for vaccine refusals, so it definitely is an issue here as well," she says.

Researcher **Bill Buckingham** also focuses on health geography and recently published an "area of deprivation index," which helps medical researchers examine the long-term health impact of living in a distressed neighborhood. His work in this area merges spatial information with social and economic data to create a nationwide map of health risks that stem from social disadvantage.

The APL team is excited to get its data-driven insights out of academic journals and into the hands of Wisconsinites who can use them.

"We're not just doing research for the sake of research or crunching numbers that go into the Twittersphere," Veroff says. "We're thinking about how what we're doing gets used and applied in the lives of the citizens of Wisconsin, how we can make a difference or help those who are on the front lines make a difference. That's something that we get sparked by every day."

And while APL remains busy, researchers say they always have time for one more interesting project. "We're for hire!" Curtis says with a laugh. "We like puzzles, so send us your puzzles, and we'll find an answer for them."

A DIFFERENT Beet

As the nation's only university-based plant breeder of table beets, Irwin Goldman is pushing this loved and loathed vegetable in new directions

BY NICOLE MILLER MS'06

PHOTOS BY MICHAEL P. KING

Undergraduate student Alex Williams BSx'20 works with others from the Goldman Lab to harvest beets at Tipi Produce in Evansville, Wis.

Last fall, when the "Gastropod" podcast came to UW–Madison to participate in the 2018 Wisconsin Science Festival, hosts **Cynthia Graber** and **Nicola Twilley** asked **Irwin Goldman** PhD'91 to be a guest on the live show. A professor and chair in the horticulture department, Goldman is a plant breeder and geneticist who focuses on carrots, onions, and beets, and outreach is a regular part of his job. Naturally, he said yes.

Horticulture professor Irwin Goldman slices and inspects beets at the UW Carrot and Beet Lab.

Many people enjoy learning about vegetables, and Goldman loves talking about them — and he's good at it, always ready to serve up fun facts and stories with a dash of science. He's a popular teacher and a sought-after media expert. You may have heard him on the radio — he's been a regular guest on Wisconsin Public Radio's "Garden Talk" for decades, one half of the veggie expert duo known as the "Vicars of Vegetables."

To help prepare for his "Gastropod" appearance, Goldman met up with Graber and Twilley at the UW Carrot and Beet Lab, where he stores the materials and tools for his plant breeding programs. As they sampled a variety of carrots — the focus of the upcoming show — the conversation shifted to the subject of beets.

"Cynthia told me that she doesn't eat beets," recalls Goldman. "She said, 'I hate beets. I can't stand them.'"

For Goldman, who loves beets right down to the center of their "beet-y" little hearts, it's a discouraging sentiment. But it's one he's heard many times before. If one of Goldman's vegetables needs a champion, it's definitely the beet. It's a rather polarizing plant.

To many children, beets are pickled horrors that should be avoided at all costs. To some, they constitute peasant food, a steaming bowl of magenta borscht. To others, they are the star attraction of a gourmet salad, roasted to perfection and tossed with arugula and goat cheese in a vinaigrette dressing.

"If you talk to consumers about beets, you'll find a few people that say they love them and can't get enough of them, but you'll find many more who say, 'I can't stand them because they taste like dirt,'" says Goldman.

And so they do.

Beets contain geosmin, a compound with a distinctly earthy smell and flavor. It's the same molecule responsible for the aroma of freshly plowed fields and newly turned garden beds.

Geosmin has been associated with beets since the beginning of time, notes Goldman. His beet breeding program, however, has come up with some new options for people who don't dig the earthy pungency of the typical beetroot. And it's developing more.

These options are the result of a career that has taken some surprising turns over the years. After starting with a focus on serving the traditional beet industry, Goldman's program abruptly expanded to include culinary beets for gourmands and foodies. He set out to develop an un-beet-y beet, something a kid could like, and then went on to crack a long-standing beet mystery central to the vegetable's earthiness.

At the Carrot and Beet Lab, Graber tried some of these new un-beet-y varieties. "I cut them up, and Cynthia could not get enough of them," says Goldman. "We just chowed an entire beet, and she was like, 'This doesn't taste like a beet.'"

Indeed. It's meant to be something entirely new.

BEETS WERE ORIGINALLY CULTIVATED IN THE MEDITERRANEAN REGION as a leaf crop. The plant's greens were harvested for salad while the small, bitter roots were largely ignored. Over time, pushed by the need for crops that could overwinter in more northern latitudes, people selected for larger and larger root size, eventually creating the swollen, durable root of the modern table beet.

Table beets are a healthy food, high in fiber, folate, and vitamins A and C. Eastern Europeans brought beets with them when they immigrated to North America in the 1800s and early 1900s, along with carrots, onions, and other root vegetables.

"Root vegetables are the simple, staple peasant food of Eastern Europe," says Goldman, whose own family tree goes back to rural Belarus. "They are really like part of my family."

Goldman grew up in Skokie, Illinois, a suburb of Chicago. He always had a proclivity for nature and science. In his teens, he fell hard for the theory of evolution, which continues to be his "favorite idea of all time." During his undergraduate years, he happened upon a course about plant breeding — which he quickly identified as the perfect profession.

"It dawned on me that evolution is totally analogous to plant breeding — those things are parallel," Goldman says. "It's just that plant breeding is driven by humans and the direction they want things to go. I remember getting so excited about that."

After doing graduate work in soybean and pea breeding and postdoctoral research focused on corn genetics, Goldman joined the UW–Madison horticulture faculty in 1992. As the new person in charge of breeding and genetics of cross-pollinated vegetable crops, Goldman was given the choice of what vegetables to work on. He opted to follow in the footsteps of his predecessor, **Buck Gabelman**, a pioneer of modern vegetable breeding who was the first person to apply certain hybrid corn technologies to vegetables crops, including developing the first beet hybrids.

"There was just this wealth of germplasm developed by my predecessor on beets and carrots and onion, and they're all biennial crops important to Wisconsin, so I decided I just wanted to keep those breeding programs going," says Goldman. "Also, there were very few people in the country doing those crops."

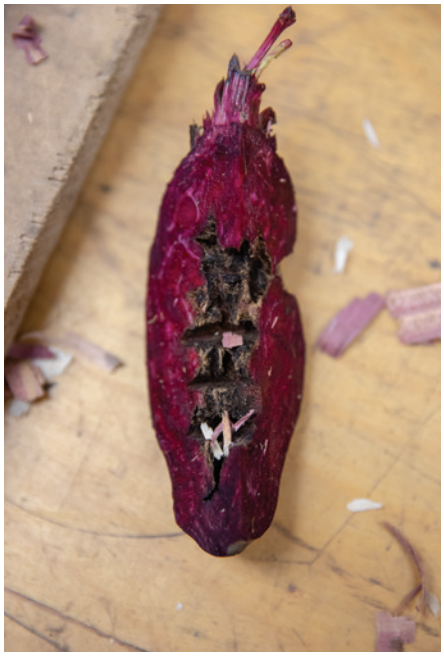
Wisconsin has a long history of vegetable canning, including peas, corn, cabbage, snap beans, and beets. Today, Wisconsin is the nation's top producer of table beets. State producers grow more than 50 percent of the country's crop, and the majority of the harvest is processed for canning.

In terms of acreage, however, it doesn't add up to much. There are only around 5,000 acres of beets grown in the state, compared to 2.3 million acres of soybeans, 3.9 million acres of corn, and 68,000 acres of potatoes.

This makes beet a minor crop, and, as such, there aren't many plant breeders working to improve it. Right now, Goldman is the nation's only plant breeder at a public institution who works on table beets, making UW–Madison a key resource for all things beet research and breeding. This includes the development of new and improved varieties and serving as a repository for one of the world's best collections of beet seeds.

"If you go to the store and buy a beet, or you order a beet dish in a restaurant, it's almost certain to have its origin here in our program, which is cool," says Goldman.

A beet from one of the Goldman Lab's experimental breeding lines.



LEFT: A beet undergoing inspection at the UW Carrot and Beet Lab shows evidence of infection by the fungus Rhizoctonia.

RIGHT: Katharina Wigg, a plant breeding and plant genetics graduate student, inoculates beet plants with Rhizoctonia at UW's Walnut Street Greenhouses as part of a long-term project to develop fungus-resistant beets.

"And it's not that the [finished] varieties were bred by us, necessarily, but that we supplied the parent materials that companies used to make their commercial varieties."

One constant since the beginning of Goldman's career has been his work on agriculturally relevant projects to support the beet industry. One of his first projects involved continuing Gabelman's efforts to develop high-pigment beets for the production of natural food dyes, a collaborative project with UW–Madison food scientist **Joe von Elbe** BS'59 MS'60 PhD'64. Goldman and von Elbe, with the guidance of the Wisconsin Alumni Research Foundation (WARF), went on to found a spin-off called Phyto Colorants to make these pigment-saturated beets available to industry. Dyes derived from the company's beets are now used by national food companies to color ice creams, yogurts, chips, and candies, among other products.

A new project involves developing table beets that are resistant to Rhizoctonia, a soil-borne fungus that is considered a major scourge of the beet industry. Infected beets develop areas of black, dead tissue, which leads to a lot of food waste during processing.

"[Processors] take the beets and peel away the skin. And the deeper the fungus has penetrated, the more tissue they have to take off," says **Katharina Wigg**, a plant breeding and plant genetics graduate student who is part of the Rhizoctonia research team.

The project, funded primarily by the Midwest Food Products Association, involves using traditional plant breeding to take a known source of genetic resistance from sugar beets and incorporate it into popular commercial table beet varieties. At the same time, Wigg and Goldman are searching far and wide for a table beet that already has some level of resistance, which, if found, could help speed the breeding effort.

It's the perfect project for a public plant breeding program. While industry is eager for the fungus-resistant beets, it may take 10 years or more to complete the project, well beyond Wigg's Ph.D. work.

"We can take on riskier and more long-term projects here, things that private companies can't do because they need a more immediate return on investment," notes Goldman.

GOLDMAN'S BEET PROGRAM TOOK AN UNEXPECTED TURN in the late 1990s — thanks in part to the preferences of a celebrity lifestyle guru.

"Martha Stewart began incorporating beets into her recipes, and then it was in *Gourmet* magazine and *Bon Appétit* and *Cook's Illustrated*," says Goldman, who shortly thereafter started fielding phone calls about beets — where to buy them, how to grow them, how to cook them.

"[There developed] a whole community of people interested in beets," he says. "I think about beets as this old-fashioned root vegetable, as

peasant food. But now they've got this high-end, fancy culinary thing going on," he says. "There's been this beet renaissance, and it's still happening. It's been wonderful."

Goldman quickly adjusted his program to meet the new demand for specialty beets, developing new and improved fresh market varieties for restaurants, farmers markets, stores, and home gardens. He's been working to improve the seed quality of yellow beets so they germinate and emerge better. He's also nearly finished creating a beet with an entirely novel hue: solid orange.

"You can almost paint these however you like by crossing and using the [pigment] genes that are available. I often feel like I'm playing, like this is an art project," says Goldman. "But these beets still benefit our farmers. The whole culinary world has exploded for beets, and our farmers want to grow things that people want to eat, so I'm working to develop [more options]."

When this renaissance started, Goldman decided that he wanted to try to develop a beet that his own kids, as well as other beet-averse folks, would enjoy. This launched a 15-year odyssey to develop his Badger Flame series of beets — Badger Flame, Badger Torch, and Badger Sunset — which were released as finished varieties in 2012. These beets, developed in partnership with UW–Madison vegetable breeder **Nick Breitbach**, are oblong with vibrant yellow, orange, and red interiors. And they're designed to be eaten raw.

"When you give somebody the Badger Flame beet, you can peel it, and you can just chomp on it like a stick of jicama," Goldman says. "It's sweet and crunchy with about as much earthiness as spinach. So you get that hit of sucrose and not the hit of the soil."

This is the beet that Goldman served to a pleasantly surprised Graber from "Gastropod."

Badger Flame beets are proving quite popular as far as culinary beets go. The seeds are available for purchase through Row 7, a specialty seed company founded in 2018 by **Dan Barber**, award-winning chef at Blue Hill at Stone Barns in New York. In February, *The New York Times* featured the company, which led to a boost in seed sales.

Goldman works with WARF to release the new beet varieties he develops that have commercial potential as well as new inbred lines that seed companies may want to use to produce new hybrid varieties. When companies license his germplasm, the resulting royalties help support more research and breeding.

THE BADGER FLAME PROJECT SHOWED GOLDMAN that earthiness can be dialed down in beets. This got him thinking about what's going on with geosmin in his favorite root vegetable. He wondered: Where do beets get their geosmin? Is it from the soil that they grow in, or do beets produce it themselves?

Soil microbes, particularly certain strains of Streptomyces bacteria, produce geosmin in vast quantities. That's what makes the soil smell earthy.

"We always thought that [beets are earthy] because they live in the ground and that the soil bacteria were maybe living inside the skin of the beet or something," says Goldman. "But we didn't know."

The effort to solve this mystery started with **Amy Freidig** MS'10 MS'13, one of a series of talented graduate students in the Plant Breeding and Plant Genetics program to work on this long-term project.

Freidig tapped into a new, shared campus resource: a gas chromatograph mass spectrometer, which can measure volatile compounds such as geosmin. She was able to show — in a quantifiable way — that geosmin is cultivar-specific. In other words, different beets have different levels of geosmin.

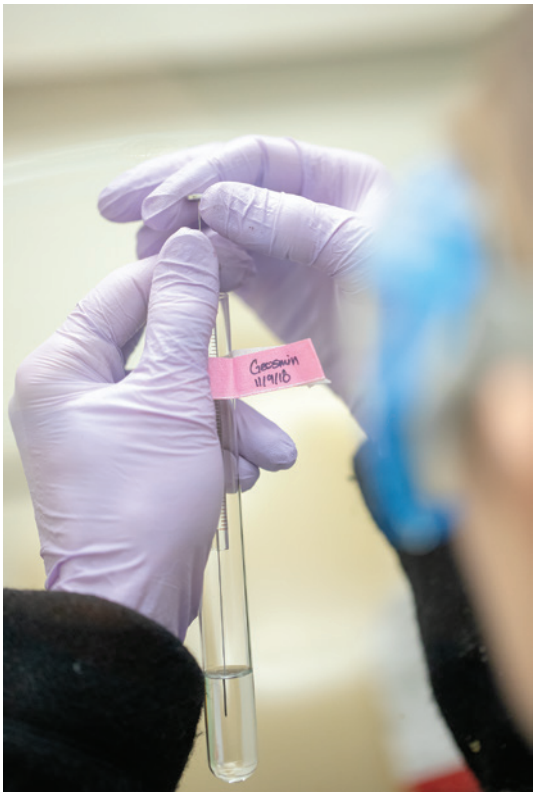
Next came **Lynn Maher** PhD'17.

"When I joined, the next question was, 'Can we breed for this?'" Maher says. "The biggest part of my project was to see if we could select for geosmin as a trait."

While Goldman had already had success with his Badger Flame beets, Maher needed to quantify the geosmin throughout the breeding process to show it changing over time. Maher started crossing high-geosmin lines with other high-geosmin lines and low-geosmin lines with other low ones, trying to increase and decrease geosmin levels, respectively.

And it worked. Very well. For the high-geosmin lines, they raised geosmin levels by more than 50 percent. For the low, the levels basically "hit the floor."

"As an emerging plant breeder, it was exciting



Graduate student Solveig Hanson works with geosmin in preparation for analyzing beet slurry samples via gas chromatography mass spectrometry testing in Horticulture/Moore Hall.

Plant Breeding: 'The Slowest of the Performing Arts'

The table beet is a biennial plant. That means, left to its own devices, a beet plant takes a full two growing seasons to complete its life cycle — from a seed planted to a new seed produced. Fortunately for Irwin Goldman, professor and chair in the horticulture department, there's a low-tech way to go from seed to seed in a single year.

In the spring, Goldman and his lab members plant seeds in the field, an all-hands-on-deck activity. In late summer, they work together to harvest the roots. From there, the beetroots are put into cold storage for around 12 weeks, which "feels" like winter and makes the roots competent to flower.

Then, over the course of the winter, the roots that move forward in the breeding program get planted into pots, where they grow, flower, and are pollinated in a greenhouse. Seeds are collected in spring, ready for planting out in the field, and the next cycle begins. At this rate, it can take 10 to 15 years to develop a new beet variety.

"I often think of plant breeding as the slowest of the performing arts," says Goldman. "And it really is. It's glacial."

Being a plant breeder involves long hours of monotonous, physical work during certain stretches of the year, particularly in the planting, harvesting, beet assessment, and pollination stages. For Goldman, these times correlate with extra loads of laundry — as well as good, solid sleep.

These also are days when lab members spend a lot of time together.

"It's very much a team work effort," says Katharina Wigg, a graduate student in plant breeding and plant genetics. "And we have lunch together on those days, and those are some of my favorite parts of the year because we get to reconnect."

These group work days also provide an opportunity for graduate students to practice their leadership skills by directing the efforts of the whole team on their individual projects.

"On a daily basis, working with bright, enthusiastic students is a total and utter joy," says Goldman. "They are just smart and interested and motivated, and they want to extract stuff from their time here. They give you hope for the future."

Solveig Hanson, far left, a graduate research assistant with the Department of Horticulture, trims and bags beets with undergraduates after harvesting at Tipi Produce in Evansville, Wis.

to see that selection really works," says Maher, who now works for Bejo Seeds, Inc., the U.S. subsidiary of a Netherlands-based vegetable seed company.

Next, to rule out the possibility that some environmental factor could be involved, Maher grew various beet lines in sterile tissue culture. Grown in an isolated, microbe-free environment, the beet-y beets still managed to produce earthy roots. The results, published in *HortScience* in 2018, were the final proof.

"[We showed that] beets produce geosmin on their own, endogenously," says Maher.

After Maher graduated, doctoral student **Solveig Hanson** picked up the reins. On the research front, Hanson is looking for the genetic markers associated with beets' geosmin genes. On the breeding side, she leads a participatory breeding effort to improve culinary beets with ongoing, direct input from local chefs, farmers, and consumers.

The project, supported by the U.S. Department of Agriculture, is heading toward more diverse beet flavor profiles, including both high-geosmin and low-geosmin beets with various levels of sweetness.

One way Hanson solicits consumer feedback is through tasting events. Last fall, she helped staff the beet table at the UW Farm to Flavor dinner, which features promising vegetables from the university's various breeding programs prepared by local chefs into gourmet amuse-bouche fare. At the beet table, participants sampled an assortment of roasted roots and filled out a survey about their perceptions and preferences, including selecting from a list of 20 taste-related terms for each beet they tried: caramel, dirt/soil, grass, herbal, mineral, musty, stewed meat, white sugar, and so on.

"We want to come up with a flavor lexicon — a flavor vocabulary — that helps people describe flavors and tell varieties apart," says Hanson, who plans to organize the top terms into a "flavor wheel," a handy descriptive graphic. "We hope this

OPPOSITE PAGE: Tubes of frozen beet slurry sit in a rack before they are thawed and prepared for gas chromatography mass spectrometry analysis in Horticulture/Moore Hall.

Attendees assess samples of cut and steamed beets during the Farm to Flavor dinner at UW's Discovery Building.

will help farmers describe flavors to their customers and help plant breeders describe flavors to farmers looking for seeds to buy."

At the recent Farm to Flavor dinner, Hanson found it interesting that beet table visitors seemed to like the high-geosmin and low-geosmin varieties about the same. And, whether earthy or not, people consistently expressed a preference for sweeter-tasting beets. Overall, she takes it to mean that there's room for all kinds.

"What things are pointing to is that there are a range of appealing flavor profiles in beets, which is really exciting for the specialty beet marketplace," says Hanson. "I think there's an explosion of diversity in beet that is still to come, and I think there's space in the market — and space in people's palates — for it."

Goldman, who sees himself as a steward of beets for the public good, is committed to pushing the field in new and promising directions. He's proven that he's willing to do what needs to be done to ensure his beloved root vegetable has a bright future — including, in certain cases, expunging the very essence of what makes a beet a beet. And he has made peace with that.

"Initially, I felt bad about creating something that was un-beet-ish, because it seemed like that was the opposite of what my job should be, in a certain way," he says. "But it has been very gratifying because more people have gotten into this vegetable, more people have started experimenting with it. It's like a vegetable gateway drug to enjoying other beets."

Residential learning communities immerse CALS students in a unique and focused academic experience

TO LIVE & LEARN TOGETHER

BY ERIC HAMILTON

The summer vegetables sag in the wake of the first frosts. But the low October sun still warms the fields of the Eagle Heights Community Garden as **Devon Hamilton** BS'17 and **Kristin Fischer** BSx'22 walk out to a large plot next to the F.H. King Student Farm on the north end of campus.

"Want to dig some carrots, Kristin?" asks **Tom Bryan** BS'13 MS'15, as they hike up to the plot. "Yeah!" responds Fischer, a first-year resident in the GreenHouse Learning Community. GreenHouse is a residential learning community at UW–Madison dedicated to teaching and living the practice of sustainability in its many forms.

The food order for the day: 15 pounds of carrots, 10 pounds of yellow potatoes, 10 pounds of sweet potatoes — and whatever else looks good. Bryan, the greenhouse and garden manager for GreenHouse, is taking the day's harvest to a University Dining team that will prepare a community meal for residents the following evening. Tending the garden and sharing its produce are keystone experiences for GreenHouse residents.

Hamilton is preparing to speak at the dinner about his work with the Michael Fields Agricultural Institute, where he teaches sustainable growing practices to farmers and educates students about food justice. An alumnus of GreenHouse, Hamilton can also be found around Madison volunteering on local boards, learning to cook soul food, and serving up community meals with the aid of his hardwood charcoal smoker.

Since coming to UW–Madison from Los Angeles, Hamilton has carved out a space for himself at the intersection of South Central Los Angeles food culture and southwestern Wisconsin farms, using food and sustainability as a way to connect to his own roots and encourage reflection and action in others.

"Trying to make those connections has been an important part of my work," says Hamilton as he bundles stacks of collard greens, "and also what GreenHouse helped foster within me."

Photo by Michael P. King

Freshman environmental sciences major Kristin Fischer, left, who is a GreenHouse Learning Community resident, and CALS alumnus Devon Hamilton harvest kale and other vegetables at the F.H. King Student Farm on the UW–Madison campus.

A SMALL-COLLEGE FEEL

CALS supports three residential learning communities on campus: GreenHouse, BioHouse, and Women in Science and Engineering, better known as WISE. The university's 10 learning communities offer students from across campus — primarily freshmen — opportunities to enhance their academic and social transition to college by organizing small seminars, providing frequent interactions with faculty, and centering residence life on common interests. With fewer than 100 residents in each CALS-supported learning community, they also create a small-college feel on a large campus.

Learning communities at UW–Madison have a philosophical foundation dating to the 1920s, when Alexander Meiklejohn, the former president of Amherst College, founded the Experimental College on campus. In Adams Hall, students shared living quarters with faculty and pursued the broad goal of education day and night through readings and self-guided discussion.

"Their learning wasn't confined to the classroom," says **Cindy Holzmann** who, as assistant director of residence life at the Division of University Housing, oversees the residential learning communities. Meiklejohn's ideas were ahead of his time, and the Experimental College closed after a few years.

Nearly 70 years later, the College of Letters & Science and University Housing founded the Bradley Learning Community to create the experience of a liberal arts college on a growing campus. The next year, in 1996, CALS, the College of Engineering, and University Housing created WISE in the Waters Residence Hall, which at the time was for women only. GreenHouse followed in 2013, and BioHouse was founded by the Wisconsin Institute for Science Education and Community Engagement (WISCIENCE) in 2014.

John Klatt, assistant dean in the CALS Academic Affairs Office, says college backing for these learning communities comes from a "desire to support strong student communities." The college provides $5,000 per year in direct funds to each community, with additional support through faculty advisors, graduate and undergraduate mentors, program coordinators, and wide-ranging programming. Much of that programming centers on connecting students with professors.

"One of the key things in our learning communities is that students get to know a faculty member in their first year," says Holzmann.

WISDOM FOR WOMEN IN SCIENCE

Over plates of Thai curry, students pepper **Chris Seroogy** with questions about her path to the table they share. Seroogy, a professor of pediatrics at the UW School of Medicine and Public Health, shares her long journey through industry, medical school, fellowship, and research labs in her pursuit of understanding the body's immune system. Her connection to her hometown of Green Bay briefly diverts conversation to the Packers before it returns to her research and travel goals.

Seroogy is one of 13 faculty members distributed around as many tables in the Carson Gulley Center for one of WISE's regular dinner seminars. At the meals, students connect with professors over shared interests and receive advice on navigating their first years in science. The mood is casual and collegial, helping to break down barriers between women at the start and the height of their careers.

Since its founding in 1996, WISE has served well over 1,000 women. After Waters Hall opened to men in 2006, WISE moved to other residence halls. But in 2016, WISE returned to Waters Hall — on a women-only floor — which has coincided with a surge of interest among incoming students. In response to demand, WISE is slated to expand considerably in the fall of 2019, from 81 to more than 130 residents.

Close connection with women faculty and business leaders is a core component of WISE. Following fall seminars led by dozens of faculty members, WISE's spring seminar series features women from science and engineering companies around Madison. They come to campus to provide residents with networking opportunities and insight into private enterprise.

At the dinner, senior neurobiology major **Colleen Krueger** oversees the discussion as it ranges from the students' research interests to the different farming practices in France and the U.S., which Seroogy studies as part of her work. As an undergraduate mentor, Krueger, an alumna of WISE, facilitates conversation between the residents and professors during these seminars.

"I'm four years deep into WISE," says Krueger. "WISE is probably the reason I stayed on the STEM path."

"You get to meet so many different people who are doing research here, and it gives you lots of opportunities to join them," first-year genetics major and WISE resident **Hailey Thurston** BSx'22 says of the dinners. "And being able to know the people who are conducting these experiments is a very quick way to get into research."

The programming at WISE is designed to introduce residents early on to research opportunities, which are vital for women pursuing advanced degrees or careers in science and engineering after college. In addition to direct connection to potential faculty advisors at the dinners, WISE organizes lab visits to show research in action. In the spring, three awards help departing residents take on funded research for the summer.

This strong emphasis on academic opportunities is supported by social experiences that help WISE residents find their place on campus, says **Anna Christenson** BSx'22. A genetics major and first-year WISE resident from Bayside, Wisconsin, she chose WISE for its mix of academic and social elements.

"I really like WISE because it connects me with a whole bunch of other students who are interested in the same things as me," says Christenson, who recently began research on genes linked to autism in the **Peter Lewis** lab at the Wisconsin Institute for Discovery. "WISE really did push me to find the research opportunities I'm looking for."

Behind much of the social and cultural programming is **Suzanne Swift**, the program coordinator for WISE. In the minutes before the dinner seminar begins, Swift and a small army of undergraduate peer mentors sweep into the room. The team quickly lays out tokens of appreciation for visiting faculty, sets out resident name cards, and distributes copies of *What the Eyes Don't See*, Mona Hanna-Attisha's account of her research uncovering dangerous lead levels in water in Flint, Michigan.

"I spend a lot of my time thinking about how we can create lifelong engagement in STEM," says Swift.

Engagement includes sharing science with others. WISE residents routinely participate in Saturday Science outreach events at UW–Madison's Discovery

Photo by Michael P. King

Students listen to chemical and biological engineering department chairperson and professor Regina Murphy, right, at a Women in Science and Engineering dinner seminar at Carson Gulley Center on the UW–Madison campus.

Building and staff tables during the Wisconsin Science Festival on campus.

Among its most important mandates, WISE also provides support for students as they join fields where, in many cases, women remain underrepresented. Earlier in the fall, a workshop addressed "imposter syndrome," the all-too-common false sense of fraudulence at work or in school. Beyond formal training, every WISE event — social outings or outreach events, company tours or campus concerts — emphasizes how the residents belong. At the dinner set for more than 100, every scientist, student, and mentor, from freshman to full professor, is a woman.

"[WISE] prepare[s] you for knowing that you do belong there," says Thurston. "They do a lot to make sure you feel empowered, important, and prepared for your field of study."

THE FULL BREADTH OF THE BIOSCIENCES

Bill Karasov joined the faculty of UW–Madison in 1985, but he had yet to teach a first-year class when, in 2015, the opportunity arose to become faculty director of BioHouse. The position would have him serve not just as a teacher to residents but as a mentor, helping them explore the full breadth of the biological sciences on campus. Excited to get outside his comfort zone and share a passion for biology with students, he signed on.

Now, more than three years later, Karasov has been leading BioHouse for most of its time on campus. He sees research as a crucial experience for students studying the life sciences, and much of his BioHouse curriculum centers on helping students feel comfortable seeking out these opportunities. That starts with the fall seminar.

"I bring in a dozen faculty members to talk about research," says Karasov, a professor of forest and wildlife ecology who studies how animals process energy in their natural environments. In the spring, Karasov invites BioHouse residents to his home for monthly dinners. The casual atmosphere helps him get to know the students better and connect them with advisors who suit their interests.

The biosciences, broadly defined, encompass some three dozen majors on campus — and they are among the most popular. Nearly 8,000 students are pursuing life sciences-related majors, making up more than a quarter of the undergraduate population. Biology

alone is the third-most-popular major on campus, with more than 1,100 declared students.

BioHouse serves 66 of these students each year, bringing them together in Cole Hall. Despite the immense diversity in the life sciences, the students remain connected by a common curiosity: How do living things tick? The breadth of disciplines is surveyed in the first-year seminar to help students explore and decide on a major.

"Sometimes students learn about areas of biology they've never heard of," says Karasov.

In the minutes before professor of integrative biology **Monica Turner** begins speaking about her work studying wildfires in Yellowstone National Park, **Adriana Golding** moderates student discussion of an article about Turner's ecological research. In this BioHouse seminar, students are seated at tables in the Frank Holt Center, each group led by graduate student mentors like Golding.

"Were you aware this is a field and this goes on at UW?" asks Golding, a Ph.D. candidate who researches cellular changes during wounding and cell division in the lab of **Bill Bement**, a professor of integrative biology.

For many students, this is their first exposure to ecology. First-year genetics major **Caitlin Kestell** BSx'22 links Turner's work to her species extinction class. She discusses with **Austin Yeung**, a neurobiology major, how more frequent fires could change not just the landscape but also species distribution.

In BioHouse's first year, Golding joined as a graduate student mentor to facilitate discussion before, during, and after the weekly seminars. Although she long ago fulfilled the teaching requirement for her degree, she has remained with BioHouse throughout graduate school.

"It's a nice way to continue having relationships with students," says Golding. She fondly recalls mentoring residents on the transition to college, helping them identify resources for writing and studying or providing tips for living in a crowded dorm. Her mentoring work has reinforced her goal of remaining in higher education and staying involved in teaching.

Photo by Claire Zettl/UW–Madison Housing

Residents of the UW–Madison BioHouse Learning Community dress a skeleton model in their Cole Residence Hall lounge during a spring semester "welcome back" gathering in January 2018.

During one fall seminar class, **Amber Smith** teaches students the skills they need to find and secure research opportunities. Smith is the director of mentor and mentee training for WISCIENCE, the principal partner in BioHouse. In her class, Smith explains how to develop a mentor network, where to look up faculty profiles, and how to master the art of the professional email. Most importantly, she gets students reflecting on their curiosity.

"I really advocate that students take some time to figure out what they're curious about," says Smith, pointing out that a good intellectual fit makes the inevitable frustrations of research much more manageable.

WISCIENCE's sponsorship also helps the residents focus their experiences on outreach and the effect they could have on the wider world with their research. One seminar assignment has students communicate biology to the general public by writing articles or producing videos or podcast episodes.

"We encourage students to think about how biology relates to modern society," says Karasov.

As a first-year student, BioHouse resident **Morgan Blaser** got connected to **Fola Arowolo**, a graduate student working in the lab of **Dhanansayan Shanmuganayagam** BS'97 PhD'06, an assistant professor of animal sciences. Now a senior majoring in biology and psychology, Blaser has been researching fat metabolism in swine models with Arowolo and Shanmuganayagam ever since.

Blaser has worked on several projects during her tenure in the lab, including

using stem cells to develop a 3D model of pig intestines and feeding trials to explore the effect of dietary lipids on pig health. Blaser has presented her research at conferences and is a co-author on a research paper being prepared for publication. She plans to apply to medical school after earning a master's degree.

"Throughout my experience and time at UW doing research, I've come to find that the people I work with are a huge reason that I continue to do what I do," says Blaser, who credits BioHouse with introducing her to the realities of research.

"I also just love to learn," says the Rhinelander, Wisconsin, native. "Research is something you can't predict. Each day can be something different. I really like that ability to think on your feet and roll with the punches."

LIVING LEOPOLD'S LEGACY

In the garden, Bryan, Hamilton, and Fischer reminisce about the season's earlier harvests while digging up carrots, snapping off the tops, and tossing them in collection bins. For four community meals in the fall, GreenHouse will send University Dining some 1,000 pounds of produce. They have already harvested 1,000 pounds of potatoes alone.

"That's day one of some people's GreenHouse experience, coming out here and digging potatoes," says Bryan.

The extra produce is stored in a pantry in Leopold Hall, where all GreenHouse residents live, and is accessible to any of them. With a commercial-scale kitchen in the basement and smaller kitchens on every floor, cooking is a source of community.

"It always smells good on our floor," says Fischer, an environmental sciences major from Hudson, Wisconsin, whose specialty is curry. "I've always been super passionate about sustainability. I've always loved the outdoors and nature. So when I heard about GreenHouse, I thought, 'sounds like the perfect fit.'"

In addition to the garden, the learning community fittingly boasts a physical greenhouse on the roof of Leopold Hall. Residents use the facility to start seedlings for their garden. Planted each spring by departing students, the garden is managed by student workers over the summer, and its harvests feed the next generation of GreenHouse residents the following fall.

"It continues the theme of sustainability in our learning community, because it's the previous generation taking care of the present," says Bryan as he harvests richly colored bitter greens.

Han DePorter BS'18 took the garden's sustainability message to heart. After growing seedlings for the GreenHouse's garden, DePorter started working at the F.H. King Student Farm, which led to a job in the lab of horticulture professor **Irwin Goldman** PhD'91. In 2017, DePorter and Goldman started the UW Campus Food Shed, where, to reduce food waste, extra produce from plant breeders like Goldman is stashed in two refrigerators on campus for anybody to take.

"Living in GreenHouse really sparked my love even more for environmental issues," says DePorter, who is now pursuing a law degree at the University of Denver.

Although most GreenHouse residents hail from Wisconsin, their familiarity with Aldo Leopold and his writings varies when they arrive. The founding chair of the precursor to the Department of Forest and Wildlife Ecology, Leopold is regarded as the forefather of modern environmental thought. He provides not just his name to the learning community's residence hall but a foundation for their seminar.

Residents read Leopold's philosophy in *A Sand County Almanac*, hear from his successors at the university, and visit his farm-turned-inspiration and famed shack in Sauk County. These experiences and reflections all steep the students in UW–Madison's unique legacy of environmentalism.

Part of that legacy is grounded in the physical campus the students now inhabit. In the early part of each fall semester, GreenHouse faculty director **Tim Van Deelen** invites campus historian and cultural resource manager **Daniel Einstein** to join the students at Picnic Point, where they start to absorb the historic context of the studies they're beginning.

"He talks about everything from the glacial history of this place to the mound-building cultures to early Madison and what the campus was like to give them a sense for place, which is an important part of sustainability," says Van Deelen, a professor of forest and wildlife ecology who has been faculty director since 2017.

That sense of place is apparent in the garden, as Hamilton, Fischer, and Bryan dig into the autumn soil and consider the spice of mustard greens or the earthiness of carrots they pop in their mouths. Here, the garden's cycle of taking and giving back captures the core concept of GreenHouse.

"You've reaped the rewards," says Bryan. "And now you need to pay that back."

Photo by Joel Ninmann/UW–Madison Housing

Residents of the UW–Madison GreenHouse Learning Community in Leopold Residence Hall spread seeds into growing trays during a seminar in the community's rooftop greenhouse in February 2018.

Note: *Grow* only includes degree and year notations for CALS alumni and students.

in the field

by Stephanie Hoff BSx'20

KATHERINE BS'08 and TYLER BS'08 ROWE

For **Katherine (Kate)** and **Tyler Rowe**, the most influential part of their CALS experience was their Horticulture 122 lab section, where they first met and later became a couple. Besides their enduring partnership, CALS gave them many of the skills they rely on to run their business, Burr Oak Gardens, LLC, a certified organic vegetable farm and retail greenhouse in Rio, Wisconsin. "We are constantly using information we gained from plant pathology and entomology courses," says Kate. About a year after graduating with degrees in horticulture, Kate and Tyler pursued their dream of forming a community-supported agriculture farm, or CSA. "We believe that everyone should have access to locally grown produce; and as farmers, the ability to know the customer and form a solid relationship based on respect and understanding was key to our decision to start Burr Oak Gardens," says Kate. Named after its resident 300-year-old burr oak, the farm has three traditional greenhouses for starting crops, a stationary high tunnel to house plants before they're transferred outside, and a portable hoop house to extend the growing season. These facilities are a rich source of satisfaction for Kate, who has a passion for watching seeded trays become a lush, flower-filled greenhouse, and Tyler, who finds nothing more gratifying than a freshly worked field lined with new transplants. With 18 acres of land, the Rowes have room to leave some fields under cover crop each year to build up organic matter in the soil and rotate crops to counter disease and insects. "In 2014, we began installing swales — low tracts of land — to help with erosion issues," Kate says. "And we plan to install grass waterways and other more permanent erosion controls."

ANNETTE WILKUS BS'80

Annette Wilkus was working at a greenhouse in high school when a landscape architect recommended their profession to her. "It was total happenstance," says Wilkus, founding partner of SiteWorks, a specialty landscape architecture practice based in New York City. "But once I got on a construction site, I was sold." Wilkus earned her CALS degree in landscape architecture, and she found her instructors to be valuable mentors who influenced who she is today. "I learned to listen and collaborate in a studio setting, which is why our office is organized as a studio," she says. Wilkus launched SiteWorks in 2005 after seeing a need to bridge the communication gap between designers and contractors. "My practice is focused on construction versus design because I realized early on in my career that my talents were in project management and the technical aspects of the profession." SiteWorks is a niche landscape architecture firm, working closely with design landscape architects to realize their visionary landscapes, such as the High Line, Governors Island, and Hunters Point South in NYC. "Seeing a design come to life is really what fuels me," she says. "And I love working with younger professionals and teaching them about construction — bringing them onto sites, showing them the nuances of collaborating with designers, construction managers, and contractors." Getting others excited about her craft is a big reason why Wilkus loves what she does.

JOHN STEPHENSON BS'99

As the owner of Stephenson Tree Care, Inc., **John Stephenson** wears many hats, including bookkeeper, mechanic, and urban forester. And when it comes to big tree removal and working with climbers, cranes, and pulleys, he puts on another hat (or helmet) as a safety expert. "I am actually a risk manager first and a contractor second," says Stephenson, a trained resource manager who graduated from CALS with a degree in forest science. With a home and family in Madison, Wisconsin, and an affinity for working outdoors, he decided that starting his own business in urban tree care was the right fit. "CALS gave me the confidence to be able to pretty much troubleshoot any problem I encountered along the way as a business owner and an urban forester," says Stephenson. "CALS extends way after graduation in that the collegial network and atmosphere of the school is only an email or phone call away. The networking never ends, and the payback is always present." His typical work includes tree removal, pruning, insect and disease diagnosis and treatment, cleanup after summer and winter storm events, and consulting in urban wood utilization at the USDA Forest Products Laboratory. "After nearly 20 years of this, it never gets old," Stephenson says. "And seeing my clients happy and my crew enjoying the challenges of their jobs makes this very rewarding." He is also active in local and regional urban wood utilization efforts for salvaging and marketing logs into lumber. "So maybe a second career could be starting," he says.

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. This is the third and final part of a special series on CALS graduates who have gone on to become entrepreneurs. For more about CALS alumni, visit* ***cals.wisc.edu/alumni****.*

Alumni making their mark as ENTREPRENEURS

TODD WILLER FISC'89, BS'92

A fifth-generation farmer, **Todd Willer** says agriculture runs in his blood. "It's what our families do. I was born a farmer," he says. As a child, he showed cattle and worked on his dad's farm. He still enjoys the farm today, but the scope has expanded. Willer is partner and vice president of operations for Milk Source, LLC. Headquartered in Kaukauna, Wisconsin, the company operates numerous farms across the Midwest that focus on premier animal care, sustainability, employee development, and community partnerships. "When I went to CALS, I took a trip with the dairy science department to California to see large dairy farms in the late 1980s," Willer says. "That fueled a passion in me to get into the expansion of the dairy industry in Wisconsin, which — at the time — was at the leading edge of becoming more modernized." Willer says his bachelor's degree in agronomy provided the perfect nexus for his passions. "It touched on agronomy, animal science, soil science, plant science, economics, and business — all of which I use on a regular basis," he says. At Milk Source, Willer is responsible for managing all facilities, maintaining structures and machinery, ensuring environmental compliance, and overseeing the design and construction of future farms and capital improvements.

CHRIS BLANCHARD BS'93

EDITOR'S NOTE: We are sad to report that Chris Blanchard passed away in late October. From a tribute to Chris, written by his wife, Angie Sullivan, and friend, David Bacchuber: "Chris helped to chart the path for what farming can look like going into the future. He lived in a constant state of learning and teaching. He wanted his community to live balanced lives filled with hard work for a clear purpose, all in the name of healing the planet. Chris was a light in the world. We love him and we will miss him dearly."

Chris Blanchard's career in agriculture began while studying liberal arts at Deep Springs College in California, where he also worked to maintain the college's vegetable garden. After realizing his knack for farming, Blanchard reevaluated his career path, which led him to CALS, where he earned his horticulture degree. He was particularly drawn to the college's potato breeding program, where he enjoyed preserving genetic diversity. In 1999, Blanchard started Rock Spring Farm, a family-owned, certified organic farm in northeast Iowa. Equipped with mobile greenhouses for growing year-round, Rock Spring became well known for its high-quality produce. It grew quickly, marketed through a community-supported agriculture model, food stores, and farmers markets. In 2013, Blanchard closed the farm to focus on another venture: Purple Pitchfork, a one-stop shop for advice and education for farmers and farm businesses. Blanchard's workshops, writing, consulting, and podcasts focused on farm business concepts, food safety, and organic vegetable production, among other topics. He gained a national reputation for fresh approaches, down-to-earth information, and honesty. And the significance of his company's name? "Everybody uses a pitchfork at some point in farming," Blanchard says, "whether it's to spread mulch across a garlic field or to pitch hay for the sheep. We decided that made a fitting symbol for the big tent we are seeking to build in the organic, sustainable, and local community. Plus, purple is just a cool color."

JORDAN ROBBINS BS'17

Jordan Robbins's concept for a swimwear company that helps people find their confidence began just two months before graduation. "I had no idea what I wanted to do but had this idea for a blog about body image issues," says Robbins, who played varsity volleyball at UCLA and then UW–Madison after transferring. She grew up in Southern California, where she "basically lived in a bikini" but always felt self-conscious because she has scoliosis, a curvature of the spine. She wanted to face her fears head-on by diving into an industry that evokes anxiety and stress in her and others, and her blog notion morphed into an idea for a brand. "The main goal for REVLY is to empower women to be the best versions of themselves and uplift those around them," says Robbins of her California-based company. With a degree in life sciences communication (LSC), Robbins is well equipped with the skills she needs to market her product. "[LSC instructor] **Don Stanley** [MS'00] was great at helping me focus my thoughts and turn an idea into a reality," she says. "I apply a lot of what I learned in CALS to my marketing strategies for REVLY." Robbins's duties include more than just leading the company. She designs and markets the products, coordinates promotional events, and handles customer service. "There is so much that goes into running a brand that it tends to get very overwhelming," says Robbins. "Staying on top of my to-do lists and not getting too stressed out is definitely one of the hardest parts."

Catch up with…

Lynne Maquat PhD'79 Biochemistry

It might seem like **Lynne Maquat** had the deck stacked — or maybe the test tubes racked — against her. The first-generation college student was entering a male-dominated field while overcoming her shy nature. Nevertheless, she found a successful formula. Today, as a professor at the University of Rochester School of Medicine and Dentistry, she is a force in the field of RNA research and a trailblazer for women in science.

As a doctoral student at CALS, Maquat worked with professor emeritus **Bill Reznikoff**, who she describes as a great supporter of women graduate students at a time when many departments had few women faculty. She has filled the years between graduation and now with a long list of accolades for her research. Recently, she received the Wiley Prize in Biomedical Sciences and the Vanderbilt Prize in Biomedical Science; the latter also acknowledges contributions to mentoring other women in science. She was inducted into the National Academy of Sciences in 2012 and the National Academy of Medicine in 2018 in recognition of her pioneering work on the complexity of RNA.

Photo by Matt Wittmeyer/University of Rochester Medical Center

RNA, or ribonucleic acid, is part of a biological sequence familiar to students of the life sciences everywhere: DNA is transcribed into RNA, which is best known to be translated into the proteins that organisms need to survive. Maquat's work has uncovered layer after layer of complexity in this process. She led the discovery of what is called nonsense-mediated mRNA decay, a mechanism by which a cell can prevent the production of unwanted proteins that could lead to disease if left unchecked. But there's much more to RNA's story — and to Maquat's motivations as a scientist.

WHAT MAKES RNA SO IMPORTANT AND INTERESTING TO STUDY?

RNA does so many critical things for our cells. Most of our genetic material — our DNA — produces RNA. And there are many types of RNA. One type contains information from which proteins are made. Another type is the catalytic center of our protein synthesis machinery. Still other types regulate either our DNA or other RNA molecules. And all RNA molecules self-regulate how long and where they reside in cells depending on their particular sequence and structure. RNA is a very versatile molecule. I've been working with RNA for a long time, and, in my own lab, we study defects in RNA metabolism in disease. It is now accepted that how our RNAs are processed is key to how our genetic material — our genes — are expressed and how our cells adapt to changing environments — caused by stress and disease — during development and differentiation.

WHAT PROPELS YOU TO MENTOR YOUNG WOMEN IN SCIENCE?

When compared to men, many fewer women who earn a Ph.D. go on and use that degree in a career. The reason is largely cultural — because of what we have been taught to believe and the lack of infrastructure available to us to succeed. Many people can't understand why women would choose science as a career path. For all of these and other reasons, it is important to mentor women, and I believe one of the best ways to mentor is through example.

WHAT IS YOUR MENTORING PHILOSOPHY?

I tell young scientists that it is important not to discourage yourself from taking the next step by looking too far in the future. Success doesn't happen overnight but in small steps that, at the time, are manageable. I believe it is important for young women (and also young men — actually everyone) to set goals and seriously chip away at working to fulfill them. It is also important to have resilience and perseverance when life happens in unanticipated ways.

—Kaine Korzekwa MS'16

Student Launches Scholarship Before Graduating

Abagail Catania spends much of her time in UW–Madison's Multicultural Student Center.
Photo by Michael P. King

Senior **Abagail Catania** BSx'19 couldn't wait until graduation to make a difference in the lives of students like herself. So she didn't. Instead, she established a scholarship for her peers before even having her diploma in hand.

Catania, who is studying agricultural business management, says she is one of a few students of color in her major. She felt a void in her academic community, so she decided to help fill it by establishing the Abagail Catania Agricultural and Applied Economics/Agricultural Business Management Diversity Scholarship. Her original goal was to set up the scholarship after graduation, but she decided she could start promoting diversity in her field right away.

"I have never experienced a student wanting to give back while they are still on campus," CALS scholarship director **Karen Martin** says. "She has this need that she wants to fulfill in terms of growing the major."

Before coming to UW–Madison, Catania became accustomed to a racially diverse student body at the Chicago High School for the Agricultural Sciences. But her experience at UW, especially within her major, has been quite different, something she noticed as early as the recruitment stage.

"If I go up to a table and I'm talking to someone, and every student that I see in every department that I see is white, I'm not going to feel like I belong," Catania says.

Guided by her enthusiasm for expanding opportunities, Catania says she wants students of color to feel there is a place for them in agricultural studies. She aims to do this by growing recognition of the assets of her major and increasing diverse representation within it.

The recipients of her scholarship will be persons of color of at least sophomore standing who are focused on advancing the agricultural and applied economics and agricultural business management majors through involvement with student organizations. They will be asked to promote the two fields by writing for the CALS student e-newsletter and working at the annual campus Majors Fair. The first recipient of the scholarship, senior **Mfonobong Ufot**, was selected in summer 2018.

Catania says she didn't limit her scholarship to someone from a low-income background because she doesn't believe that true need is restricted to definitions established by the university or the federal government. As a student, she understands the difference any amount of money can make. For now, the scholarship awards $500 annually; but Catania plans on increasing it to $1,000 when she begins working full-time, following the completion of a master's degree in cultural and critical studies at the University of Westminster in London.

Catania's scholarship is one of 600 that CALS awarded to 456 students in 2018–19. The scholarships provided just over $1 million.

According to Martin, all recipients write a thank-you note to their donor to express their gratitude. "These letters tell so many stories about students and the impact of these scholarships," she says. "I would say the greatest impact on students, and what they are most grateful for, is just relieving the stress or pressure of financing 100 percent of their education. Students are then able to focus more on their studies and on extracurricular experiences, such as internships and research, which are related to their majors and careers."

—Andrew Pearce

Would you like to help CALS students succeed by supporting scholarships?

*Visit **supportuw.org/giveto/CALSscholarships**.*

To donate to the Abagail Catania Agricultural and Applied Economics/Agricultural Business Management Diversity Scholarship Fund, contact Brooke Mulvaney at brooke.mulvaney@supportuw.org or 608-308-5330.

nextSteps

Day of the Badger

April 9, 2019, is your day to make a difference in the lives of CALS students! On this campus-wide day of giving, we will be directing all gifts to CALS QuickStart. This new program helps incoming first-year students get a summer start on their UW–Madison coursework, reduce their time to graduation, and join a supportive cohort of scholars.

All gifts of any size will count toward UW's collective goal of obtaining 1,848 gifts throughout the day. You can also show your Badger pride by wearing red, connecting with other alumni, and sharing your efforts on social media (**#dayofthebadger**).

Check out **dayofthebadger.org** or our CALS social media accounts for more details on how to be a part of the Day of the Badger.

From food systems to healthy ecosystems, from bioenergy to community development. These are just some of the fields where CALS faculty, staff, and students are leading the way with new discoveries and innovations. We are grateful to sponsors like Covance for helping to make these advancements possible.

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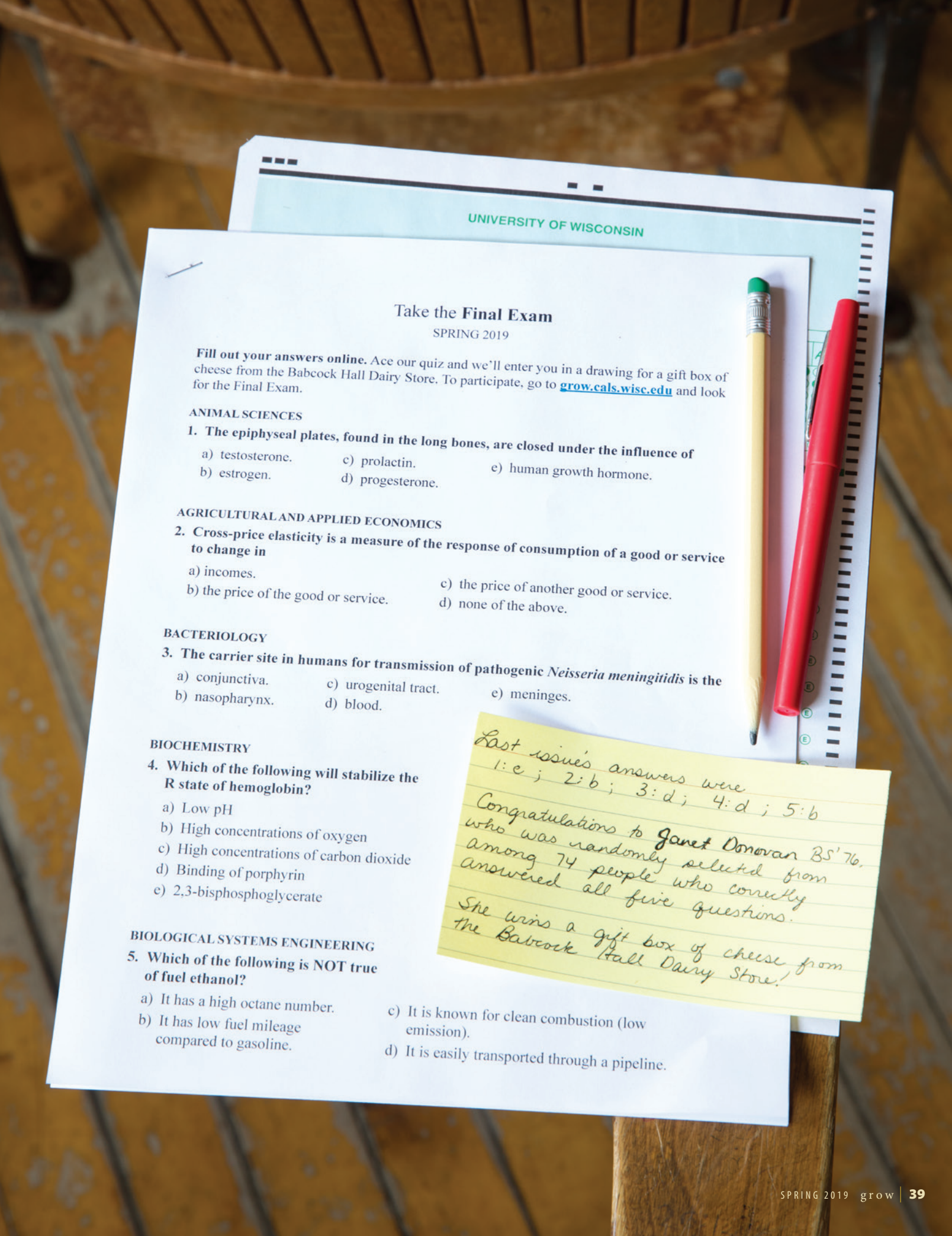
UNIVERSITY OF WISCONSIN
Take the Final Exam
SPRING 2019
Fill out your answers online. Ace our quiz and we'll enter you in a drawing for a gift box of cheese from the Babcock Hall Dairy Store. To participate, go to grow.cals.wisc.edu and look for the Final Exam.
ANIMAL SCIENCES
1. The epiphyseal plates, found in the long bones, are closed under the influence of
a) testosterone.
b) estrogen.
c) prolactin.
d) progesterone.
e) human growth hormone.
AGRICULTURAL AND APPLIED ECONOMICS
2. Cross-price elasticity is a measure of the response of consumption of a good or service to change in
a) incomes.
b) the price of the good or service.
c) the price of another good or service.
d) none of the above.
BACTERIOLOGY
3. The carrier site in humans for transmission of pathogenic Neisseria meningitidis is the
a) conjunctiva.
b) nasopharynx.
c) urogenital tract.
d) blood.
e) meninges.
BIOCHEMISTRY
4. Which of the following will stabilize the R state of hemoglobin?
a) Low pH
b) High concentrations of oxygen
c) High concentrations of carbon dioxide
d) Binding of porphyrin
e) 2,3-bisphosphoglycerate
BIOLOGICAL SYSTEMS ENGINEERING
5. Which of the following is NOT true of fuel ethanol?
a) It has a high octane number.
b) It has low fuel mileage compared to gasoline.
c) It is known for clean combustion (low emission).
d) It is easily transported through a pipeline.
Last issue's answers were
1: c ; 2: b ; 3: d ; 4: d ; 5: b
Congratulations to Janet Donovan BS '76, who was randomly selected from among 74 people who correctly answered all five questions.
She wins a gift box of cheese from the Babcock Hall Dairy Store!

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ANT 'FARM' FUNGICIDE

A queen ant, imaged under an electron microscope in the lab of bacteriology professor Cameron Currie, is covered in tiny pockets that evolved to protect and feed symbiotic bacteria, the lab's research shows. The helpful bacteria produce antibiotics that prevent a parasitic fungus from infecting another fungus the ants cultivate and consume.

Image by Richard Noll and Hongjie Li