grow

Wisconsin's Magazine for the Life Sciences • Spring 2017

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

The Science Farm

A decades-long CALS field project compares various approaches to agriculture

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN-MADISON

THE WONDERS OF LACTATION • FOSTERING YOUNG RESEARCHERS • FUN FACTS ABOUT SLOTHS

Flowering redbud in Allen Centennial Garden

Photo by Wolfgang Hoffmann BS'75 MS'79

Volume 10, Issue 2 • Spring 2017

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Wisconsin's Magazine for the Life Sciences

On the Cover: The sun rises over the Arlington Agricultural Research Station, illuminating a remarkable crop systems study that's been conducted there for more than 25 years. Learn more starting on page 16. *Photo by Sevie Kenyon BS'80 MS'06*

Dean Kate VandenBosch

It's time to reinvest in UW

"The University of Wisconsin–Madison is an engine for economic growth in Wisconsin."

By the time you get this magazine, early spring will be in the air. Time again to think about growing—about tending to and protecting the things we care about. This goes for institutions as well as living things.

The University of Wisconsin–Madison is an engine for economic growth in Wisconsin. Every dollar spent on UW–Madison generates $24 for the Wisconsin economy by attracting other investments to the state, fostering startup companies that create new jobs and supporting nearly 200,000 jobs around Wisconsin.

As an institution, UW–Madison has been on a stringent diet, taking cuts in the last five out of six state budgets. While we have managed those cuts well—we still rank among the top 10 public universities nationwide—years of reductions without relief is impacting our students and threatening quality through loss of faculty and reputation.

Our Board of Regents has made a budget request we hope you'll join us in supporting. The budget proposal seeks a total of $42.5 million in new state funding over the next two years, and assumes that $50 million will be restored to the UW System that reverted back to the state in the current biennium. This results in $92.5 million more in state dollars for the UW System in the next budget compared to now.

A particular highlight for our college is that the proposal includes funding for facility maintenance, which benefits all CALS programs; it was not included in the last state budget.

How can you help? Now is the time for advocacy. Consider contacting the governor and your legislators with a call or note of support. Attend budget listening sessions that members of the Joint Committee on Finance will be holding in communities around Wisconsin. Attend UW Lobby Day in Madison on Wednesday, April 12. You can find information and supporting materials for all these activities at **www.uwalumni.com/support/advocate/.**

Meanwhile, in the midst of budget discussions, I always find it heartening to take a look at what our researchers and students are accomplishing. One of our top funding priorities is preparing students for the future. And one of the most life-changing ways we do this is by providing "beyond classroom" experiences such as research and internship opportunities and study abroad.

You will find excellent examples of those experiences throughout this edition of *Grow*. Our story on page 28 highlights students who travel to Washington, D.C. on behalf of rural health care, launch a peer-reviewed journal to publish undergraduate research, make discoveries to improve food safety and more. Our Field Note on page 11 features a student who worked with orphans in Peru to start a hydroponic growing system. And our "Class Act" story on page 10 highlights a student helping to make important strides in stem cell research.

These are all fine examples of how CALS grows the future. With your help during this budget season, we look forward to doing our best at this for many decades to come.

grow
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A New Weapon Against Bacterial Disease

Meet the "designer phage," a potential assist or alternative to antibiotics

Photo by Robin Davies/UW–Madison MediaLab at Biochemistry

Vatsan Raman in his lab: The biochemist is engineering viruses that can vanquish harmful bacteria.

Bacteria that are resistant to antibiotics are one of the biggest problems facing public health today. About 800,000 children worldwide die before their fifth birthday from diarrheal diseases that evade treatment. The concentration of those diseases is highest in parts of Africa and Asia.

To address the problem, CALS biochemist Srivatsan ("Vatsan") Raman hopes to harness the power of phages—viruses that infect bacteria but leave humans unscathed. With help from a grant from the Bill and Melinda Gates Foundation, Raman's team is designing phages to specifically target bacteria that are causing diseases in infants.

Raman describes antibiotics—how doctors usually fight infections—as hammers that take out many bacteria, both harmful and beneficial. This means they can affect the entire human microbiome, which is the community of microbes on, inside and around the human body.

"We do not yet have the tools to selectively edit the composition of a microbiome," Raman explains. But that is one of the goals of his lab's work with phages. Unlike antibiotics, phages are very specific. A phage only infects one type of bacterial host. It is this specificity that presents Raman and his researchers with opportunities—but also some challenges.

Phages, which resemble lunar landers, locate bacterial hosts by attaching to specific receptors on the cell's surface. Once they have found their host, some phages, called obligate lytic phages, quickly infect the cell and replicate. Once replication is complete, the new phage progeny burst out of the cell, ready to infect and kill the next available host.

Raman's goal is to be able to control many steps in this process. He is investigating a way to engineer a phage that can be programmed to target specific bacteria. By changing just the "legs" of the lunar lander, the designer phage can target and eliminate any bacteria the researchers wish.

However, while destruction of bacteria is the ultimate goal, the process also creates problems. Many bacteria contain toxins that are released if the bacteria die in large numbers. So Raman's team is also trying to control the rate at which phages infect and kill cells inside the body. "We can keep the phage on a leash and determine when and where it can infect," describes Kelly Schwartz, a postdoctoral fellow in Raman's laboratory.

Raman believes "designer phages" have great promise for human health.

"I was drawn to this research because designer phages can provide a potential solution to the antibiotic resistance problem," notes Raman. "These bacteria are resistant to anything you throw at them and are killers in developing countries.

"And the next question, if we are successful, is 'How can we turn these phages into actual medications that can be delivered to these areas?' That challenge awaits us further down the road," Raman says.

—Kaine Korzekwa MS'16

A Big-City Ag High School Blossoms

With leadership that includes CALS, Vincent Agricultural High School is reborn

It's just after lunch at Milwaukee Vincent, and students are settling into their two-hour Advanced Animal Science class. Using their fingers to write on an electronic whiteboard, they quickly assign themselves animal care tasks. There is much to keep them busy.

While some kids clean the rabbit and chinchilla cages, others try to hold the hedgehog without getting pricked or feed the 1,000 crickets purchased for conducting breeding experiments. (They eat fresh vegetables.)

The classroom is abuzz—not with the beehives located a few hundred yards away outside—but with talk about the newest member of the menagerie, a goat named Susan. A half dozen students head out to the pole shed that now accommodates Susan's pen. Water sloshes out of the five-gallon buckets students pull in a wagon toward the goat, the 26 chickens and the two ducks. The refrigerator is already full of eggs, but kids find seven more under one broody bird.

Forty-two buses bring students to the 70-acre North Side campus from all parts of Milwaukee. While the school was built in the late '70s to focus on international studies, agribusiness and natural resources, it has strayed from that specialization over the past few decades.

But new life is being breathed into the school's original mission, in part due to the infusion of funding through a USDA grant obtained by the University of Wisconsin–Madison to develop an agricultural curriculum at the high school. This, plus four new ag teachers and a principal who is dedicated to the school's agricultural roots, are starting to turn things around.

"Agriculture may sound like an unusual choice for a big-city high school, but our expansive campus and, more importantly, significant career opportunities in the field, make for a strong match," says principal Daryl Burns. "All the agricultural pathways help students build the skills needed for in-demand STEM careers and the skills needed for success in almost any career, as well as in college and in life."

Each freshman is required to take a yearlong Introduction to Agricultural Sciences class. Students can then pursue four different pathways: Animal Science, Horticulture Science, Food Science and Environmental Science. A three-room greenhouse is back in use, and an enormous vegetable garden, chicken coop, animal room, apiary and aquaponics facility in which fish and plants are grown together have been added.

Photo by Colleen Kottke/Wisconsin State Farmer

Photo by Carolyn Rumery Betz MS'83

Photo by Colleen Kottke/Wisconsin State Farmer

Tending goats and chickens (opposite) and growing lettuce (above): Vincent Agricultural High School offers hands-on experience for students considering farming or related agricultural and life science fields.

And the school has been renamed Vincent Agricultural High School. Gail Kraus, an agricultural outreach specialist, is helping the Milwaukee Public Schools initiative to see Vincent grow into its new name. Now in her fourth year there, she is funded through the CALS-based Dairy Coordinated Agricultural Project grant.

"This transformation will provide Vincent students the opportunity to engage in hands-on learning that builds the necessary knowledge and skills for one of Wisconsin's largest industries," says Kraus.

Much of the inspiration for bringing the school back to its roots comes from CALS agronomy professor Molly Jahn, who had visited and was impressed by the Chicago High School for Agricultural Science (CHSAS). There, students clamor for enrollment space because of its curriculum and reputation as a safe school that promotes academic excellence.

"We want Vincent to be as desirable to attend as CHSAS," says Jahn. "Through the new ag curriculum, students may be prepared for jobs right out of high school or go on to college to study things they would not otherwise have been exposed to. I envision the day when the ag curriculum at Vincent will be used as a model for other urban high schools in Wisconsin and elsewhere."

Some Vincent students have completed the college application process. Jeremy Shelly, a senior who is a member of the National Honor Society, wants to become a veterinarian. Dawson Yang is aiming for UW–Green Bay.

"I took the Intro to Environmental Sciences class here and loved it," says Yang, who also likes to hunt, fish and camp. "I want to study environmental sciences and maybe one day work for the Department of Natural Resources."

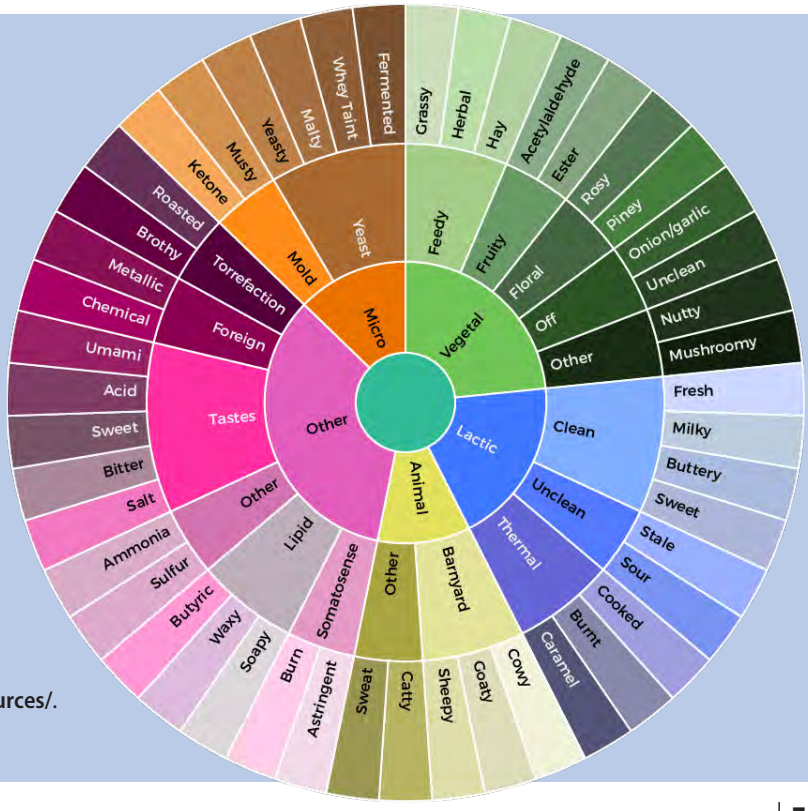
—Carolyn Rumery Betz MS'83

Easy Cheesy

Is your cheese of choice best described as bitter (aged cheddar), soapy (Romano), curdy (young Colby) or chalky (feta)? If those terms don't readily spring to mind, you probably have not received sensory training from the cheese scientists at the CALS-based Center for Dairy Research (CDR).

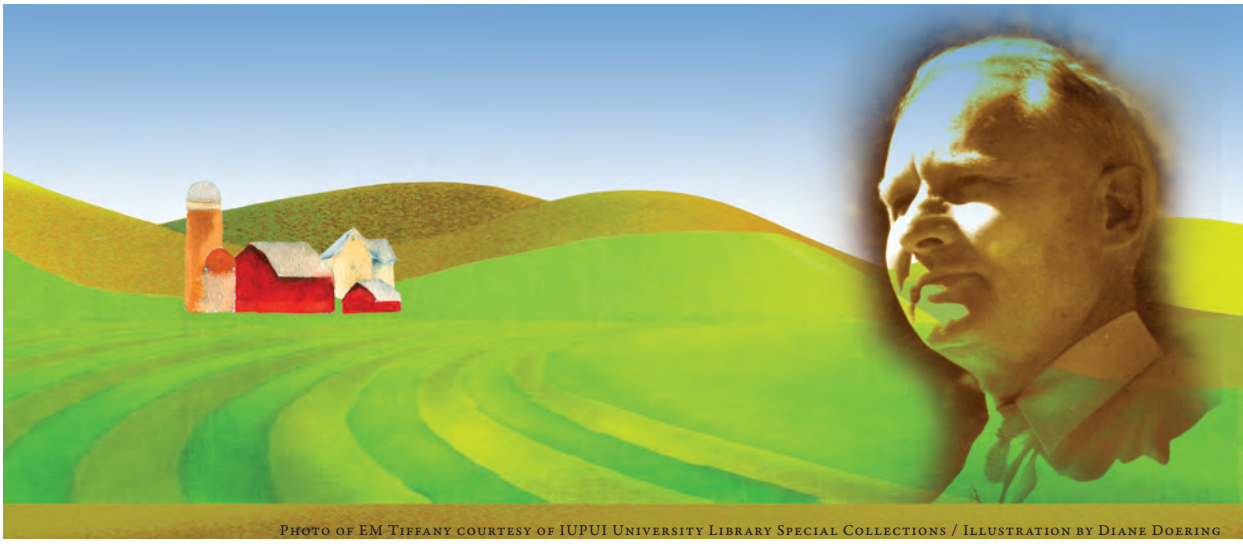
But there's hope for you yet. The CDR has produced new sensory resources that can help you, too, become a cheese whiz. They include materials covering basic flavor and texture, sensory quality control and a colorful cheese flavor wheel that visually organizes cheese attributes and their sources. Downloadable materials include the cheese flavor wheel and a "sensory placemat" that helps you organize cheese tastings by texture and flavor.

You can find these materials online at **cdr.wisc.edu/sensory/resources/**.



Inspiring Young Farmers, Then and Now

Celebrating the 100th anniversary of the Smith-Hughes Act—and remembering the CALS ag educator who soon after its passage wrote an inspiring creed for farmers



Erwin Milton Tiffany, a CALS graduate and ag educator, has inspired millions with his FFA creed.

Photo of EM Tiffany courtesy of IUPUI University Library Special Collections / Illustration by Diane Doering

One hundred years ago, two men introduced a piece of legislation to the U.S. Congress that would forever change the future of agricultural education. Senator Hoke Smith and Representative D.M. Hughes, both from Georgia, brought forth the National Vocational Education Act, now known as the Smith-Hughes Act.

The Smith-Hughes Act encouraged establishing vocational agriculture to train individuals "who have entered upon or who are preparing to enter upon the work of the farm." As such, the legislation created one of the first federal grant-in-aid programs, offering federal aid to states for high school vocational education courses.

Agricultural educators embraced the curriculum and a few short years later, some schools began to form student organizations for male students enrolled in their agriculture classes. In 1928, with interest growing across the country, a group of students gathered in Kansas City and created the Future Farmers of America.

That group, known today as the National FFA Organization, has grown to nearly 650,000 members in all 50 states, Puerto Rico and the Virgin Islands, and encompasses ag-related areas such as communication, food science and genetics. Female students have joined and hold key leadership roles at all levels. No matter the student's gender, religion or ethnicity, all members share a love of agriculture.

And over the decades, FFA members have been inspired by the words of a Wisconsin educator: Erwin Milton Tiffany, a CALS alumnus and professor of agricultural education. He expressed a love of and vision for agriculture in the form of a creed, adopted at the Third National FFA Convention, that nearly every member learns in his or her first year. The words are powerful, meaningful and passionate. They tell a story of pride and purpose. They are so impactful that many alumni, of all ages, can still recite them today:

"I believe in the future of agriculture, with a faith born not of words but of deeds—achievements won by the present and past generations of agriculturists; in the promise of better days through better ways, even as the better things we now enjoy have come to us from the struggles of former years."

Tiffany not only wrote the creed, he lived by it and spread the word. As a CALS professor, he taught and mentored other educators who would continue introducing youth to the many opportunities offered in an organization whose mission is to make a "positive difference in the lives of students by developing their potential for premier leadership, personal growth and career success through agricultural education."

Student members, alumni, agricultural educators and supporters alike all live by an oath penned by a Badger: "I believe that American agriculture can and will hold true to the best traditions of our national life and that I can exert an influence in my home and community which will stand solid for my part in that inspiring task."

—Sara Schoenborn BS'10

To read the complete FFA Creed, visit ffa.org/about/who-we-are/ffa-creed

Five things everyone should know about . . .

Sloths

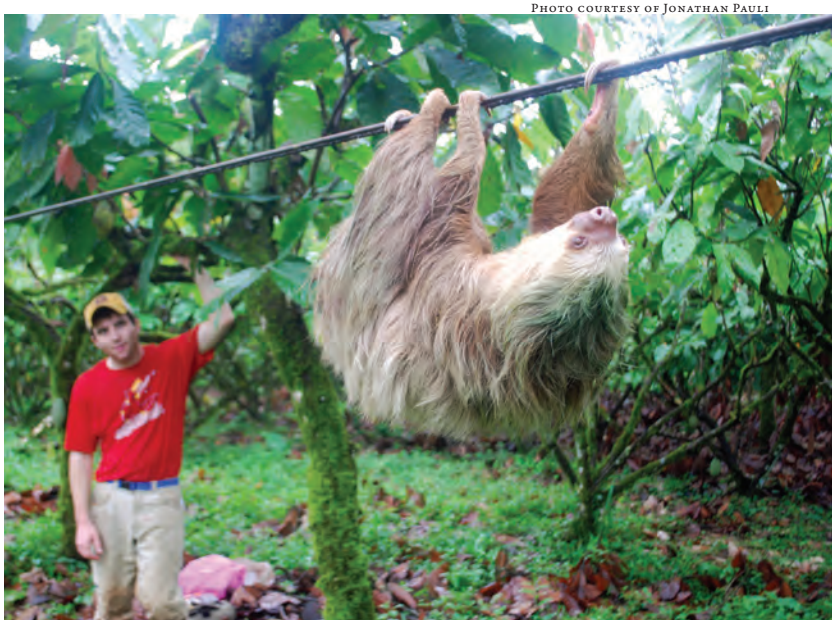
By Jonathan Pauli and Zach Peery

1 | **A sloth is not a sloth.** There are two types of tree sloths that diverged roughly 20 million years ago—two-toed and three-toed sloths, so named for the number of digits on their forelimbs. They differ greatly in what they eat, when they're active, the trees they use, how far they move and even their mating systems. In a nutshell, two-toed sloths are generalists, using a wide variety of habitat types and resources, while the three-toed sloth is much more specialized, eating leaves from just a few species of trees, and even spending the majority of their lives in just a few individual trees.

2 | **They are extremely low-energy.** Both types of sloths have slow metabolisms, but the three-toed sloth has the lowest energetic needs of any mammal ever recorded. Sloths achieve this by not moving very much, and also by letting their body temperatures fluctuate with outdoor temperatures. In terms of calories, a single potato is all a three-toed sloth would need each day to survive (if sloths actually ate potatoes).

3 | **Constipation is a way of life.** Sloths consume plenty of fiber in the form of leaves (three-toed sloths) and a variety of leaves and fruits (two-toed sloths). Yet these foods are digested so slowly that sloths need to pass feces and urine only about once a week. Three-toed sloths climb down to defecate at the base of their host trees—practically the only time they leave the canopy.

Photo courtesy of Jonathan Pauli



Jonathan Pauli watches after releasing a two-toed sloth in Costa Rica.

4 | **The sloth is a miniature ecosystem.** And understanding that ecosystem helps clarify sloths' odd bathroom behavior. Sloths host a dedicated species of algae in their fur as well as scores of flightless "sloth moths" that depend on the sloth's defecation descent for reproduction. The moth lays eggs in the sloth's dung and then returns to the sloth's fur. After the eggs hatch, the caterpillars feed on the dung, become moths, and the moths find—during the only brief moment in their lifetime that they can fly—another sloth to live on. When the moths die, their bodies are decomposed by fungi and bacteria in the sloth's fur. The products of this decay, nitrogen in particular, provide fertilizer for the algae, which the sloths eat—thus adding nutrients to their diet.

5 | **Made for the shade.** As tropical forests in Central and South America are cleared for agriculture and other uses, sloths (like many other species) need to find or adapt to new habitats in order to survive. Our team studied sloth populations at a large shade-grown cacao plantation in Costa Rica. With its diverse overstory of native trees, the plantation provides suitable habitat for sloths—especially two-toed sloths—and seems to point the way to at least one kind of farming that can benefit sloths and other native tropical animals.

Jonathan Pauli and Zach Peery, professors of forestry and wildlife ecology, have studied sloths in Costa Rica since 2009.

classAct

Timothy Guthrie

Making strides with stem cells

Biochemistry senior Timothy Guthrie knows that science and success are about small steps. It's those tiny strides that drive him to excel both in the lab and in the pole-vaulting pit.

Last summer Guthrie, a student athlete, earned a summer Biochemistry Undergraduate Summer Research Scholarship and spent lots of time in the lab of biochemistry professor Judith Kimble. There he worked, and continues to work, on making different mutations in a protein important for stem cell renewal.

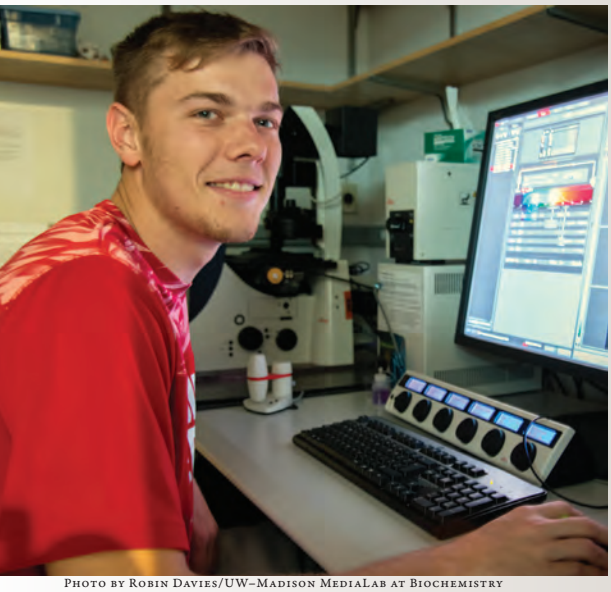


Photo by Robin Davies/UW–Madison MediaLab at Biochemistry

"When I finally get something right in the lab that I've been working on for a month or two, it's a really satisfying feeling," says Guthrie, who plans to apply to medical school this summer.

Guthrie's work allows the lab to better understand the molecular mechanism behind stem cell renewal in a tiny roundworm species called *Caenorhabditis elegans*, used as a model because their stem cells are easier to study than those in humans. Stem cell renewal is essential for the organism to keep producing cells it needs to develop and reproduce. By making different mutations to a protein important to this process, researchers can work to determine the role of the protein.

"The ultimate goal of stem cells is for therapeutic use, but we've got to work to understand the stem cells first—and the only way to do that is piece by piece," says Guthrie. "That's what Professor Kimble's lab is doing."

Getting involved in undergraduate research has helped Guthrie gain critical lab experience and also helped build connections between what he learns about in class and the experiments he performs in the lab.

"Along with knowledge of lab techniques and research, I've gained a better appreciation for the scientific discoveries we've already made," he says. "All of those big successes and drugs we've discovered were made up of small steps like the ones I get to be a part of in the lab."

—Kaine Korzekwa MS'16

NAMED a Fellow of the American Association for the Advancement of Science, biochemistry professor **Ann Palmenberg**, for groundbreaking research in the field of positive-strand RNA molecular virology and for outstanding leadership in the American Society for Virology.

APPOINTED associate dean for research at CALS, **Bill Barker**, who most recently served as director of the Offices of Research Policy and Industrial Partnerships in the UW–Madison Office of the Vice Chancellor for Research and Graduate Education. Barker brings a wealth of experience in research administration, including compliance issues, oversight of animal care and use and working with industry partnerships. As associate dean for research he succeeds **Rick Lindroth**, who is returning full-time to his position as a professor of entomology.

ELECTED as a Fellow of the National Academy of Inventors, biochemist **Ronald Raines**, for his research illuminating both the chemical basis and the biological purpose for protein structure and protein function. This honor is conferred upon academic inventors who have demonstrated a prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development and welfare of society.

HONORED with the 2016 Award for Excellence from the University of Wisconsin Colleges and University of Wisconsin–Extension, CALS biological systems engineering professor and UW–Extension bio systems specialist **John Shutske**. The annual Chancellor's Awards recognize UW Colleges and UW–Extension partners, supporters and employees for their outstanding contributions to the quality of life in Wisconsin.

CELEBRATED with a grand opening in October, the new Connor Forestry Center at the Kemp Natural Resources Station in Woodruff, Wisconsin. Made possible through a generous gift from **Mary Connor Pierce** and her husband, **Dudley Pierce**, the 4,500-square-foot building includes two large classrooms and will serve as a place to train future leaders in forestry and natural resource management.

Number Crunching

7,500 **PERENNIAL/NATURALIZING BULBS** have been planted in Allen Centennial Garden over the past two growing seasons. These selections, which include *Narcissus*, *Muscari*, *Anemone blanda*, *Pushkinia*, *Chionodoxa*, *Galanthus* and *Eranthis*, come back and even get better year after year, rather than needing to be dug and replanted, notes garden director Ben Futa.

PERU

Undergrad helps teach orphans about hydroponic farming

There are capstones, and there are capstones.

For his capstone—a discipline-spanning research project required of all students graduating from CALS—soil science student Jacob Kruse BS'16 spent a summer working with orphans in Lima, Peru, to set up and run a hydroponic growing system.

More than 60 children from the Casa Hogar Juan Pablo II orphanage—a mission of the Diocese of La Crosse, Wisconsin—participated in growing crops that included tomatoes, peppers, bok choy and lettuce. The kids learned all about hydroponics, the art of growing plants in water, sand or gravel instead of soil, adding nutrients as needed.

But the project's overarching benefits ran deeper. Beyond producing and learning about healthy food, "The goals were to teach children about water and natural resource use and reuse, help build connections between families and friends through common interests and projects and help the children develop responsibility," says Kruse.

Kruse spent three months helping build the system and offering hands-on instruction on the basics of hydroponics—one class for older children and another for the younger ones. The kids learned about the environmental benefits of hydroponics, how to build home hydroponics out of household items and how to care for the garden.

A manufacturer of specialty chemicals for construction and industry, Sika Peru S.A., funded the project and built the garden structures with recycled materials. Mantisee, a nonprofit organization, provided the system design and plants. Both organizations, Kruse says, are concerned with natural resource use and social development, and they see the hydroponic system as a way to teach water use and nutrient efficiency—an important point in Lima, the world's second-driest capital city.

Sika has also set up a scholarship and internship program for children at Casa Hogar who complete the hydroponic classes. "Sika's scholarship and internship program will truly be life-changing for our children, and this collaborative project will have a lasting impact on our orphanage and the children who call it home," says Jordan Zoroufy, Casa Hogar's director of development.

Photos courtesy of Jacob Kruse BS'16

Kruse's faculty advisor, soil science professor Phillip Barak, is both impressed and delighted with the project. "We like our capstone experiences to be very hands-on and to have a service component," Barak says. "Jake's self-designed capstone sets a very high bar—food, children and education. Helping build a hydroponic food system from the ground up and turning it over to the children in the orphanage is quite an accomplishment."

—Barbara Sanford

Vegging out: Jacob Kruse and kids growing and tasting hydroponically grown greens.

Top) An overview of the growing system.

THAILAND

Adventures in global health

When it comes to study abroad experiences, an elephant ride in Thailand is pretty hard to beat.

"The entire time we were around the elephants, I was smiling uncontrollably," says Gilad Segal, a microbiology major. "It was amazing to interact with them and get a sense of their personalities. Riding on the back of an elephant through the jungle and into a watering hole is something I never imagined I would do."

And it was a great way to learn about the animals and efforts to protect them. Located in the "Golden Triangle"—the fabled convergence of Thailand, Myanmar and Laos—the Anatara Elephant Sanctuary improves the health and well-being of elephants by renting them from their owners and then caring for the elephant, the owner and his family as they continue to work humanely with tourists. In that part of the world, elephants frequently are victims of exploitation in the tourist industry, where their owners, called "mahouts," earn a living by offering rides and having elephants perform tricks, often while not receiving adequate care.

"This solution allows the mahout to still live comfortably in that the camp provides them with a place to live and a monthly stipend for their elephant," explains fellow microbiology major Lauren Raasch. "The elephants are cared for and are not overworked for tourist purposes."

The students also examined the elephants' microbiota by swabbing various parts of the animals and isolating and identifying microorganisms back in the lab at Mae Fah Luang University in Chiang Rai, Thailand.

The elephant camp was only one of several excursions during the seven-week, five-credit study abroad experience. The combined Microbiology 304/Languages and Culture of Asia 300 program was the brainchild of bacteriology instructor Jon Roll BS'88 PhD'96, who developed the idea with biology advisor Todd Courtenay and teamed with Anthony Irwin, a doctoral student in the Department of Asian Languages and Cultures, to lead the course's cultural components.

Wet and wild: UW students capturing their elephant ride on a GoPro.

The program debuted last summer with 14 students and is poised to reach its cap of 20 students in summer 2017. It satisfies a required field study component for the popular Undergraduate Certificate in Global Health, a CALS-administered program in UW–Madison's Global Health Institute.

Roll got the idea when visiting Mae Fah Luang University to explore research collaborations. "I saw their instructional lab facilities and was very impressed," he says.

The course kicks off with a week of cultural orientation at another institution, the International Sustainable Development Studies Institute in Chiang Mai. There students learn some basic Thai and become acquainted with various aspects of Thai culture, which include wearing uniforms to class (a white top and dark pants or skirts); not pointing at things (which is considered rude); taking shoes off when entering a home; eating dinner food for breakfast (the Western idea of breakfast food doesn't exist); and, above all, keeping voices down. "Tone it down like 10 notches," advises Raasch in a blog she kept on the trip, noting that the Thai communication style tends to be quieter and less confrontational.

(Left) UW students pose in their "uniforms" at the International Sustainable Development Studies Institute in Chiang Mai and (below) work with instructor Jon Roll at Mae Fah Luang University in Chiang Rai.

(Bottom) Students visiting the Academy of Buddhist Economics in Chiang Rai, which includes studies offering Buddhist perspectives on agriculture and health.

Photos courtesy of Jon Roll BS'88 PhD'96

In addition to the elephant camp, field trips included meeting with SOLD, a nonprofit that offers job training to young people at risk for sex trafficking, and learning about nutrition and food safety from a monk who is well known for his scholarship in those areas.

As for the basic science component, although Microbiology 304 is a demanding course, students appreciated the program's hands-on, in-the-field approach to learning.

"The microbiology lab helped me learn a lot not only about microbiology, but also how science applies to everyday life," says biology major Therese Renaud.

Students came home with a much bigger picture of the world.

"I just want to talk forever about everything I had the opportunity to experience," says Raasch. "The cumulative experience of adapting to and gaining an appreciation of a new culture was by far the most memorable part."

—Joan Fischer

Gut Reactions

Garret Suen's study of microorganisms involved in herbivore digestion holds promise for human health and our environment

Interview by Caroline Schneider MS'11

GARRET SUEN, an assistant professor in the Department of Bacteriology and an Alfred Toepfer Faculty Fellow, focuses on microbiomes and how microbes convert biomass into nutrients. "Microbiome" has become a more common word in the public consciousness in recent years. While the definition of microbiome remains somewhat up for debate, Suen defines it as the totality of the microbes that make up a community living within a particular environment—whether that's an ocean, the tip of a pinky finger or—in Suen's case—a cow rumen.

Through his studies of the microbiome of the cow rumen, Suen is working to understand the evolution and ecology of microbial communities and how those communities change in response to the host, the animal's diet and other influences. He wants to use the microbes and their activities to improve the health of the animals, benefit farmers and even produce biofuels. Suen's research has also led him to the microbiomes of other herbivores, including sloths and pandas.

Why are you looking at the microbiome of the cow rumen?
I'm very interested in helping Wisconsin farmers improve milk production in their cows. I'm trying to understand the interaction between the host cow and the microbes it has inside its rumen, and I want to know how we might go about altering that interaction so that we can improve milk production efficiency. There are a lot of farms in Wisconsin with small herds—100 or 200 head. Especially for these farmers, milk production efficiency is really important.

What role do microbes play in milk production?
Well, cows are strict herbivores. They only eat plant biomass, and without microbes they would not be able to digest that biomass. The microbes break down the plant polysaccharides found in the plant cell wall—things like cellulose—and they convert that into simple sugars like glucose, which is then fermented into fatty acids that the animal uses as its source of energy. It is those fatty acids that are also the building blocks of milk fat. So if we can better understand that process and which microbes do it best, we can improve milk production and make the animals more efficient in how they use the biomass they consume.

Why is understanding the relationship between microbes and milk production important?
Beyond the benefits to cows and farmers, making milk production more efficient will help feed the expanding population. It's a better option than increasing the number of farms and land usage. Also, if we can use microbes to change milk composition, we could help cows produce milk with different fats or sugars. Studies have shown that human breast milk is healthier for babies in terms of promoting immune development, and we know that the types of sugars found in human milk are different from those in cow's milk. So can we learn from that? Could we find ways to use microbes to make cow's milk more like human breast milk? Changing milk composition could also affect the quality of downstream products such as yogurts and cheese.

How does your work with cow microbiomes relate to biofuel production?
Let's take corn as an example of a crop we can use to make biofuels. The corn kernel is just one small part of the plant. The rest of the plant, called stover, is usually either silaged or burned. But there's a lot of carbon in the stover that's being wasted. So we want to know if we could take that carbon, break it down into simple sugars and have microbes ferment them into new fuels like ethanol. Cows are highly optimized to do that first part because we domesticated cows. We pushed cows to be as efficient as possible to produce as much milk as possible, and optimized the microbes at the same time.

So we're very interested in taking some of the individual microbes from the cow rumen, bringing them into the lab and seeing what types of products they can produce. One of the microbes we study actually produces ethanol directly from cellulose. We view the rumen as a place where we might be able to identify novel enzymes that could be part of a larger industrial production facility producing next generation biofuels. We're learning from nature, as I like to call it.

Garret Suen using an anaerobic chamber to study ruminal bacteria.

Photo by Matt Wisniewski/UW–Madison WEI

Another animal you study is the panda. Why are you interested in the gut microbiomes of panda bears?
In captivity, giant pandas get very painful episodes, called mucoidal episodes, during which they produce abnormal poop known as mucoids. Normally panda poop looks like chewed bamboo. Their system is inefficient at extracting energy from the food that they're consuming, so bamboo moves very quickly through the gastrointestinal tract. But once or twice a year, they stop eating completely and produce these mucoids, poop that looks like their gut lining—the gooey, mucosal layer of the gastrointestinal tract.

But why would pandas shed their gastrointestinal tract lining? To answer that question, we worked with Ashli Brown Johnson, an associate professor at Mississippi State University, to look at the microbiota in the mucoids and compare them to regular poop of two giant pandas at the Memphis Zoo. We found that they're very different from each other. So we came up with the hypothesis that maybe what's happening is that pandas are eating these rough pieces of bamboo, which are actually causing physical abrasions to the gastrointestinal tract. The pandas then have an inflammatory response to the abrasions that results in the sloughing off of the internal gastrointestinal tract layer, producing mucoids.

Why is helping these pandas important?
The key thing is that these mucoidal episodes usually coincide with the gestation period of a panda. If the pandas are trying to get pregnant but not eating, how hard will it be to get pregnant? How hard will it be to carry a fetus to term—especially when you should be eating more to support the developing fetus? We don't know why these episodes coincide with gestation, but anything to help pandas breed is important. Successful breeding of pandas is difficult and a big problem.

Are you studying other animals with interesting gut microbiomes?
We're working with Hannah Carrey in the School of Veterinary Medicine to study what happens to microbes in ground squirrels during hibernation. When animals prepare to hibernate, they pack on weight, and while hibernating, they drop their internal core body temperature to around the temperature inside your refrigerator. We'd like to know what's happening in that system. Understanding the activity of the microbiomes before and during hibernation can give us insight into host metabolism and diseases such as diabetes and obesity.

We also recently published a paper on sloths, which are on the complete opposite end of the spectrum from pandas. Pandas are eating all the time and are inefficient at getting energy from their food. Sloths eat much less than what you would predict for their body size. Physiologically it makes sense because they have much fewer energetic needs, but the three-toed sloth poops only once a week. That made me wonder what is going on from a digestive perspective! What we've found in sloths is completely different from anything we've seen in terms of microbial composition, so we want to figure out what's so different about them. Animals that eat too much or too little for their body size are very interesting in terms of their gut microbiomes.

The Science Farm

A decades-long CALS field project offers key insights into different approaches to agriculture

By Ron Seely

Photos by Sevie Kenyon BS'80 MS'06

ON A STILL AND WARM SUMMER morning, as scientists drive along the dirt roads that crisscross the Arlington Agricultural Research Station, the fields sweep in a green carpet to the horizon.

This land some 20 miles north of Madison was once part of the vast Empire Prairie, a sea of grassland that stretched south to the Illinois border. So high and thick were those grasslands, history tells us, that they could swallow a rider on horseback.

Named by settlers from New York in the 1830s for their home state, the prairie and its rich soils would prove to be ideal for growing corn and other row crops that are the mainstays of modern-day agriculture. And today, the region is home to hundreds of farms, some of which date back a century or more.

It makes sense, then, that this place with its productive soils and old farms would also be home to a most unusual agricultural endeavor—a 26-year-old research project aimed at bridging the gap between past and future farming practices. It's called the Wisconsin Integrated Cropping Systems Trial, or WICST for short.

On 60 acres of land at the CALS-based Arlington Agricultural Research Station, university researchers from a number of departments within CALS are doing big science with tractors and combines and manure spreaders. Clad in blue jeans and work boots instead of lab coats, these scientists are engaged in ambitious long-term research that is relying upon the study of the ancient soils of the Empire Prairie to point the way toward a sustainable agricultural future.

WICST director Randy Jackson examines some big bluestem in one of the project's native prairie plots. Inclusion of prairie or native systems provides a "control" of sorts for understanding soil biogeochemistry in agricultural systems and how it might differ from what is found in the historic vegetation.

(Opposite) This peaceful scene includes a good mix of the research being done at WICST: pasture for grazing and no-till conventional soybean as well as organic corn.

From this effort, started in 1989 by an idealistic and insightful young agronomy professor named Josh Posner, has come research that shows farmers can both run a sustainable farm and grow enough food to play a significant role in feeding a burgeoning world population. It is important, forward-looking work at a time when many farmers face an uncertain economic future as well as changing climatic conditions that are only going to heighten the risks associated with bringing a crop to harvest or livestock to market.

"It's among the most important farm-scale research being done in the UW system," says Dick Cates PhD'83, associate director of the CALS-based Center for Integrated Agricultural Systems, the administrative home for WICST.

Cates, who also owns and works a managed grazing farm near Spring Green, praises WICST for the quality of its research as well as its unusual long-term approach to studying varied approaches to farming. He uses the research in teaching young farmers in a program he helped found, the Wisconsin School for Beginning Dairy and Livestock Farmers.

The science on sustainable practices particularly resonates with younger farmers, Cates says: "They understand long-term consequences."

Research at WICST has been conducted on fields that are farmed using three cash grain and three forage-based production systems common in the Midwest. They include 1) conventional corn; 2) no-till corn-soybean rotation; 3) organic corn–soybean–wheat rotation; 4) conventional dairy forage; 5) organic dairy forage; and 6) rotationally grazed pastures. In 1999, Posner added plots devoted to the study of switchgrass and diverse prairie, which has allowed for grazing and bioenergy

An aerial view shows a patchwork of various WICST crops (in foreground) at the Arlington Agricultural Research Station, with dairy operations behind them.

studies nested within the bigger experiment.

Toiling in their plots at Arlington, WICST researchers (including a steady stream of graduate students) have compiled an impressive archive of publications showing that sustainable farming practices, such as managed grazing and crop rotation, make sense from both economic and ecological perspectives.

They've studied everything from the effect of alternative crop rotations on farm profitability to soil health and carbon sequestration. They've tallied earthworms and ground beetles. They've analyzed weed populations. They've learned more about manure than you would suspect is possible.

Among their key findings:

- Organic- and pasture-based farming systems have been the most profitable cropping systems at WICST.
- Organic systems produced forage yields that were, on average, 90 percent of conventional grain systems and as high as 99 percent in two-thirds of the study years.
- Over a 20-year period, all five grain and forage cropping systems—except for grazed pasture—lost significant soil carbon to the atmosphere.

It's a record that would have impressed and pleased the late Posner, who died in 2012. It is rare for any conversation about WICST not to lead eventually to Posner and his pioneering idea of a decades-long research project dedicated to the science of agricultural sustainability.

Posner, who held a Ph.D. in agronomy and a minor in agricultural economics from Cornell University, had conducted significant sustainability research from South America to West Africa before coming to the University of Wisconsin–Madison. His interest in agriculture grew from his work as a Peace Corps volunteer in Cote d'Ivoire, Africa, in a school gardening program.

Posner was hired by UW in 1985 to coordinate a UW research program in Banjul, The Gambia. He arrived in Madison in 1987 and began teaching and research in the Department of Agronomy. In 1993, he and his family moved to Bolivia, where he led a UW research program on sustainable agriculture for several years. From 1998 to 2001, he directed CONDESAN, an international agency based in Lima, Peru, to support sustainable mountain agriculture across the six Andean countries in South America.

Posner's widow, Jill Posner, who still lives in Madison, recalled that her husband first started thinking about the project that would become WICST

What bugs are those? Randy Jackson and researcher Gregg Sanford (left) send a photo of an unknown insect to CALS entomologist Claudio Gratton for identification.

Photo courtesy of Jill Posner

The founder of it all: Agronomist Josh Posner out at WICST wearing Badger red, talking with fellow researchers (from left) Gregg Sanford, Esteban Miramontes, John Hall (with clipboard) and Janet Hedtcke. Posner kept a close eye on WICST no matter where in the world his other projects took him. This photo was taken ca. 2009.

while working in West Africa with farmers who grew crops without the benefit of modern-day fertilizers and pesticides.

"There was a real link between what he was doing in Africa and the low-input systems he wanted to study here," Jill Posner says. "It was one of those things that he always kept on the back burner. No matter where we were, he was always thinking about that connection."

In 1988, Posner, a focused and persuasive scientist, would pull together the team that created WICST. His plan was to establish a research project that would compare sustainable land management practices, organic agriculture and traditional approaches. And the project would be ambitious in both size and duration. Research would be conducted on a scale that approximated the conditions on an actual farm. The science would stretch over not just a year or two but decades. Wherever Posner's work took him around the world, he continued to oversee WICST, reviewing the plans and results and returning to Madison to connect with his research team at least twice a year.

That Posner would propose such an audacious project didn't surprise those who knew him. He thought big, recalls Dwight Mueller, director of all UW Agricultural Research Stations—and Posner saw something else that many others didn't fully understand at the time: The eventual emergence of organic and other conservation-minded farming as powerful and necessary trends.

"If you knew Josh, you might have had an inkling," says Mueller regarding Posner's long-range vision of field research that would meet the challenges posed by increasingly stressed resources. This was a time, Mueller notes, when crop farming largely meant planting year after year of corn with little rest for the soil. And organic agriculture was thought of by many as a hobby or possibly a passing fad.

"'Organic' was a dirty word when we started," says Mueller.

Randy Jackson, a CALS agronomy professor and grassland ecologist who now leads WICST research and has been involved in the project since 2003, says the crop experiments played an important role in bringing science to bear on organic and other sustainable practices. For such practices to become more widely accepted, it was important to demonstrate that these grain and forage production systems could yield as much as conventionally managed systems in most years, he says.

The two main questions posed by Posner are still in play at WICST, says Gregg Sanford, a research scientist in the Department of Agronomy who has worked on WICST since joining Posner's lab as a graduate student in 2004: Whether organic agriculture would be able to provide enough calories to feed the world and whether agroecology, or sustainable farming, would be embraced as economically feasible.

Key to the project was its scale, its focus on the long horizon and its collaborative nature, Sanford explains while driving along the project's dirt lanes.

Conducting the research on the scale of an actual farm-sized operation in large plots has proven a boon, Sanford says, because it lends more validity to the science. Farmers tend to take the results more seriously when they know that the research had to be conducted in the face of the same challenges they face—everything from bad weather to insect infestations to equipment breakdowns.

This element of the research project becomes immediately clear on a visit to Arlington. There is little doubt that this is a working farm with its crops, grazing livestock, and sheds and barns, where begrimed farmhands coax tractors and cultivators and other equipment into working order.

The true-to-life nature of the research is strikingly apparent in annual reports that are similar to the notes kept by scientists in their laboratory notebooks but refer instead to the vagaries of storm and drought and insect scourges.

In a report from 2011, for example, Posner and researcher Janet Hedtcke reported "unseasonable cold well into May resulting in delayed start to the cropping season." We find out that "in late September, strong winds knocked down a lot of corn, especially the organic corn, which was tall, had big ears way up high, and thin stalks," they

wrote, referring to a particular cropping system treatment.

Or there is the 2012 report, in which Hedtcke laments that crops and livestock endured extreme heat and drought. "Springtime," she noted, "arrived early with temperatures soaring to above 80 for eight days in March." Then one can hear the relief of a real farmer when she writes that, after a dry June, "an unforgettable and precious soaking rain came on July 18."

Such challenges make conducting the research much like farming itself.

"We've had years where we're trying to get manure applied and it starts snowing on us," Sanford says. "We've had years where we've had complete crop failures because of the rain."

But there is a twist, of course. The harvest at Arlington isn't just of crops but also of science. A lost crop year represents a loss of crops, but it also provides a critical piece of data in a real-world experiment that shows how risky growing particular crops can be.

Even so, the length of the project has allowed researchers to weather the ups and downs. And the many years of data collection have paid off in ways that traditional science, conducted over periods of months or maybe a year or two, has trouble duplicating.

"It has shown the value of a long-term project," says Mueller. "That can't be overestimated. There are things you learn only by having a trial for a long time."

Jackson says such long-term research is crucial when studies involve dynamics that unfold over a period of years or longer. He cites climate impacts as an example.

"It allows us to separate the vagaries of interannual climate variability and actual directional changes," Jackson says.

Also, natural systems can be slow to respond to change, Jackson notes. Sometimes when a particular treatment is applied to a parcel of farmland, the result does not become apparent for two or three years or more.

Both the size and the length of the project have made the data more realistic, says Sanford, allowing scientists to account better for variables thrown their way by weather and other obstacles.

The value of research flowing

from WICST has also been enriched by another characteristic built in by Posner with his original plan—the project's collaborative nature. From the beginning, WICST has involved not just CALS scientists but also farmers, business owners, nonprofits and, notably, UW–Extension educators.

And, as envisioned by Posner, the research on WICST's 60 acres at Arlington has been conducted across multiple disciplines in CALS, from soil scientists to grassland ecologists to entomologists.

Entomology professor David Hogg, along with his students, has spent long hours on WICST land sifting through the soils looking for links between soil health and insect health.

"It's a great laboratory for doing this kind of work," says Hogg. "And it's unusual."

Much of the work at the Arlington plots has focused on the soil, the single resource that farmers value more than any other for providing them a living and the world its food.

The science of soil has been approached from many angles by WICST researchers, with a number of surprising and useful results. Among the more eye-opening work has been the study of soil for its ability to store atmospheric carbon to help mitigate the changing climate. This characteristic has thrust agriculture and soil health and management into the climate discussion in a big way, according to Sanford.

The issue has driven much of Sanford's work with WICST. In fact, the subject of his dissertation was land management and its effect on carbon in soil, where he comments that "the

Researcher Gregg Sanford uses portable fencing to move Holstein steers in rotationally grazed, cool-season pastures. This system has proven to be one of the most profitable at WICST—and it is the only non-native system to build soil carbon.

(Bottom) A sign put up in 1995 remains at WICST today. "We haven't had the heart to take it down because of nostalgia and the fact that it is still forward-thinking 20 years on," says Sanford.

importance of soil in the global carbon budget cannot be overstated."

Soil, Sanford reports, contains almost twice the combined amount of carbon found in the atmosphere and vegetation globally. Through his work with WICST, Sanford has been able to demonstrate which practices—using cover crops, for example, or increased crop rotation—help keep more carbon in place and out of the atmosphere.

As was Posner's intent, the science coming out of the WICST fields has found its way into some of the most prestigious scholarly journals—and, importantly, into the hands of farmers. In the best tradition of the Wisconsin Idea, the shared knowledge from the trials has given farmers new tools for improving their yields, boosting the health of their soil, and protecting resources such as water.

Few are more aware of the power of WICST science than UW–Extension county agents, who spend their days in farm fields and barn lots working with farmers and sharing with them the latest knowledge gleaned from university research plots.

"Arlington research has helped greatly with crop production questions," says Ted Bay, an agricultural extension agent in Grant County.

Bay cites a heightened interest among farmers in soil and water conservation and sustainable practices as reasons for sharing with them the results of the WICST research. More farmers, he says, are asking how they can use cover crops to protect and improve their soil in row crop production. Research from WICST has confirmed the value of using cover crops to protect soil, and provided information on integrating cover crops in grain production systems.

"Farmers are interested in the long-term impact of production practices that WICST research can help explain," Bay says.

Gene Schriefer, the agricultural extension agent in Iowa County, in hilly southwest Wisconsin, says he's had Sanford out to talk with farmers about the WICST research. He says farmers, who are nothing if not practical, tend to be more trusting of information that comes from a research program that has stretched over decades.

"Most research is over two or three years," says Schriefer. "This research has been going on for nearly 30 years. That's amazing."

Schriefer sees particular interest among farmers in research that tells them how to return their soils to health and how to keep it in place in the face of storms that are both stronger and more frequent.

"We're out here in the hills," Schriefer says, "and any time it rains, there is not a clear stream out here. That's our soil."

Such growing consciousness in the farming community of the connections between agriculture and a healthy environment is heartening to researchers such as Sanford. For Sanford and other WICST researchers, it's a testament to the power of Josh Posner's vision all those years ago in distant Africa.

Sanford, tooling around the WICST fields on a summer morning in his beat-up pickup truck, stops to show off a fading sign that dates back nearly to the start of the research. He notes the prominent mention of sustainability, agroecology and organic agriculture. Staffers, Sanford says, are reluctant to take the sign down despite its age because it is a poignant reminder of Posner's hope and optimism.

"When Josh built this experiment, he was setting us up to understand how crop yields and soils respond not only to farm management, but also to a changing climate," says Jackson. "These are critical questions whose answers should guide agricultural production in the 21st century."

Dairy scientist Laura Hernandez marvels at the miracle of milk—and she's exploring how to improve the processes that create it, for the benefit of both cows and humans

By Erik Ness

Lactation Sensation

Photos by Sevie Kenyon BS'80 MS'06

When the city girl decides to study lactation, she must first learn to milk a cow. Laura Hernandez, an assistant professor of dairy science at CALS, remembers that lesson.

Her tutor that day was Jessica Cederquist, then a fellow grad student and now CALS herd manager. "People who have never milked are used to what you see in the movies," Cederquist explains. You know the choreography: grab a teat, pull down, milk squirts into the bucket. But that technique simply squeezes milk back into the udder. And just about everybody makes the mistake. "It is a rite of passage to stand back and laugh," she admits.

"She thought it was very funny," Hernandez recalls. "I think that was the beginning of a very good friendship."

The milking got a little crazier once Hernandez ramped up her inquiries into how lactation works. Her first experiments required milking two halves of the same cow, comparing milk production. Because she was pairing the front right with the back left and vice versa, she had to replumb two half milkers, using a surplus of hoses and buckets. She'd also recently had knee surgery.

"You're already kind of crowded in there and now you've got her fancy contraption and all of her buckets and a big old knee brace," says Cederquist. And it's a waterbed stall, so every time anybody moves, the floor moves, and the buckets yaw precariously. "She's darn near laying on the floor under the cow, trying to figure out how she's going to get this thing to stay on."

Hernandez is still making things unusual for Cederquist. Lactation is a delicate enough phenomenon that the typical dairy farmer puts animals who are in the late stages of pregnancy on vacation. This is exactly when Hernandez needs to poke and prod, monitor and manipulate.

The hassle seems worth the reward: Her exploration of the role of serotonin in lactation has the potential to significantly improve animal health and boost milk production. There may also be profound lessons about the role of serotonin in human health. While seratonin was once considered the miracle molecule of mental health, Hernandez is helping unravel its role in many more parts of the body.

"There is still an infinite box of things it probably does that we can't understand," says Hernandez. Which is all the more interesting because it's such a simple molecule, just a modified amino acid. It's as if a Lego block were able to control a nuclear reactor. "I really am just completely fascinated by how a modified amino acid can regulate what feels like the universe at times," Hernandez says.

On the road between Hernandez's hometown of El Paso, Texas, and the New Mexico State University campus in Las Cruces, a line of dairy farms stretches across the landscape. Despite her urban upbringing, the cows fascinated her. "As an athlete I was like: how does she do that?" recalls Hernandez, then a scholarship swimmer. "I just thought they were really cool animals, what they could do from a biological standpoint."

Drawn to biology, Hernandez chose animal science over straight biology because she was more interested in working with mammals than with crabs and nematodes. But her real immersion didn't begin until her senior year, when she transferred to New Mexico State from Iowa State University. In Ames her swimming schedule had kept her out of the lab, but that changed when she got to Las Cruces.

"I loved working in the lab," says Hernandez. "That was where I found my home." When she couldn't decide between professional schools, she continued at New Mexico State to earn a master's degree in animal science and toxicology.

In 2005 she started her doctorate at the University of Arizona with Bob Collier, a physiologist in the dairy sciences. He was interested in how genes interacted with the environment, and lactation was the ideal process to study: genetically programmed, but initiated and controlled by changes in the environment of the cow.

The year before Hernandez arrived, the small world of lactation science had been upended by the unexpected discovery that serotonin, long considered simply a neurotransmitter, also had a role in regulating lactation. Collier reached out to Nelson Horseman at the University of Cincinnati, where the discovery had been made. Horseman studied breast development, but his central interest was breast cancer. Collier offered his dairy expertise and suggested that they collaborate on expanding this discovery from the mouse to the cow.

Hernandez undertook the research for her dissertation, supervising many of the active experiments. Deeper she went, her work encompassing an intense collaboration into the complex molecular underpinnings of milk production.

Rapt attention: As part of a course in lactation physiology, students observe Laura Hernandez performing a biopsy of a bovine mammary gland in the Dairy Cattle Center's surgical procedure room.

After finishing her Ph.D. she began a postdoc in Horseman's lab. One day in Cincinnati, Gerard Karsenty, a geneticist visiting from Columbia University, presented his research involving gut serotonin, calcium and bone mass. Afterward Hernandez turned to Horseman and wondered aloud: If gut serotonin had a role in bone mass, could this also help explain its role in lactation?

Nursing typically requires more calcium than diet alone can provide, and the difference comes from the mother's bone. A nursing mouse will lose up to 20 percent of bone mass in 21 days. Human mothers can lose 6 to 10 percent of their bone mass over six months. Studies in West Africa and Korea suggest that the longer a woman breast-feeds, the lower her bone density.

It's not surprising that serotonin might have more than one role in the body. Along with dopamine it's the oldest known hormone, and nature loves to reuse its creations. In fact, serotonin first evolved in plants. Plants have no nervous system, so it couldn't have been a neurotransmitter. How a simple molecule engages in complex processes is by acting as a molecular key in many different cellular locks. Scientists have now identified 20 different serotonin receptors. The mammary gland alone has five.

So how to uncover serotonin's role in withdrawing calcium from bone? Scouring some old genetic assays, Hernandez found a likely ally: parathyroid hormone-related protein (or PTHrP). Her initial tests were so strong that she suspected her equipment was off.

But further experiments confirmed that serotonin was causing an increase in PTHrP in the mammary gland during lactation. This, in turn, was a key signal liberating calcium from bone for the mammary glands.

HERNANDEZ'S RESEARCH portfolio made her an obvious match when a position opened at CALS. As a newly hired professor in 2011, her first question was obvious: Could she leverage our knowledge of PTHrP in the dairy cow?

Lactation is hard, and one of the biggest problems faced by dairy farmers is the "transition cow," a cow in the three weeks before and after calving. Between the physiologic stress of birth and the metabolic stress of commencing lactation, for the first 20 to 30 days of lactation the cow is expending more energy than she can take in.

Calcium complicates things, as it takes a couple of days to activate the mechanism that borrows from the bone. Sometimes that leads to a calcium deficit—or hypocalcemia, also known

Proper care, feed and housing help cows produce more milk. Here, some contented cows at the Dairy Cattle Center on campus, which houses nearly 90 cows used in teaching and research.

as milk fever. Because calcium is critical for biological functions, assisting with everything from muscle contraction to immune function, a shortage can lead to a variety of potential health problems including ketosis, displaced abomasum and retained placenta. Gut issues can arise because the intestines aren't contracting. Reduced immune function leaves the cows more susceptible to mastitis.

"That's a precarious time frame for them," Hernandez says. "If you have a calcium problem, other issues compound."

It's a daily concern for dairy farms. Even on a very good farm, 3 to 5 percent of the animals are going to wind up with milk fever. Scaled up to a 10,000-herd farm, that means one or two affected cows every day.

"Not every farmer is going to automatically relate to Hernandez's deep molecular work," says herd manager Jessica Cederquist. But put it in terms of milk fever and the transition cow, and "every dairy farmer on the planet knows what that means," she says.

With startup money tight and a big idea, Hernandez developed an ambitious research agenda. She found a collaborator in Jimena Laporta, a graduate student fresh from Uruguay. Laporta read the plan and committed the very next day. "We were throwing all of the chips on the table and hoping for a win," says Hernandez.

The idea was simple: Could you boost PTHrP levels with nutritional supplements? They fed rats two amino acids—5-hydroxytryptophan (abbreviated as 5-HTP) and straight tryptophan. Both are chemical precursors in the synthesis of serotonin.

They began with rats, and feeding was the easy part. The hard part? They also had to milk them. Forty-five rats. Every day.

How do you milk a rat? After knocking it out with sleeping gas, you inject a minute quantity of the hormone oxytocin. A small suction device evacuates the teats; each animal has 10. It was a time-consuming, two-person job. Hernandez and Laporta sacrificed weekends and postponed professional travel. Eventually they got the process down to about an hour and a half.

The 5-HTP worked. Then they confirmed that it works in the cow via IV infusion. Now the lab is working on developing a cow feed that accomplishes the same thing.

Meanwhile, on the molecular level they were focusing on how the serotonin was actually affecting the mammary gland and how it translated into the chemical signals that drive bone resorption. In addition to the PTHrP they identified a gene—already nicknamed sonic hedgehog—as another link in the chain in collaboration with researchers Chad Vezina and Robert Lipinski at the UW–Madison School of Veterinary Medicine.

"It's a very big picture of a very small molecule," says Laporta, now teaching at the University of Florida. "Nobody knew that serotonin could do all these things. I think we opened a black box."

Repeat: lactation is

hard. Hernandez became a mother in the first year of her professorship, and nursing was as fulfilling as it was excruciating. She was lactating, she was teaching about lactation, she was

Collecting milk from an anesthetized mouse. (Right) Hernandez showing the mouse's milk yield with Hannah Fricke, a dairy science student and an undergraduate researcher in her lab.

manipulating lactation. Under the grueling stress of a new research program she took only nine days of maternity leave.

One day in mid-February her husband came home to find Hernandez crying on the bathroom floor. She couldn't find time to pump, and her hair was falling out. He suggested it might be time to stop nursing. She'd made it seven months under a colossal workload. They still had some milk stored to facilitate transition to the bottle. "But I want to make it a year," Hernandez objected. "I'm a lactation biologist! I must!"

"It was so hard," she reiterates. "It's made me even more of an advocate for helping women after they give birth. That's where my biggest interest is: The mother's ability to deal with lactation and to do so healthily for herself while also taking care of her baby."

And so Hernandez has forged into human health. As the role of serotonin beyond brain chemistry continues to unfold, obvious questions arise. Selective serotonin reuptake inhibitors, or SSRIs, now dominate the antidepressant market and include such household names as Prozac, Paxil and Zoloft. Among their side effects is a decrease in bone density. Nursing also decreases bone density. With 12 percent of pregnant women taking SSRIs, does the combination of SSRIs and nursing set these women up for severe bone health issues later in life?

Most studies that looked at nursing and SSRIs focused on the infant. "Almost nothing out there looks at the long-term implications for the mother," reports Sam Weaver, a third-year Ph.D. student in Hernandez's lab. Weaver began as an undergraduate in the lab, assisting Laporta with her milking. Now Weaver supervises her own mouse dairy as she tries to untangle the precise impact of SSRIs on lactation and the health of the mother.

Weaver harvests more than milk. The mice are dissected with precise determination as blood, mammary glands, kidneys, intestines and bone tissue are examined for health and their reactivity to serotonin. Their femur bones are sent off to a collaborator in Boston for specialized imaging.

"Can we somehow help women breast-feed but also stay on their medication, and help them avoid some of these long-term bone issues?" asks Hernandez. She hopes to begin working with human populations soon.

Now that the lab has characterized the complexity of serotonin in lactation, the team is trying to get a handle on its role as one of the body's master regulators. Only about 2 percent of serotonin actually resides in the brain; the vast majority circulates throughout the rest of the body. "We're finding it popping up in all sorts of places," says Weaver.

A newer project is working on yet another serotonin-lactation connection. Obese women tend to have higher serotonin levels—and they also have a harder time initiating nursing. This suggests yet another crucial role for serotonin as a regulator of energy balance in the body. By unlocking its role, they hope to find a way to make nursing easier for these mothers.

THE LEGACY OF WISCONSIN is so milk-soaked it can be hard to remember that lactation still holds mystery and marvel. It's a unique biological process that has given up its secrets slowly, and there is still much to learn. Experiments with a wide variety of mammals have shown that as long as you keep removing milk, the gland will keep making it.

Though she's unlocked some of the secrets behind this apparent superpower, Hernandez remains entranced: "It just fascinates me that it can continue to do that."

It's not a stretch to call lactation one of the more significant developments in the evolution of life on this planet. The expanded ability to feed our young has allowed mammals to adapt to a wide array of variations in our environment. "Keep the baby alive," says Hernandez. "I think it ties back to that, making us better mothers." Our human accomplishments are stamped with an indelible mammalian signature.

Hernandez's peculiar dairy, with its few hundred mice and few dozen patient cows, keeps producing under the labors of a handful of motivated students. "Sometimes it's overwhelming, and it feels like we're not getting anywhere and we're not going to get anywhere," Hernandez says. "Because with every answer comes another question."

Even as she continues her fine-scale investigations, Hernandez hopes that young farmers can go back to their dairies and incorporate some wonder into our conversations about animal agriculture.

As Hernandez and dairy farmers know, when it comes to a cow's well-being, milk is a marker.

"If cows are not being fed properly, or taken care of properly or housed properly, they are not going to make a lot of milk," Hernandez says. "That's a basic mammalian response. That should tell you something about the welfare of the animals."

STUDENTS *on the* Cutting Edge

Photo courtesy of Allen Centennial Garden

Research positions and internships allow undergraduates to make substantive contributions to knowledge—and give them a competitive advantage when they enter the job market

By Nicole Miller MS'06

Working in water: As an intern at Allen Centennial Garden, Saige Henkel created an online database to help people identify plants. But she also got her feet wet (and much more) taking care of the water lilies.

CALS undergrads are an impressive bunch, eager to get the most out of their time at college. As they tackle the challenging coursework required for their degrees, many also pursue research and internship experiences to augment their education—and help prepare them for their future careers.

Such experiences can be found on campus and off, with companies, nonprofits and governmental agencies. Some are summer gigs, others run year-round. The work students perform in these roles is as diverse as the disciplines that CALS covers: basic biological research, crop management trials, marketing campaigns, food product development, nutrition-focused meal planning and so much more.

"These experiences are important because they allow students to test-drive potential career paths, to get a true sense of what they would be doing in a job setting, which in many cases can't be grasped from what they learn in the classroom or read in a book," says entomologist Rick Lindroth, until recently associate dean for research at CALS.

They also help CALS students stand out in competitive environments.

"When organizations review candidates for jobs and graduate school applications, it's the transferrable skills gained from research labs, internships and similar experiences that set students apart from each other," says Megan O'Rourke of CALS Career Services.

CALS prides itself on being a great college for such experiences, a place where researchers are eager to have undergrads come work in their labs. CALS Career Services maintains strong connections with state and national organizations looking for talent and helps place students in internships—and jobs.

At the most recent UW–Madison Fall Career Fair, there were more than 110 organizations recruiting students from CALS disciplines, notes O'Rourke.

For researchers and organizations that hire CALS student researchers and interns, there are a number of benefits from investing in young scientists and professionals.

According to Lindroth, who has had a number of undergrads in his lab over the years, they help move projects forward, including some that might not otherwise get done. "And they bring a level of energy, enthusiasm and wonder that is refreshing," he notes.

To illustrate the benefits of these experiences for students, mentors and organizations alike, here are some recent research and internship experiences of six CALS students.

Name that plant!

Thanks largely to the efforts of **Saige Henkel**, visitors to Allen Centennial Garden who ask themselves "I wonder what plant this is?" have a new way to find out.

Allen Centennial Garden is a gem on the CALS campus, a resource for students, area horticulturalists and home gardeners alike. The 2.5-acre garden features 21 mini-gardens, from English to rock to native Wisconsin, showcasing more than 1,000 kinds of plants. It's no wonder that most visitors need some help in identifying them.

Henkel, a junior majoring in landscape architecture, led the effort to assemble the garden's new Online Plant Database, an interactive public platform where students and community members can search through the garden's entire plant collection and find photos and key information about the plants.

"People can use specific filters to find exactly which plant they are looking for. It's a great tool for when you're in the garden on the weekend and staff aren't around to identify plants for you," says Henkel, who created more than 800 of the database's 1,100 entries so far.

Henkel started interning at Allen Garden in spring 2015. Her career plan involves joining a landscape architecture firm—preferably one that specializes in planting design and sustainable urban development—where she will likely spend most of her time in front of a computer doing design work. Prior to this, however, she knew she wanted some kind of practical horticultural work experience.

"I wanted to get my hands dirty and learn more about the physical maintenance of the plants I'd be putting in my designs," says Henkel.

Allen Garden provides a number of opportunities for undergrads to have meaningful experiences. When garden director Ben Futa joined the garden in 2015, he created six year-round "student director" positions.

Photo courtesy of Eddie Ruiz

Spotlight on youthful discovery: Eddie Ruiz and Stephanie Seymour started a peer-reviewed journal to showcase undergraduate research.

"Student directors take an active role in everything we do, from planning public programs to envisioning new horticultural displays. This real-world experience is preparing them for success in a competitive job market," says Futa.

Henkel was in the first cohort of students that Futa hired. She's had a number of different responsibilities at the garden since she joined, including leading a major garden design project. She developed a design for a new bulb lawn in the English garden—and then got to plant it and see it bloom last spring.

"I've definitely beefed up my horticultural knowledge, which was my original goal in applying for this internship," notes Henkel. "Working here, I've also started to realize that landscape architects work on a variety of projects, from hardscape plazas to public garden spaces, and it's really shown me the variety of possibilities that I'll have with my degree."

Two ways to publish

Eddie Ruiz is a go-getter.

As a freshman, he took a student employee position in the lab of Dr. Timothy Kamp, a cardiology professor and stem cell researcher. He started out maintaining equipment and cell lines. Over time, as Ruiz learned more about the lab's research program, he started contributing to various research projects, including helping to develop a protocol to produce a special type of heart cell, called a cardiac fibroblast, from human pluripotent stem cells.

Ruiz, a genetics major, quickly realized he's not the only undergrad doing meaningful research on campus, with significant results to share. In fall 2015, he teamed up with Stephanie Seymour, a molecular biology and economics double major, to give more undergrads an opportunity to go through the publication process and share their findings. The duo founded the *Journal of Undergraduate Science and Technology* (*JUST*). Student research journals are already popular at other research universities such as Caltech, Harvard and the University of Texas at Austin.

"People tend to think undergrads are working on small parts of a research project. While this is definitely true, there are also many students like Stephanie and me who are working independently on research projects that justify greater attention," says Ruiz.

Ruiz and Seymour, serving as co-editors-in-chief, assembled a team of 30 undergrad volunteers to put together the journal. Ruiz calls it "an incredibly challenging yet rewarding leadership experience." The group tackled—from scratch—the tasks of careful review of scientific research, editing, design, marketing and publication production. The first issue came out in May 2016, while the second appeared in December.

"*JUST* has given our editors—who are all UW–Madison undergrads—a unique opportunity to learn how to dissect and critique an array of scientific manuscripts. *JUST* has trained undergraduates how to peer-review scientific papers and enabled students who are passionate about art and science to explore this intersection through the design of our publication and website," says Ruiz. *JUST*'s website, justjournal.org, which houses its online publications, has been visited more than 10,000 times in the one year since its creation.

And *JUST* is not the only publication experience Ruiz will have during his time at CALS. After attending a scientific talk with fellow members of Tim Kamp's lab, Ruiz came up with a research idea and took it to Kamp.

"His research project was largely motivated by a seminar in which he learned about 2-photon microscopy and its application to biological research," says Kamp. "He knew the questions we were investigating in the lab and thought this technique could help us understand the matrix proteins that cardiac fibroblasts generate."

Kamp's group is in the process of preparing a scientific paper describing this project. Ruiz, now a senior, will be a co-author.

"It has been wonderful to see him master this somewhat challenging methodology and optimize data analysis," says Kamp. "Eddie is an undergraduate driven to explore and understand, which will serve him very well in a future career in science."

Driving Arlington ARS toward precision ag

Ryan Seffinga spent a good part of last summer in an ATV driving around the Arlington Agricultural Research Station. While it may sound like an aimless task, it was actually a key step in Arlington's ongoing effort to adopt precision agriculture technologies.

Over the course of three weeks, Seffinga BS'16 navigated his souped-up

(Below) Not just cruising: Ryan Seffinga outfitted an ATV to serve as a data-gathering field surveillance machine.

ATV, which was outfitted with a GPS receiver, a cellular modem and a monitor, around each of the station's 350 research plots, gathering field boundary data to input into the station's new farm management system—which Seffinga also helped install.

"I helped set up a server at the station's headquarters and installed a farm management program on it. This program helps automate data collection and makes it easy for those with access to view key data for any given field," explains Seffinga, who was a summer intern at Arlington last year.

Now, monitors attached to the station's equipment—including the forage chopper and combine—and located around the grounds can send crop yield, soil moisture and other key data directly into the station's new program, where staff can assess the information, field by field.

This big project likely wouldn't have come together last summer without Seffinga's help, notes his supervisor, Kim Meyers, assistant superintendent at Arlington.

"As with any farm, there is never enough time in the day to get everything done," says Meyers. "But Ryan got it all set up and got the pieces working together. He was a huge asset."

Meyers expects big payoffs down the line. "With enough years of data, we can make educated decisions about where our research and management practices should go in the future," she says.

Seffinga graduated this past December with a bachelor's degree in biological systems engineering. On campus, he was involved in the American Society of Agricultural and Biological Engineers (ASABE) student organization, ASABE's collegiate quarter-scale tractor design competition, and the Engineers in Business student organization.

He already has a position with John Deere as a product design engineer for hydraulic excavators, and he hopes to start his own engineering and sales business someday.

Seffinga says his time at Arlington shaped his goals and helped him realize the importance of precision agriculture.

"I now know that the agricultural industry is investing more money into the precision side of things," he says. "By remaining involved in this part of the industry, I can expect tremendous opportunities to present themselves, especially in new product development."

Photo by Sevie Kenyon BS'80 MS'06

Minding the meat: Makala Bach focused on eliminating a pathogen from slow thermal processing procedures.

Photo courtesy of Makala Bach

Improving food safety

As a freshman, **Makala Bach** had already figured out that she wanted to be a food science major. Tough decision over, right? Not so much.

"I soon found out that the world of food science is a broad one, and that I would have to narrow down my interests even further—and the Food Research Institute's summer internship program seemed like the perfect way to do that," says Bach.

The Food Research Institute (FRI), housed in CALS, is a premier center for the study of microbial foodborne pathogens. Outreach is part of the institute's mission—helping communities, government agencies and companies identify and resolve food safety issues. Another component of FRI's mission is education.

"We developed the summer undergraduate research program to provide students, who may or may not have been thinking of careers in the food industry, exposure to important issues in food safety," says FRI director Chuck Czuprynski, who helped establish the program in 2012.

Participating students work on research projects, discuss food safety topics with campus faculty and take field trips to food processing plants to learn about their challenges.

For her program, Bach worked

Photo courtesy of Abagail Catania

The big picture: In two internships with John Deere, Abagail Catania focused on the very different areas of logistics and marketing. The common thread? Both involved working globally.

on a research project sponsored by the Wisconsin Association of Meat Processors with the purpose of helping Wisconsin meat processors improve the safety of their processes and products. With guidance from a number of FRI faculty and staff mentors, including Jeff Sindelar, Andy Milkowksi and Kathy Glass, Bach studied the growth of the foodborne pathogen *Staphylococcus aureus* on the surface of ham that utilized slow-cooking (aka thermal processing) procedures to assess the risk of toxin production by the bacteria. The results of this study will provide practical solutions for ensuring that slow thermal processing procedures used in many Wisconsin meat products (examples: bone-in hams and summer sausage) won't result in food safety concerns.

Bach received a lot of guidance at the start. Her mentors helped her set up the experimental design. One of them taught her how to pipette. Another, how to make ham. Before long, however, she was working primarily on her own.

"We work very hard to make sure it's a good first research experience for our students," says Sindelar, a CALS professor of animal sciences and UW–Extension meat specialist.

And for Bach, it certainly was.

"During the first week or so, there were days and days of monotonous prep work. Everyone in the lab told me to just wait until I had data—that that's when the exciting part would begin. And they were right," says Bach. "There's nothing more exciting than being able to draw conclusions that might actually have an impact, all based on work you've done."

Bach ended up staying on at FRI working in the applied research lab to help finish the project. The team is planning to publish the results in a peer-reviewed food safety journal.

"Bach's work will have a practical impact. It affects many meat manufacturers around the state and the nation," notes Sindelar.

And there's another positive outcome: Bach is now considering going to graduate school to study food microbiology.

Getting a global perspective

When **Abagail Catania**, as a freshman, attended a Career Fair run by MANRRS (Minorities in Agriculture, Natural Resources and Related Sciences, a national professional development society), she figured it was too early for her to land an internship. But a John Deere rep encouraged her to apply, and even gave her an hour to polish her resume before conducting an on-the-spot interview.

"That employee took a leap of faith and allowed me to fix up my resume, and ultimately I was hired during the second-round interview stage," says Catania.

That summer, Catania moved to Moline, Illinois to work as a sales and marketing intern for John Deere's construction and forestry division in order fulfillment and logistics. One of her projects involved assessing the shipment and storage of large machinery being sent to five U.S. ports from Japan. In certain ports, older units were sitting in storage too long, taking up valuable space.

The work involved digging into five years' worth of pertinent sales data, and, for Catania, it was exciting because it had a clear end goal: to help John Deere improve operations.

"As a student going through classes, we are assigned work with data sets, but we don't see how it's applied or how to pull it from an actual database. I was able to do this in my everyday work environment, and I was able to learn a great deal about different ways to analyze data," says Catania, who is majoring in agricultural business management with a certificate in criminal justice.

The following summer Catania returned to John Deere for a second internship, this time as a global marketing intern with the company's worldwide customer experience team. This position was perhaps a bit closer to

PHOTO COURTESY OF AHEC

From UW to D.C.: Jordan Gaal (third from left) met with Wisconsin's federal representatives on behalf of a statewide rural health program.

Catania's heart, as she has a taste for international travel and dreamed of someday working abroad.

The work put her in contact with employees in John Deere's various foreign offices as she led an effort to revamp the company's customer experience survey process.

"I had to effectively communicate with key stakeholders from all over the world to ensure they were all aligned on how the survey process should take place," says Catania.

It was another great experience, one that provided Catania with valuable networking opportunities and solidified her good feelings about the company.

"The intent of our internship programs is to provide meaningful assignments providing value to Deere while giving students valuable real-world experience," says Gary Hohmann, a manager of outbound logistics and order fulfillment to Brazil. He supervised Catania's first internship.

"It is great to know that I have people at John Deere who are looking out for me and want to support my career," says Catania, who wants to work for an agricultural company in sales and marketing or marketing communications after she graduates in spring 2019.

But first, she's spending a year abroad. Catania spent the past fall semester studying in London, and now she's interning and volunteering in Nkokenjeru, Uganda, at a children's aid organization. There she assists in social work along with supporting the village's agricultural practices. It's a dream come true for Catania, who hopes to continue helping improve people's lives around the world.

Better health for all

When **Jordan Gaal** graduates from CALS, he'll be able to add an interesting line to his resume: "Legislative advocacy on Capitol Hill."

Gaal, a senior double-majoring in life sciences communication and political science, traveled to Washington, D.C., last summer as an intern for the Wisconsin Area Health Education Centers (AHEC). He was part of a state delegation advocating on behalf of the National AHEC Organization, which seeks to enhance access to quality health care around the nation, particularly for rural and underserved populations.

"We visited the offices of Senators Johnson and Baldwin as well as Representatives Grothman, Ribble, Moore, Kind, Pocan and Speaker Ryan to talk about our program, how it benefits Wisconsin and why it should continue to be funded," says Gaal, whose position as Wisconsin AHEC's statewide communications assistant continued into the school year.

For Gaal, it's been the perfect internship to help him make a significant academic transition. When he first came to UW–Madison, he wanted to be a biological sciences researcher, but then he quickly figured out that his true passion lies in communications, advocacy and policy work.

"My general duties are primarily communications and marketing," says Gaal. "I've had the opportunity to create documents for legislators and lawmakers to emphasize the importance of public health issues, such as the need for more health care workers in rural areas. And before heading to D.C., AHEC helped prepare me to make legislative visits."

The internship, which will last through the end of the academic year, also has Gaal working on news releases, social media, a quarterly newsletter, an annual report, website maintenance and more. The position comes with attentive mentoring and coaching as well as ample independence to pursue assigned projects.

Gaal's supervisor, Keri Robbins, assistant director of Wisconsin AHEC, takes pride in offering meaningful internship experiences to undergrads. The trip to D.C., she notes, was particularly valuable.

"It will serve Jordan well in future opportunities to engage in advocacy or policy work," says Robbins. "And AHEC benefited from having the student voice represented in our meetings."

After graduation, Gaal wants to pursue two advanced degrees—a master's in public affairs and a master's in public health—and get experience at a federal government agency. He's looking for a career very much in line with AHEC's goals, one that will put him in a position to help improve access to healthcare in rural communities.

"It's a cause I believe in," says Gaal.

in the field


Brian Aukema


Ashley Bennett


Christine Buhl


David Coyle


Elisabeth Gardiner

Brian Aukema MS'99 MS'99 PhD'03 • Growing up on a corn, soybean and swine farm, Brian Aukema was drawn to bugs, trees and the outdoors at an early age. At CALS, he took advantage of the wide variety of majors, emerging with two master's degrees (in entomology and biometry) and a PhD in entomology. After completing his doctorate, Aukema joined the University of Minnesota, where he runs a lab in forest entomology and enjoys teaching as an associate professor. Though he's currently running with the Gophers, Aukema is still loyal to his Badger heritage. "Defending our choice of a 'W' in front of our house on football Saturdays" accounts for a large portion of his fall weekends, he says.

Ashley Bennett PhD'09 • With a PhD in entomology followed by numerous postdoctoral research positions, Bennett's passion for entomology remains strong. Her early research at CALS focused on conserving beneficial insects in urban landscapes, an area of study and practice she continues today as an urban IPM and small farms extension specialist at New Mexico State University. Her favorite part of her job is educating homeowners on how they can create a comfortable coexistence between people and bugs in order to benefit local landscapes, prevent harmful pests and protect valuable insect populations. Her job includes a lot of outdoor activities, but Bennett's love for nature continues even outside of her career. In her free time she enjoys hiking, biking, insect photography and tending to her family's 30-acre tall grass prairie.

Christine Buhl PhD'13 • Christine Buhl discovered her passion for entomology as an undergraduate at Oregon State University. "There was a moment when I looked at a small, seemingly innocuous wasp under a microscope for the first time and saw a complex world of body armor, colors and textures, and just felt the need to explore more," says Buhl. She came to Madison to earn her PhD in entomology and begin her diverse career path. Over the years she has worked for universities in Oregon, Texas and Wisconsin, with the U.S. Department of Agriculture, the U.S. Geological Survey, county public health departments, and various environmental consulting groups. Currently Buhl is back in Oregon working as the state forest entomologist at the Oregon Department of Forestry. Her main focus is providing technical assistance regarding insects and diseases found in urban and forest trees and conducting aerial and ground surveys of damage.

David Coyle PhD'11 • David Coyle directs the forest health and invasive species program for Southern Regional Extension Forestry, an agency that works to identify, prescribe and implement a mix of education and technical services to increase the efficiency of forestry programs throughout the southeastern United States. He also is a member of the forestry outreach staff in the D.B. Warnell School of Forestry and Natural Resources at the University of Georgia. From his home base in Athens, Coyle oversees the training of federal, state and local forest health professionals. Through this work, he ensures that forestry experts are informed and knowledgeable about the region's plants, insects and diseases

Elisabeth Gardiner PhD'00 • Elisabeth Gardiner began her training in entomology as a PhD student in CALS. "It was my hope that I could learn some really cool techniques in a lab focused on human biology and bring those techniques back to entomology," she says. While at CALS she met her future husband, Anthony Orth PhD'00, and gave birth to their first child before completing her doctorate. During her postdoctoral fellowship with the Scripps Research Institute in San Diego, Calif., and her first industry job, Gardiner learned that her training in entomology could be directly applied to human biology, which unlocked a world of opportunity. Today Gardiner works as the chief science officer at Meditope Biosciences in San Diego, where she focuses on developing antibody therapeutics to target and eliminate cancer.

Michael Hillstrom BS'03 PhD'09 • With a BS, a PhD, multiple research positions and postdoctoral work behind him, Michael Hillstrom has certainly put in his time at CALS. As a boy Hillstrom

Alumni making a difference through Entomology


Michael Hillstrom


Patrick "PJ" Liesch


Rachel Mallinger


Anthony Orth


Ezra Schwartzberg

had always been fascinated with bugs, which made his decision to pursue a degree in entomology relatively easy. During his time at CALS he spent much of his free time volunteering for the Insect Ambassadors outreach program, which brings bug "show-and-tell" presentations to schools and other venues, and eventually he was elected program director. Through the Insect Ambassadors, Hillstrom discovered a passion for education and outreach. The experience also solidified his love for insects and the outdoors. Upon graduation, Hillstrom took a position as a forest health specialist with the Wisconsin Department of Natural Resources. There he works in the diverse forests of Wisconsin to control insects and diseases across Wisconsin and serves as a public leader for insect management.

Patrick "PJ" Liesch MS'10 • Patrick "PJ" Liesch—better known as Wisconsin's "bug guy"—received his master's degree in entomology from CALS in 2010 and worked as a research associate on campus. After Phil Pellitteri, the legendary king of insect diagnostics, retired in 2014, Liesch took on the position. As director of the UW–Madison Insect Diagnostic Lab, Liesch completes a variety of duties including communicating insect information to the public and acting as a bug identification guru to curious residents and businesses from all over Wisconsin. Liesch estimates that he tackles more than 2,000 cases per year. Liesch also serves as an instructor with the Wisconsin Master Gardener Program and the Wisconsin Pesticide Applicator Training program as well as with Farm and Industry Short Course. As part of his public outreach work, Liesch is a regular guest on Wisconsin Public Radio's Larry Meiller Show.

Rachel Mallinger MS'09 PhD'15 • Rachel Mallinger discovered her interest in insects as a biology major. An undergraduate research project involved pest control, which introduced her to entomology, a field that combined many of her passions. In 2009 Mallinger came to Madison, where she completed an MS in agroecology and entomology and a PhD in entomology. Mallinger is now doing postdoctoral work with the USDA as a research scientist in the sunflower entomology lab in Fargo, North Dakota. There she works with sunflower breeders in order to make the flowers more attractive to pollinators. When she's not observing bees, Mallinger takes care of her six-month-old son, works in her vegetable garden and tries to squeeze in some of her earlier pastimes, including dancing, hiking and cross-country skiing.

Anthony Orth BS'93 PhD'00 • As an undergraduate, Orth was inspired by entomology professor Walter Goodman and proceeded to write an honor's thesis about the work being done in his lab. "I learned resourcefulness, resiliency and independence of mind because it was largely just Walt and me and a few other students," says Orth. He remained on campus and completed a doctorate in entomology before discovering his interest in genomics. He also met his future wife, Elisabeth Gardiner PhD'00, and ventured with her to San Diego, Calif., where they both landed jobs focused on human biology. Orth works for Novartis, a multinational pharmaceutical company, where he sifts through the human genome seeking new therapeutic targets for human disease. Though his work today does not directly pertain to entomology, Orth says that the whole-organism CALS training he received was invaluable and that the methods he utilizes today directly relate to what he learned.

Ezra Schwartzberg PhD'11 • Ezra Schwartzberg is the founder and director of Adirondack Research, an ecological and environmental consulting firm based in Saranac Lake, New York. Established in 2012, the firm focuses on social science, climate change and invasive species. The company's tag lines—"We use science to inform decisions" and "We communicate science to influence policy"—describe its mission to use science for decision-making and for policy. Schwartzberg originally began his career in academia, with degrees from multiple universities around the country. It wasn't until his postdoctoral research work at CALS that he gained the confidence to break off and start his own business, he says.

by Gilliane Davison

Catch up with …

Jacquelynn Arbuckle BS'91 Genetics

Dr. Jacquelynn Arbuckle's exposure to the medical field began when her younger brother Adrian was born with cystic fibrosis. Arbuckle, only six at the time, recalls a childhood consumed with Adrian's care. "We spent many days and weeks at the children's hospital. I watched the doctors and nurses carefully try to find ways to keep Adrian alive," Arbuckle says. Each year he was expected to have only a limited time to live.

Photo courtesy of University Communications

That experience led Arbuckle to dedicate her life to medicine. After graduating from the UW–Madison School of Medicine and Public Health (SMPH) and completing her surgical residency in Massachusetts, Arbuckle returned to Madison, where she is an associate professor and surgeon at UW.

Arbuckle's path to success was not easy. A native of Spooner, Wis., and an Ojibwe, Arbuckle grew up on the St. Croix reservation. She experienced firsthand how difficult the transition from a reservation community to a college campus can be. Now, as director of the SMPH-based Native American Center for Health Professions, she encourages young people to enroll at UW–Madison. She hopes that, once trained, they can help strengthen communities that often lack medical infrastructure and other resources—the same resources that ultimately saved her brother's life.

• What are some difficulties you experience when recruiting young Native Americans?

Coming from a close, familiar environment to a large campus can leave a student feeling isolated. Our Native culture is part of everyday life, and it can be challenging to feel free to practice our Native teachings without fear of humiliation. The Native American Center for Health Professions attempts to provide a safe cultural home for students and a place for community by providing mentoring, support and guidance as well as opportunities to explore our Native cultures around the state.

• Why is it important for more Native American students to enter the medical field?

We need more Native healers in our state and across our nation. We need to be able to provide improved health care in our home communities, and we need to provide good mentors and role models for our young people. Our reservations have limited funds and limited access to health care. We need providers at all levels of health, including public health researchers, nurses, doctors, physician assistants, physical therapists, social workers and pharmacists. At NACHP, we reach out to interested students around the state and encourage them to consider coming to UW for their education. We are able to provide rotations at tribal clinics for those who are interested in this experience. During the rotations, students are exposed to true patient-centered, coordinated care as well as a wealth of cultural experiences.

• How do you maintain your connection to the St. Croix reservation?

Mainly through my family. I go home routinely and spend time there. I have made connections with our tribal health director as well as our education director, and we are working on ways to improve resources and motivate young people together.

—Gilliane Davison

Daughters of Demeter Celebrate 100

Photos by Jan Martin

The Daughters of Demeter planting bulbs at Allen Centennial Garden and honoring recipients of their scholarships.

In Greek mythology, Demeter is the goddess of the harvest and agriculture, presiding over the fertility of the earth. And in that spirit, members of a century-old nonprofit called Daughters of Demeter perform community service and award scholarships and grants to CALS students to ensure that agriculture and the college remain strong.

Daughters of Demeter was formed in 1917 by a group of women whose spouses were on CALS faculty. Since then, the organization has expanded membership to welcome all faculty, staff and friends of the college and recently invited its first male member. The group now has some 120 members and hopes to increase membership during its centennial year.

A Daughters of Demeter loan fund was established in 1944 with a $25 gift; soon after, the group established a scholarship fund. Student scholarship support has grown over the years, and, in the last decade, the organization has awarded more than $300,000 in scholarships and grants to CALS students and student organizations.

"The Daughters of Demeter are consistently one of the most generous annual donors to CALS scholarship funds, and a subgroup has sewn thousands of hats and scarves annually donated to University of Wisconsin cancer patients," notes Daughters of Demeter president Liz Henry BS'83, an emeritus CALS academic staff member.

But there's no pressure for members to participate in all activities, notes Henry: "Members can join and be as involved as they choose and are not held to any more or less involvement than they are comfortable with."

Janice Martin has been a member since 1983, became president in 1988 and has since chaired numerous committees, including the Annual Corn Roast Committee. She currently chairs a bulb-planting committee that plants more than 1,500 bulbs at Allen Centennial Garden each fall.

"I find the friendship and camaraderie in this organization, from working on committees to sewing cancer scarves once a month, to be a very important part of my life while serving UW–Madison," says Martin, whose husband, A. Jeff Martin, is an emeritus professor of forest and wildlife ecology. "These members are a dedicated group, very generous in giving to our scholarships and grants, very dependable and willing to help when needed to provide the students in CALS with funds to continue their education. We also have a good time!"

Centennial events this spring include the Annual Meeting and Spring Luncheon on Wednesday, April 12 at Blackhawk Country Club (featuring CALS emeritus biochemistry professor David Nelson speaking on CALS history) and a Centennial Gala on Thursday, May 18 at Allen Centennial Garden. You can find more information about upcoming events on the group's Facebook page, http://go.wisc.edu/fb_daughters_of_demeter.

To donate to Daughters of Demeter, visit http://supportuw.org/giveto/demeter

nextSteps

SCIENCE OPEN HOUSE—Come join the fun at **Science Expeditions, March 31–April 2**, offering hands-on learning free of charge at various venues across campus. CALS faculty offer "Exploration Stations" at the Wisconsin Institutes for Discovery along with activities at other locations. More info at **science.wisc.edu/events-science-expeditions**.

BIKE FOR A CAUSE with Ride to Farm, a ca. 50-mile bike ride in southern Wisconsin to benefit the Wisconsin School for Beginning Dairy and Livestock Farmers. The ride takes place on **Saturday, June 3.** Even if you don't bike, you can pledge a rider. More information at **ridetofarm.dojiggy.com**.

College of
Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN–MADISON
Growing the future

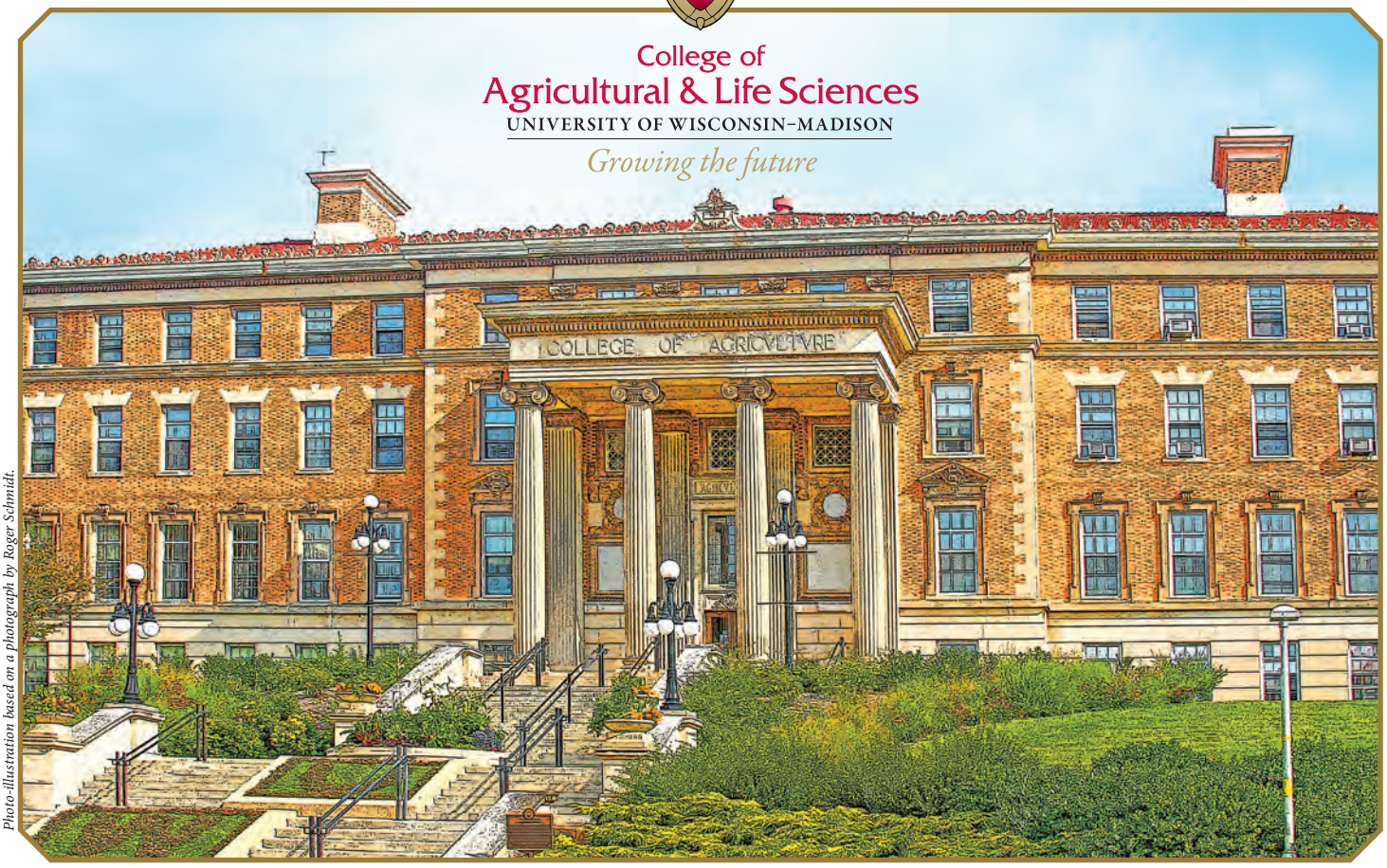


Photo-illustration based on a photograph by Roger Schmidt.

Thank you for helping us grow our future

PLATINUM

COVANCE

BRONZE

DOW Dow AgroScience

kikkoman

Over the past year our college made great strides in discovery and innovation in our core areas: food systems, health, bionergy, the environment and communities. These advancements would not have been possible without the generous support of our sponsors. We thank them for helping CALS grow the future.

THANK YOU AND ON, WISCONSIN!

Take the FINAL EXAM!

Fill out your answers online. Ace our quiz and we'll enter you in a drawing for a gift box of Babcock Hall cheese. Go to: www.cals.wisc.edu/grow/ for more details.

Agronomy

1) The form of nitrogen that can be used by plants is:

a) Atmospheric
b) Organic
c) Inorganic
d) Synthetic
e) Urea

Animal Sciences

2) What nutrient is associated with stargazing in chicks and Beri Beri in humans? ***(Also, this nutrient has a connection with rice.)***

a) Niacin
b) Folic acid
c) Iron
d) Thiamine
e) Tryptophan

Biochemistry

3) If you could go back in time 2.5 billion years, you would:

a) Find there was no oxygen in the atmosphere, thus to breathe you would need to carry a tank of "modern air."
b) Find a planet teeming with single-celled organisms, but no plants or animals.
c) Get a sunburn much more rapidly because there is no ozone layer.
d) All of the above

Biological Systems Engineering

4) Evapotranspiration rates vary with:

a) Geographic location
b) Time of the year
c) Type of crop
d) All of the above
e) Only answers A and C

Dairy Science

5) Which of the following groups show the most gregarious behavior?

a) Cattle and chickens
b) Chickens and ducks
c) Ducks and sheep
d) Sheep and cattle
e) Cattle and ducks

Last issue: Answers were 1:A; 2:B; 3:B; 4:B; 5:E. Congratulations to Abby Hernandez, a senior biology major, who was randomly selected from 48 people who correctly answered all questions. She wins a Babcock Hall cheese box.

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SPRING STROLL along Henry Mall, heading down toward the College of Engineering.

Photo by Sevie Kenyon BS'80 MS'06