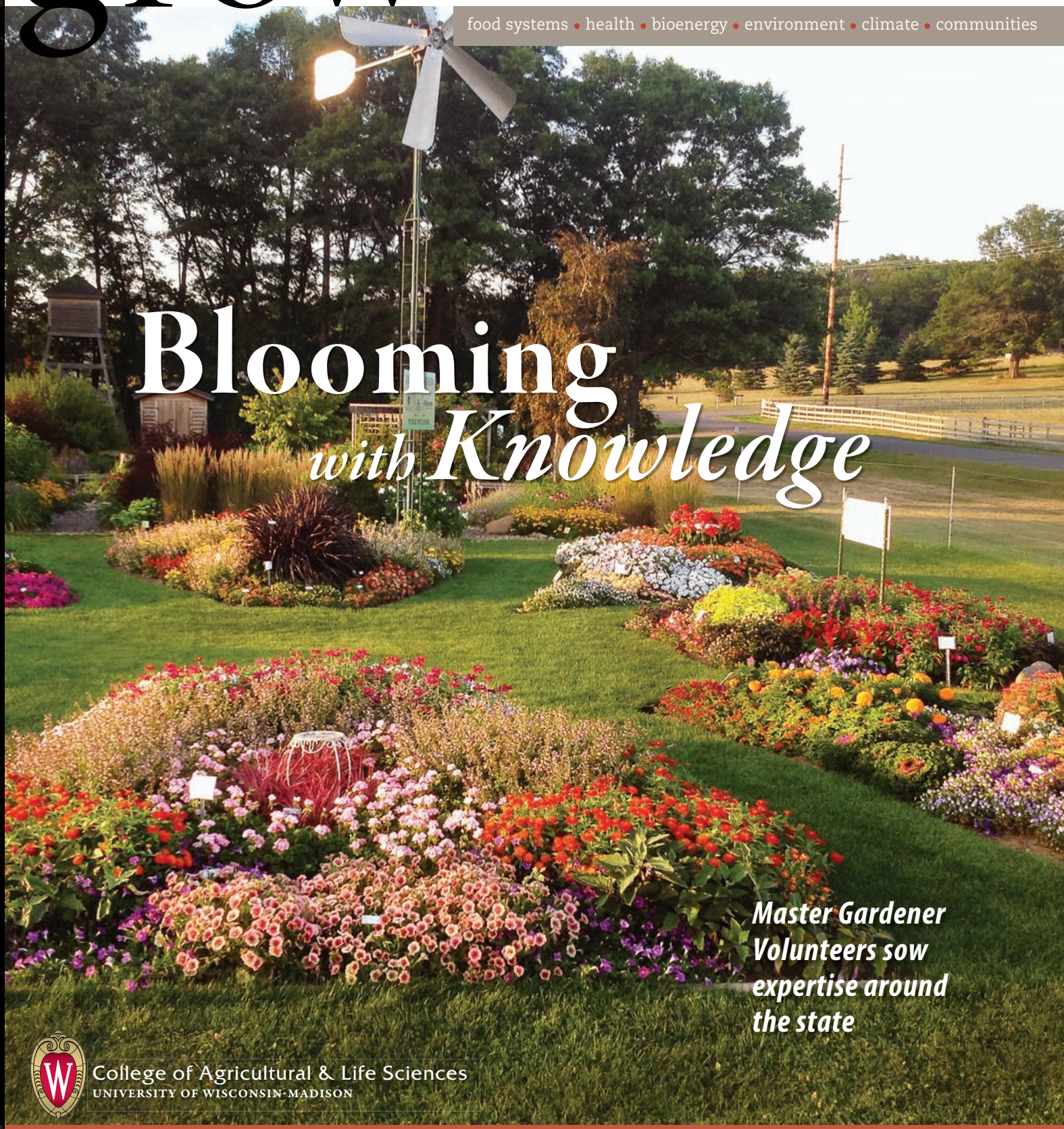
grow

Wisconsin's Magazine for the Life Sciences • Summer 2014

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



Blooming *with Knowledge*

Master Gardener Volunteers sow expertise around the state

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN-MADISON

RNA: MORE THAN A MESSENGER • BOOSTING DAIRY SUSTAINABILITY • GREEN BURIALS CATCH ON

BASKING IN STARDOM: A family of resident foxes charmed the entire campus community this past spring, with wildlife ecology professor David Drake and students using radio collars to track their movements. Learn more at **http://go.wisc.edu/cdjiq5** — and enjoy some videos at **http://vanhisefoxes.tumblr.com/.**

Volume 7, Issue 3 • Summer 2014

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Wisconsin's Magazine for the Life Sciences

Photo by Sevie Kenyon BS'80 MS'06

On the cover: The Teaching and Display Garden at the CALS-based Spooner Agricultural Research Station was created with the help of UW-Extension and Master Gardener Volunteers—and it won second place in last year's National All-America Selections Landscape Design Contest. Read more about Master Gardener Volunteers starting on page 16.

Photo by Kevin Schoessow, UW-Extension Agricultural Development Agent/Burnett, Washburn and Sawyer Counties

Dean Kate VandenBosch

A Helping Hand for Students

"Our students are asking for your guidance and advice."

A memory many of us cherish is the sense we had as young people that the world was wide open for our exploration. The CALS campus offers fertile ground for such discovery. Every day in our classrooms and labs students are learning more about the world and how they might improve it.

Their on-campus learning can be strengthened by off-campus experiences—and as a CALS graduate, you can help. As part of our strategic planning we've been talking about alumni mentorship. CALS alumni are employed in professions reflecting our 19 wide-ranging departments and 24 majors. Many of you are in a position to offer students potentially life-changing experiences with the working world. And our students are asking for your guidance and advice.

There are many ways to provide that. It can be as simple as giving a presentation about your work on campus or inviting a student group to visit your workplace. You can also share job opportunities with students in the CALS group on LinkedIn and with CALS Career Services.

One especially powerful way to draw students into the working world is through internships—and that is an area in which students could particularly use your help.

About 41.5 percent of CALS seniors report having had an internship. Internships, they say, allow them to hone such skills as managing projects on deadline, effective communication and working in teams. And when they graduate, internships provide a network for hearing about openings and getting references (many students are hired by companies for which they interned).

But while internship opportunities are plentiful, they are not evenly distributed across all fields. Demand for particular internships is changing along with our demographics (biotechnology, for example, is in high demand by students). Students in newer fields such as bioenergy, or in fields that are more public agency- or nonprofit-based, such as community and environmental sociology or community health, often have a harder time finding an internship, particularly one that pays.

As our eyes and ears in a variety of fields, you probably have good ideas about possible internship projects or know of opportunities we might not be aware of. You can help us forge links between talented students and those opportunities.

It's also an area where donations can help. Students can often find or create an internship with an organization that might not be able to pay. If we can support a student in that setting through private donations, we can have more interns in fields where we have high student interest but little industry infrastructure.

Helping students enter the working world is one of the most meaningful ways we can help CALS grow the future. Please consider what role you might play, and feel free to make use of the resources provided on the left.

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Assistant Dean John Klatt, jklatt@cals.wisc.edu

CALS LinkedIn:
linkedin.com, *UW-Madison College of Agricultural and Life Sciences*

Make a gift:
http://supportuw.org/giveto/calsinternships

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Partners in Food Safety

CALS undergrads are part of efforts to expand food safety training at campus eateries

When the managers of University Housing Dining and Culinary Services (DCS) decided a few years ago to go above and beyond state requirements in employee food safety certification, they turned to the CALS Department of Food Science for help.

The "ServSafe" certification program, produced by the National Restaurant Association, is offered nationwide. By Wisconsin state law, food service operations need at least one staff member to be certified.

But DCS has expanded that requirement as a matter of quality improvement. "We wanted to provide the people on our front lines more tools to help us assure food safety at all our service points," says DCS associate director Julie Luke. "Over the last three to five years we've probably doubled the number of staff who have food safety training built into the credentials for their position." Even for positions where certification is not required it is offered as a professional development option, notes Luke.

DCS has some 100 full-time classified staff preparing and serving an average of 95,000 food orders a week through residence halls, catering and other venues on campus, assisted by an army of 1,200 student workers.

Expanding training was and is a tall order—but DCS has an able partner in food science instructor and registered dietitian Monica Theis, who not only teaches the two-day certification class but also recruits her undergraduate dietetics students to serve as tutors. A number of food service employees have low literacy or English as a second language. For those groups both the instruction and certification exam can pose a challenge.

Dietetics junior Heang Lee Tan worked one-on-one with one such employee, helping her take notes, prepare notecards and take a practice exam.

"It was really eye-opening for me to see how hard it was to implement a food safety training program. I saw how literacy became such a challenge," says Tan. "It makes me more sensitive to the great diversity of staff working in an organization. Having that knowledge will make me a better employee or manager in the future."

Photo by Wolfgang Hoffmann BS'75 MS'79

Safety on the front lines: Serving food at the Carson Gully Center.

Student tutors like Tan have boosted the success rate of DCS employees in passing the exam, notes Theis. "It's been an amazing experience."

Theis has involved undergrads in other food safety efforts. For example, Lori Homes BS'13 partnered with DCS and University Health Services to design an online food safety training module now used by DCS student workers, who formerly had to get that training in person. Homes also served as a student supervisor at DCS.

The food safety collaboration is one of many between DCS and food science. Theis trains DCS staff on a number of food-related topics, including allergies. DCS administration offers work opportunities to dietetics students interested in one day joining large-scale food and dining operations. Recently DCS executive chef Jeff Orr worked with food science students on a contest to create a new hamburger recipe for Gilly's Frozen Custard restaurants.

Theis welcomes those collaborations. "We have opportunities right here to partner with campus units and contribute to our little community," she says. "Our students can make a tremendous difference."

—Joan Fischer

Back to the Land

Environmental and cultural concerns spark an interest in natural burials—and CALS soil scientists are lending their expertise

When Jerry Kaufman's family was selecting his final resting place, they knew which one they didn't want: The cemetery behind the strip mall.

"My father was a planner," says daughter Ariel Kaufman. "He wasn't a strip mall person. It just didn't feel right."

Jerry Kaufman, a UW professor emeritus of urban and regional planning who died in 2013, was a holistic thinker. His work involved looking at seemingly incongruent places and systems that affect our daily lives and figuring out ways to make them work together. After retiring in 2001 after 30 years on campus, he continued to serve as board president of the Milwaukee-based urban agriculture nonprofit Growing Power, a position he held for some dozen years.

Fittingly, when Kaufman died, he was interred in the Natural Path Sanctuary at the Linda and Gene Farley Center for Peace, Justice and Sustainability near Verona. Burial sites there are incorporated into a 25-acre nature preserve located near a training center for beginning farmers featuring a community-supported agriculture program.

"The center has these other activities that are part of life—the peace, justice and sustainability work and the community food program," says Ariel Kaufman. "It's not like death is separate from life. They fit together."

Natural Path Sanctuary fits because it's a place for natural burials—no embalming, no metal or concrete enclosures. Remains are placed in biodegradable shrouds or bare wood caskets and buried just 3 to 4 feet below the surface, a depth at which there's still significant biological activity.

"What goes into the ground is returned to the ecosystem quickly," says Stephen Ventura, a CALS professor of soil science who chairs the sanctuary's board of directors. "Traditional burial puts a lot of toxic chemicals into the ground and a lot of concrete and metal. People are starting to realize that it's not sustainable. And while cremation avoids some of that, it also has a significant impact because of the large amount of fossil fuel required."

Blending into nature: *(Below)* A burial site at Natural Path Sanctuary; *(Opposite)* Soil science professor Stephen Ventura (kneeling) offering advice to sanctuary coordinator Kevin Corrado (his hand rests on a site marker).

Photos by Gerhard Fischer

Since Ventura's academic work focuses on using geographic information systems (GIS) to make land use decisions, the creation of Natural Path Sanctuary has provided a teaching opportunity. Early on, seniors in a CALS soil science capstone class helped evaluate the land and map the areas best suited for burial. More recently, students in Ventura's GIS class developed a management information system to keep track of burial sites.

It's not just environmental concerns driving the interest in natural burials, Ventura says. "Not all cultures believe that bodies should be preserved forever. And for many families, it offers a more personal con-

Professor Jerry Kaufman

nection with the departed—a way to be involved at the end. Families can participate in the digging if they choose."

Jerry Kaufman's family chose to prepare his grave themselves. It was January, and there was snow on the ground and roots to contend with, but it wasn't a problem. Everybody pitched in—family and friends from campus and beyond. Kaufman's Growing Power "family" was on hand, and they'd brought picks and shovels.

"As farmers, they knew how to work the ground, but it was more than that," says Ariel Kaufman. "It was an act of love. It is the final caring act we can do for someone—to find them their final resting place."

—Bob Mitchell BS'76

"Open Source" Seeds for All

SCIENTISTS, FARMERS AND SUSTAINABLE FOOD SYSTEMS ADVOCATES recently celebrated the release of 29 new varieties of broccoli, celery, kale and other vegetables and grains that have something unusual in common: a new form of ownership agreement known as the Open Source Seed Pledge.

The pledge, developed through a nationwide effort called the Open Source Seed Initiative, is designed to keep the new seeds free for all people to grow, breed and share for perpetuity, with the goal of protecting the plants from patents and other restrictions.

CALS professors Irwin Goldman (horticulture) and Jack Kloppenburg (community and environmental sociology) have been leaders in the initiative, which arose in response to the decreasing availability of plant germplasm—seeds—for public plant breeders and farmer-breeders to work with. Many of the seeds for our nation's big crop plants—field corn and soybeans—are already restricted through patents and licenses. Increasingly this is happening to vegetable, fruit and small grain seeds.

Photo by Bryce Richter/UW Communications

"Open source" vegetable and grain seeds being packaged for public use.

Goldman, who breeds beets, carrots and onions, still plans to license many of his new varieties as usual—through the Wisconsin Alumni Research Foundation (WARF), which has been supportive of his interest in open source seeds. But he's pleased he now has an alternative for when he wants to share new varieties with fellow public plant breeders or small seed companies.

"These vegetables are part of our common cultural heritage, and our goal is to make sure these seeds remain in the public domain for people to use in the future," he says.

—Nicole Miller MS'06

Made for the Shade

New technology could help food crops thrive in crowded fields

With the global population expected to reach nine billion by 2050, the world's farmers are going to need to produce a lot more food—but without using much more farmland, as the vast majority of the world's arable land is already being used for agriculture.

One possible solution is to try to grow crops more densely in the field, thereby increasing yield per acre. But it's not as easy as just spacing seeds more closely together at planting time.

Packed too tight, for instance, corn plants will grow tall and spindly as they try to outcompete neighboring plants for access to sunlight—a phenomenon known as shade avoidance.

"The problem with shade avoidance when it comes to food crops is that the plants are spending all this time and energy making stems so they can grow tall instead of making food that we eat," explains CALS plant geneticist Richard Vierstra, who is developing a way around it. His team is reengineering a light-sensing molecule found in plants, known as phytochrome, to allow plants to grow normally even when they're packed in tight.

"Instead of 30-inch rows, this technology could enable us to plant corn in 20-inch rows, boosting yields by as much as 50 percent—if we can get the plants to ignore their neighbors," says Vierstra.

Phytochrome is the main photoreceptor that allows plants to tell when the lights are on and when they're off. It's what tells seeds to germinate and young seedlings to become green, and enables plants to establish circadian rhythms—an internal clock system, says Vierstra. "And it also allows a plant to sense whether it's in full sun or whether it's being shaded by other plants."

In the lab, Vierstra and his team developed the first three-dimensional structures of phytochromes. Using these models, they are now trying to rationally redesign the photoreceptor to have altered light-sensing properties. This reengineering involves creating hundreds of possibly interesting phytochrome mutants, and then testing them for light sensitivity both in the test tube and inside plants.

Already Vierstra's team has found a number of mutants that are extremely sensitive to light. These mutant phytochrome molecules, if genetically engineered into food crops, could trick the plants into thinking they are getting plenty of light, even when they're growing in a crowded field.

Vierstra is in the process of patenting the technology and already knows of a large agribusiness company that's eager to help commercialize it.

"We're starting to engineer the phytochrome system in corn, in lines that will eventually be used for breeding," he says. "It's exciting to think about the potential this technology has to boost agricultural productivity."

—Cathy Day and Nicole Miller MS'06

The 3-D structure of part of the phytochrome molecule.

Image provided by Richard Vierstra

25th for CIAS: Looking Back, Looking Ahead

The Center for Integrated Agricultural Systems continues blazing trails

When the CALS-based Center for Integrated Agricultural Systems (CIAS) was founded in 1989, its mission and goals were far from mainstream.

"Twenty-five years ago, you ran the risk of being seen as marginal if you advocated a sustainable and integrated approach to agriculture," says CIAS director Michael Bell, a professor of community and environmental sociology. "Now it's central to our college's mission and priority themes. This is a wonderful and quite fundamental change. And it's due in part to the work of CIAS in integrating not just agriculture but the people involved in it."

CIAS was created and funded through an act of the Wisconsin Legislature. Since then, it has provided leadership on managed grazing, community-supported agriculture, Farm to School, organic farming, integrated pest management and other agricultural innovations that have achieved mainstream acceptance over the past 25 years. CIAS has given farmers a voice in its work and connected them to CALS research through its Citizens Advisory Council.

As CIAS looks to the future, an emerging research direction is the "perennialization" of agriculture and the landscape. Integrating perennial crops—including hazelnuts, apples, forages and cover crops—with livestock and annual crops contributes to resilient ecosystems, farms and communities.

"One way to look at the perennialization of agriculture is to ask, *can* we make agriculture perennial?" says Bill Tracy, professor and chair of agronomy and a CIAS faculty associate. "Our current system is not. To make agriculture perennial, we need more perennials on the landscape, including perennial grasses."

CIAS aims to help growers successfully "perennialize" their farms by helping them better understand the production and economics of a variety of perennial crops. Continued research and outreach on forage crops for graziers is central to CIAS' future work in this area. Likewise, CIAS plans to research perennial specialty crops that offer multiple ecological, economic and quality of life benefits for Wisconsin farmers.

Farmer training plays an important role in increasing the diversity of perennial crops on farms. CIAS's schools for beginning dairy and livestock farmers as well as apple growers have helped hundreds of students plan successful farm businesses that incorporate perennial crops. A new CIAS program—the Midwest School for Beginning Grape Growers—launched in March.

Other emerging program areas include labor and fair trade in local and regional food systems. CIAS is also looking at ways to help farmers adapt to a changing climate through sustainable agriculture.

CIAS seeks to secure its financial future with a 25th anniversary fundraising challenge. The goal is to raise at least $50,000 this year. The challenge is off to a strong start with several significant gifts from Wisconsin businesses and individuals.

CIAS is planning several public events in honor of its 25th, including a barn dance at Schuster's Farm near Deerfield on June 27 and fall seminars on campus. Details for events and donations are posted at www.cias.wisc.edu.

—Cris Carusi

classAct

James Downey
A Vet-to-Be

Photo by Sevie Kenyon BS'80 MS'06

James Downey was thigh-high to a Percheron when he got his first look at veterinary medicine. As he watched the local vet treat his grandparents' draft horses, the seed for a career in animal health was planted.

He already was tuned in to the idea of a medical career because both his parents were nurses. "They do health care for people; I love animals. I saw this as a way to tie the two together," says Downey, who grew up in Manitowoc County near Valders.

By high school he was earning money raising grass-fed beef and litters of pigs and helping out on nearby dairy operations. And he'd begun shadowing a vet—the same one who treated his own stock and his grandparents' horses.

By the end of his freshman year at CALS, Downey was on the fast track. He'd been accepted to the highly selective Food Animal Veterinary Medicine Scholars program (FAVeMedS), which was created to address concerns about a shortage of agricultural veterinarians. Undergraduates in FAVeMedS are guaranteed a spot in the UW School of Veterinary Medicine (SVM) after completing their junior year.

As a designated vet-to-be at CALS, Downey pursued hands-on training in the labs of CALS animal sciences professor Mark Cook and SVM professor Dr. Gary Etzel. And he honed his people skills by serving as a peer mentor in the Bradley Learning Community (a housing program that helps freshmen transition to college life), as a house fellow in the Farm and Industry Short Course dorms, and as a leader in groups like Saddle and Sirloin and Collegiate FFA.

The business he's going into is changing fast, Downey says. "Vets are spending more of their time in a consulting role. Our job isn't just to treat animal disease. We look at the entire farm to see what we can do to prevent infections and outbreaks. As a vet in the future, it will be important to have broad knowledge for looking at the whole farm."

Getting that broad knowledge will likely take him far from home—he plans to work on swine, beef and dairy operations outside of Wisconsin in his fourth year of vet school, his "extern" year, to see different practices—but he hopes that's temporary. "I'd love to end up back in Valders," Downey says. "I love where I'm from. I want to learn as much as I can, to be well-rounded, so that when I move back I can help everybody."

—Bob Mitchell BS'76

DEDICATED, in a ceremony on April 24, the **Hector F. DeLuca Biochemical Sciences Complex.** The complex includes the Biochemistry Building, the Biochemical Sciences Building and the Biochemistry Laboratories, each bearing DeLuca's name.

ELECTED to the American Academy of Arts and Sciences, **Richard L. Gourse,** the Ira L. Baldwin Professor of Bacteriology and current department chair. Working primarily with the model organism *E. coli*, Gourse is well known for his studies of how genes are expressed in cells.

APPOINTED to a named professorship of the Wisconsin Alumni Research Foundation (WARF): **Ronald Raines**, a professor of biochemistry, and **Nancy P. Keller**, a professor of medical microbiology. They were among six to receive the honor, which includes $75,000 in research support from WARF over five years.

PRESENTED with a Kellett Mid-Career Award, **Dietram Scheufele**, a professor in life sciences communication whose current focus is the impact of social media and other new forms of communication.

HONORED by the Association for Communication Excellence, *Grow* magazine and CALS communication staff. Editor **Joan Fischer**, graphic designer **Diane Doering** and photographer/multimedia producer **Sevie Kenyon BS'80 MS'06** took gold and bronze awards for magazine work as well as work on the college's strategic plan (shared with entire staff) and audio news stories. *Grow* magazine received silver in the best magazine category.

N b Crunching

Photo by Sevie Kenyon BS'80 MS'06

434 THE NUMBER OF ICE CREAM FLAVORS/NAMES entered by students, faculty and staff across campus as well as alumni in a contest to create and name an ice cream in honor of CALS' 125th anniversary. The winner? "Happy Cranniversary," suggested by **Allison Dungan**, who happens to be outreach coordinator for the Dairy CAP project featured in this issue (page 22). Happy Cranniversary, available at the Babcock Dairy Store and other campus locations, is a cranberry-flavored vanilla base loaded with whole cranberries and swirls of cranberry sauce.

Photo, left to right: **Kurt Heiman**, **Allison Dungan** and **Marcy Berlyn**. The Heiman and Berlyn families operate Rubi Reds, the company supplying cranberry ingredients.

Five things everyone should know about . . .

Gluten

By Beth Olson

1 | **What is it?** Gluten is a substance composed of two proteins—gliadin and glutenin—that are found in the endosperm (inner part of a grain) of wheat, rye, barley and foods made with those grains, meaning that gluten is widespread in a typical American diet.

2 | **Is it harmful?** People who suffer from celiac disease, an autoimmune digestive disorder, are unable to tolerate gluten. Even a small amount of it (50 milligrams) can trigger an immune response that damages the small intestine, preventing absorption of vital nutrients and potentially leading to other problems such as osteoporosis, infertility, nerve damage and seizures.

3 | **How widespread is celiac disease?** An estimated 1.8 million Americans have celiac disease; as many as 83 percent of those suffering from it remain undiagnosed or are misdiagnosed with other conditions. Another 18 million (about 6 percent of the population) do not have celiac disease but suffer from gluten sensitivity. They report such symptoms as diarrhea, constipation, bloating and abdominal pain—which also are symptoms of celiac disease—but do not experience the same intestinal damage. For those with celiac disease or gluten intolerance, a gluten-free diet is beneficial.

4 | **Should you cut gluten from your diet even if you don't have these conditions?** Probably not. Restriction of wheat in the diet often results in a decrease in the intake of fiber at a time when most Americans consume significantly less than the recommended amount. Low-fiber diets are associated with increased risk of several acute gastrointestinal diseases (examples: constipation, diverticulosis) and chronic diseases such as heart disease and colon cancer. If not done carefully, gluten-free diets also tend to be low in a number of vitamins and minerals.

5 | **Don't diagnose yourself.** The broad range of symptoms associated with celiac disease and gluten sensitivity may be due to other causes; self-diagnosis and treatment of perceived gluten intolerance may delay someone from seeking more appropriate medical care. The only way to know for certain if you have celiac disease is from a blood test for the presence of specific antibodies followed by a biopsy of the small intestine. If you are experiencing the symptoms described above, please seek medical care.

Beth Olson is a professor of nutritional sciences. Her principal research areas concern breastfeeding support and improving infant feeding practices in low-income families.

INDIA

Dairy knowledge, from Marshfield to India

Photo by Bryce Richter/UW Communications

Anuj Modi is learning skills in Wisconsin that will help him run the family dairy business in India.

Anuj Modi was nervous when he arrived for the first day of his summer internship at the Marshfield Agricultural Research Station last year. The freshman dairy science major could have been back home with friends and family in Bikaner, India. Instead, he was on the other side of the world, tasked with helping care for a large herd of dairy cattle. It was the first job he had ever had.

And he'd never milked a cow.

"Before my internship, a cow was just like any other animal—like a horse or a camel," Modi recalls. "I didn't know anything about cows or dairy farming."

But that doesn't mean Modi didn't know a thing or two about the dairy industry. His grandfather got the family into the business more than 40 years ago. His father helped carry on the legacy, and Modi is now hoping to take the family dairy business into its third generation. Today, Lotus Dairy has three processing plants in Rajastahn, India's largest state. They process one million liters of milk a day, selling it to clients like Nestle and Mother Dairy, a subsidiary of India's National Dairy Development Board.

Considering this, the fact that it took a move to Wisconsin to acquaint Modi with a cow may sound strange. But there are very few modern dairy farms in India. The cow enjoys sacred status in the Hindu faith and legal protection in many Indian states, which means managing a large herd and culling cows that are sick or not producing is often out of the question.

In addition to political and religious considerations, having a small herd is simply a way of life for many. "People in rural areas keep four or five cows in their backyard and sell the milk to people like Lotus," Modi says. "We collect milk mainly from villages. We have chilling centers in 80 locations across our state, and the number of people bringing us milk is high, close to 35,000 or 40,000."

This arrangement is so common that it makes India the world's leading producer of milk. And it's not even close. According to a recent U.S. Department of Agriculture report, India has 48 million dairy cows, up from 38 million only five years ago. Brazil, the next closest country, has half as many. There are only 9.2 million in the United States.

Combine that level of supply with a modernizing industry that's making milk production and processing more efficient, and you have the beginning of a boom. International developments like these are being felt here on campus, says Kent Weigel, professor and chair of the Department of Dairy Sciences.

"As the dairy farms and milk processing plants in countries like India, China and Pakistan expand and modernize, they import supplies, equipment and expertise from North America," Weigel says. "And they build relationships, which lead to sending the next generation to study abroad."

Weigel says the resulting influx of international students is beneficial to the department. They provide existing students with a new and global perspective regarding dairy farming and life in other countries. And, he says, "They extend dairy science's reach and impact well beyond the borders of Wisconsin—influencing dairy production systems on other continents and building a global alumni base."

—Adam Hinterthuer

SOUTH AFRICA

Team effort in the Eastern Cape

In the fertile, rolling hills of the Eastern Cape province of South Africa, it's hard to imagine a food shortage. But hunger is a serious threat there, especially for children. The area also has high levels of poverty and HIV infection.

Researchers at the CALS-based Center for Integrated Agricultural Systems (CIAS) are teaming with local groups to try to improve those conditions. Together they have formed the Livelihood, Agroecology, Nutrition and Development project—LAND for short—to address the region's complex, interrelated problems.

"Using a participatory approach, we have built strong ties with local villagers and their co-op, the Ncedisizwe Co-op, which means 'helping the nation,'" says CIAS director Michael Bell, a professor of community and environmental sociology.

The Ncedisizwe Co-op encompasses 800 smallholder farmers in 26 villages.

Other local partners include the Indwe Trust, an NGO focusing on sustainable development, and Kidlinks World, a Madison-based charity dedicated to AIDS orphans and other vulnerable children.

The group's goals are to provide sustainable livelihoods for smallholder farmers and their communities; to integrate health and nutrition with sustainable agricultural practices; to enhance ecosystem services such as crane habitat, erosion control and carbon sequestration; and to strengthen communities through participatory decision-making.

Better use of grasslands will be key in those efforts, researchers say. "The people of this region are blessed with a wealth of grassland resources, but these resources are literally being eroded before their very eyes," says agronomy professor Randy Jackson, who accompanied the LAND team on a recent visit. "Much of this is attributable to a governance system that treats most rangelands as unregulated commons, resulting in continuous grazing that promotes undesirable plants and exposure of bare ground."

Rotational grazing, the group notes—which actually originated in Africa—will potentially double the level of animal production while also building soil quality, reducing erosion and promoting wildlife habitat. LAND has conducted workshops with farmers on rotational grazing and helped develop a supply chain connecting local grass-based meat to national and international markets.

Other activities have included helping form a women's cooperative for vegetable production, working with community members on improving water supplies, and helping establish perennial home gardens to increase the quality and variety of local diets.

The LAND project has matured to the point where it can serve as the basis of a new global health certificate field course, "The Agroecology of Health," that debuted this past winter. Bell and doctoral student Valerie Stull brought 10 undergraduate and two graduate students to the Eastern Cape for a 15-day visit that encompassed learning about agroecology and hydrology systems and working with community members to establish a one-acre vegetable garden at a school in the village of Kumanzimdaka.

The students planted herbs, tomatoes, onions, peppers, cabbage and radishes and plotted locations for future fruit trees.

"The experience left me feeling a tremendous amount of respect for the people in the community who continue to live off and use the land," says Alexa Statz, a junior in life sciences communication. "I have high hopes that the garden we built together will be something that can stay with them for generations to come."

Bell plans to continue having undergraduates participate. Learning about themselves and their place in the world, questioning and thinking critically were all objectives of the trip.

"But the biggest objective was to provide students with the chance to discover what it means to lead a life of consequence," Bell says. "Now that's a pretty grand goal—and I think it happened in South Africa. It clicked."

—Aisha Liebenow

Global health students worked with local residents to establish a vegetable garden. *(Below)* Professor Michael Bell, right, shakes hands with a community partner.

Photos courtesy of the LAND project

Upping the Orange

Nutritionist **Sherry Tanumihardjo** works around the world to increase consumption of fruits and vegetables that are high in vitamin A.

SHERRY TANUMIHARDJO is a CALS professor of nutritional sciences and director of the Undergraduate Certificate in Global Health, a popular new program that draws participants from majors all across campus. She has almost three decades of experience working with vitamin A, and her research team has conducted studies in the United States, Indonesia, South Africa, Ghana, Burkina Faso and Zambia. Tanumihardjo has acted as a consultant to many studies throughout the world to assist with study design and appropriate standardization. She is a strong advocate for the promotion of nutritionally enhanced staple foods, vegetables and fruits to enhance overall health and well-being.

Describe your work with orange vegetables.
I have worked for a number of years on carrots of many colors as well as on orange-flesh sweet potato and, more recently, orange maize. Basically we are trying to improve the vitamin A status of individuals by having them consume more orange fruits and vegetables in general.

Can you give us an idea of how you go about doing that?
For many years I have worked with carrot breeder Phil Simon in the Department of Horticulture. He was breeding carrots for more orange color. We did a series of studies in both an animal model and in humans, trying to look at the uptake and distribution of the carotenoids that give the vegetables their orange color—and the vitamin A that is made from the carotenoids. Then we moved on to orange vegetables in humans in Africa. I have worked with orange-flesh sweet potato in South Africa and with orange maize in Zambia.

Can you describe the connection between the color and the nutritional value?
There are three well-known precursors of vitamin A that are called pro-vitamin A carotenoids. Those are beta-cryptoxanthin, alpha-carotene and beta-carotene. Many of you may have heard of beta-carotene because it is one of the compounds found in many over-the-counter supplements. But those are also the compounds that give carrots and orange maize their bright orange color.

What happens if there is not enough vitamin A in the diet?
The most drastic thing that can happen is death. So we go around trying to get people to improve their vitamin A intake not only to prevent death—there are many steps before that happens, and one of them is blindness. Vitamin A is extremely important in vision and it also helps us ward off disease, so it's a very important vitamin.

How did you get started in Africa?
It actually started very slowly. I used to be a consultant and I would fly back and forth to different countries to help them look at study design. The sweet potato study was funded by the International Potato Center. I helped them design the study, they did the school implementation—a feeding study—and then I helped them get the work published. My work with orange maize started in 2004 in collaboration with HarvestPlus, a project managed by the International Food Policy Research Institute. We started working with animal models and then progressed to full-fledged feeding trials, the latest of which we finished in 2012.

What were some of the challenges in your work in Africa?
The challenge is that feeding trials, if they're going to show what we call efficacy, have to be highly controlled. So that means you have to keep the children for long periods of time and feed them all of the foods—and the foods need to be the same across the group except your test food. So in South Africa we fed orange-flesh sweet potato to half the children and white-flesh sweet potato to the other half. And then when we moved on to orange maize we did two studies. One study was similar to the sweet potato study where we fed white maize and orange maize. And then we did a second study where we had three groups, which got a little more complicated. We had white maize, orange maize and then white maize with a vitamin A supplement.

Another challenge is that all of the human work that I do involves blood—so we have to take blood from these children. Vitamin A in the human body is stored in the liver, and we use indirect markers of liver reserves of vitamin A that you can pick up from the blood.

Interview by Sevie Kenyon BS'80 MS'06

Looking down the road, what kind of goals do you have for your research?
We would like for people to have optimal health by having a diet that has not only all the nutrients you need but also some of the potential compounds that gear us toward optimal health. So it's not just about fighting blindness anymore, but to see if we can get people into a new nutritional state where they are actually able to ward off diseases such as cancer.

Can you talk a little more about the international nutritional programming you've been involved in?
Most of the work that I've done is to support biochemical labs. We have not done a lot of nutrition education on the ground, although that is a goal of mine, especially in Zambia. We have discovered that Zambians actually have really good sources of vitamin A in their daily diets, so we want to help them continue to eat the fruits and vegetables that are good sources of those phytonutrients and vitamins and minerals.

So it's a research tool. And what kinds of questions does it answer?
It is the most sensitive marker of liver reserves of vitamin A. Basically what we do is we give a dose of vitamin A that has a slightly higher amount of 13C than what's found naturally in the environment, and then we can follow the uptake and the clearance of that 13C in the human body. And from that we can calculate total body stores of vitamin A—how much is in the whole body.

> "It's not just about fighting blindness anymore, but to see if we can get people into a new nutritional state where they are actually able to ward off diseases such as cancer."

What kind of progress have you made?
We have had significant progress with sweet potato. Most people in Africa used to eat white sweet potato, not the orange sweet potato we eat here in the United States. Many countries in Africa have now adapted the vines to be orange-flesh sweet potatoes. We think that's a success story. Regarding orange maize, there are three lines of orange maize that have been released by the Zambian government. Currently orange maize is available to consumers. Right now it's at a premium price, but hopefully with time the price will come down to the level of white maize.

How did you get interested in this line of work?
It chose me. It wasn't something that I was looking for, but I was working with vitamin A and if you're working with vitamin A and status assessment, it's going to draw you to the countries that may have a history of vitamin A deficiency.

The other thing that I work on is isotope methods, which sounds a little scary!

What are isotope methods and what do they do?
We work with a compound called 13C. Typical carbon in the human body is 12C and radioactive carbon is 14C. We are working with the form of carbon that constitutes 1 percent of the human body. It's perfectly safe to use, but it also has allowed me to work with the International Atomic Energy Agency. That's the same agency that oversees radioactive bombs in different countries, so it's kind of interesting that they have something called Atoms for Peace. And they actually received the Nobel Peace Prize one year based on the safe use of isotopes in nutrition.

I have worked in several countries trying to help them understand isotope methods and to apply isotope methods at the population level to inform public health policy. It's a very technical method, but it can answer questions of public health significance.

To conclude here, there's an interesting story about your office and a more recent career development of yours—serving as director of the Undergraduate Certificate in Global Health, a program you helped develop and launch in 2011.
Yes. The Nutritional Sciences Building was originally a children's hospital, and this particular office that I sit in sat idle for many, many years, used only for small committee meetings and things like that. When we received funding for the Undergraduate Certificate in Global Health, I looked in this office again and realized that it now fits my purpose. Originally it was the viewing room for children who had died from a variety of diseases, and the parents would sit in this room and mourn their lost child. I decided that this room fit my new mantra at the university, which is to empower undergrads, to mobilize them, to try to change the world. And while I'm sure we won't have 100 percent participation, we've already had about 1,000 students go through the program.

Gardening for the People

Master Gardener Volunteers bring expertise and the joy of growing to diverse people and projects around the state.

By Jane de Broux

Photo by Kevin Schoessow/UW-Extension Agricultural Development Agent

Master Gardener Volunteers and staff planting critically acclaimed gardens for all to enjoy at the CALS-based Spooner Agricultural Research Station.

THREE YEARS AGO I WAS AT A COMPLETE loss when it came to the grounds surrounding my home. What was I going to do with a huge yard overrun with weeds and invasive species? There wasn't a single flowerbed, but there were two large crabapples with spotty leaves and burned-looking bark. Our fence line was populated with a tight row of buckthorn and invasive honeysuckle, and there was garlic mustard everywhere.

I learned this sad fact from an arborist we had hired to trim broken branches from the silver maple on our property. Determined to forge ahead and make something of the yard, I had him take out the diseased trees and the large buckthorn and honeysuckle bushes. After he finished, nothing remained but a few very old and overgrown lilacs, two peony plants, and a few bushes around the perimeter of our lawn.

I was determined to turn my yard into something beautiful, but it was clear I needed help. Trial and error did little but show me how much I had to learn. As I began to investigate ways to acquire gardening expertise, people would mention advice from "master gardeners," a title that conjured images of retired ladies in wide-brimmed hats and gloves tending gardens with lots and lots of rose bushes. I also thought of master gardener training as a kind of finishing school for skilled gardeners rather than a program that welcomed beginners.

I was wrong on both counts, as I learned from Mike Maddox MS'00, a CALS horticulture alumnus who directs the statewide Master Gardener Volunteer Program—a service of UW-Extension—from an office in the Department of Horticulture in Moore Hall. Master gardeners are, in fact, Master Gardener Volunteers—or MGVs for short—with the emphasis on "volunteer," Maddox notes. It's a role that has become more salient over the years. "The volunteer requirement became a way for MGVs to assist and offset the barrage of gardening questions coming to Extension offices," Maddox says. "We emphasize the volunteer aspect of 'Master Gardener' to distinguish it from a commercial endorsement, to differentiate it from a garden club—and to de-emphasize the expectation of the need to be an 'expert' on all subjects."

Photos by Linda Warren/UW-Extension

The Northern Lights Master Gardener Volunteers play a key role in gardening and related programs at the Harmony Arboretum in Marinette County. The mural and "chipmunk's tunnel" exhibit behind it teach learners of all ages about what a chipmunk might see in his underground home.

So much for what MGVs are not. But what are they? "MGVs are a group of very passionate people who want to learn something about plants and then make a difference in their communities," says Maddox. "The strength of our program is with our strong county presence throughout the state. The local, personal touch is what connects with our participants and communities."

Here are some examples of MGV activities around the state last year, often conducted in partnership with UW-Extension and other organizations:

- MGVs in Rock County helped create community gardens in Beloit as a part of a neighborhood revitalization project. They also worked with inmates in tending a community garden next to the Rock County Jail in Janesville.
- Waupaca County MGVs partnered with a local school district to create a three-acre community garden to grow vegetables for food pantries and for use as an outdoor classroom.
- MGVs in Racine and Kenosha counties participated in Green Works, a program developed by UW-Extension, MGVs and community partners to teach green industry vocational skills to adults with developmental disabilities.
- La Crosse County MGVs directed a monthly after-school garden club that maintains a certified Monarch Way Station/Butterfly Garden at Evergreen Elementary School in Holmen.
- MGVs in Fond du Lac County implemented a Junior MGV program to teach low-income children how to plant, care for, harvest and cook fresh produce.
- Adams Co. MGVs awarded $3,000 in scholarships to students majoring in horticulture-related fields.
- MGVs in Washington County grew vegetables at the Germantown Community Garden and donated more than 300 pounds of fresh produce to the Germantown Senior Center.

MGV projects are great and small, and taken as a whole they pack a wallop. Each MGV has to complete at least 24 volunteer hours a year to remain certified—and altogether Wisconsin MGVs contributed 194,046 volunteer hours in 2013. The value of that service for one year alone is worth more than $4.3 million.*

Small wonder that researchers at the cutting edge of horticulture see MGVs as valuable ambassadors for their discipline. "The MGV program is one of the best examples we have of engaging Wisconsin citizens and communities in the art and science of horticulture," says Irwin Goldman PhD'91, chair of the Department of Horticulture. "As a land grant institution, CALS has a particular focus on supporting and enhancing the agricultural enterprises of the state and a major role in public education. The MGV program fosters an incredibly positive learning environment in horticulture throughout Wisconsin, resulting not only in beautiful landscapes and improved local food production, but also in economic development and improved sustainability of our communities."

The statewide Wisconsin Master Gardener Association (WIMGA) was formed in 1992. Currently there are 53 active local organizations across the state. Since 1999, more than 15,000 people have completed MGV training in Wisconsin.

"The program is nothing less than the Wisconsin Idea in action," notes Goldman. "In terms of our mission to serve the citizens of the state, the MGV program goes a long way in showing the value of a unique collaboration between UW-Extension, CALS and, specifically, the Department of Horticulture."

MY OWN JOURNEY FROM all thumbs to green thumb—or at least chartreuse thumb—began in 2012 when I signed up to become an MGV. There is an evening option for classes in Dane County, which I welcomed as a full-time working professional. The 16 three-hour training sessions would run from February to September—a big commitment, but I was ready for it.

When I walked into my first training session at the Lyman F. Anderson

*Using an estimated dollar value of volunteer time of $22.14 per hour, as calculated by the nonprofit Independent Sector.

Photo by Kevin Schoessow/UW-Extension Ag Development Agent

Staff and MGVs taking a break at the Spooner Agricultural Research Station.

Agricultural and Conservation Center on Fen Oak Drive in Madison, I was surprised to see the crowded classroom. There was a range of age groups represented—and as expected, mostly women, but some men as well. I took a seat at the front row table, hoping that proximity to our instructor would keep me awake and engaged after a full workday. UW-Extension Dane County horticulture educator Lisa Johnson BS'88 MS'99 was more than up to the task. Her enthusiasm was infectious. She was organized and professional, and she retained her sense of humor after a long workday of her own.

Her orientation talk was inspiring. "Training is designed to help MGVs to become educators first and foremost," she told us. "MGVs take the research from CALS and bring it out in the community. As representatives of the UW, they provide unbiased, scientifically replicated and peer-reviewed information. MGVs learn where and how to find the needed information to provide answers to the public, backed by UW research."

In the classroom, we studied a broad range of topics in detail. From plant anatomy, taxonomy and propagation to weed identification, invasive plants and perennial and annual flowers, the curriculum covers material most useful to home and community gardeners. Topics like tree and shrub planting and pruning, growing berries and fruit trees, lawn care and houseplants may not necessarily apply to our own gardens, but they are subjects that generate questions from the public. Inquiries about plant diseases and pesticide safety are also very common, and it's important to be familiar enough to understand available resources, where to look—and who to ask if you need to do research.

I found the material on soil science the most challenging, and it soon became apparent it was likely the most critical. Inexperienced gardeners quickly discover plants are particular about things like the soil's composition, structure, pH, and biological characteristics. The ability to read soil test reports, alter pH, and amend soils with organic matter are important fundamentals. I came away from class knowing how and where to get soil tested and how to find resources on amending and fertilizing soil. One of my own gardening challenges involves a lot of rock-hard clay soil. Not all plants can thrive in it, and I learned to cultivate native plants tolerant of the conditions in my yard.

One of the classes I enjoyed most was our introduction to insects, which focused on garden pests and how to control them. The class was taught by popular CALS/UW-Extension entomologist Phil Pellitteri BS'75 MS'77 from the UW Insect Diagnostics Lab. Pellitteri brought in many wonderfully repulsive slides of insects to pique our curiosity. "Insects are the most successful animals in the world and make up two out of three living things," Pellitteri told us. "Less than 1 percent of all insects are considered pests, yet millions of dollars are spent each year to control them."

He also pointed out that about 66 percent of all insect pests are exotic or introduced species. Learning to identify insects, their stages of development, life cycles, and feeding habits determine the strategies that will likely be most effective for either drawing a particular insect to a garden or keeping it away.

Photo by Linda Warren/UW-Extension

***(Above)* MGVs teach how to make garden towers from recycled glass in Marinette County; *(Below)* MGVs and staff at the Community Outreach Garden in Janesville work with participants in a rehabilitation program at Rock County Jail, located next door.**

Photo by Gerhard Fischer

Master Gardener Volunteer Kelley Frey opens her lovely shade garden—and offers information and advice—to visitors at a home garden tour in Janesville.

Not all sessions involved three hours of lecture. We had many opportunities for hands-on learning in the Teaching Garden at the UW-Extension Fen Oak property, which Johnson helped establish some 10 years ago as an outdoor classroom for MGVs and children's groups alike. We trooped out there to observe the growth habits of many different types of plants we'd discussed in class, look for insects and evidence of disease, and practice pruning and the best ways to control various weeds. We observed the effects of heat and drought on the plants that year and learned what to look for in the following years as the effects of the drought continued—and are still obvious today in the appearance of damaged evergreens.

The Teaching Garden is open to all. "We encourage people to come out and take a look," says Johnson. She describes a new MGV project being implemented there: creating and placing QR code labels on plastic resin spindles to identify plants. The spindles are weather- and squirrel-proof, and all corresponding information on the plants is vetted. The codes will eventually match up to photos on a web page. Completion of the project will result in a valuable educational resource for MGVs, school groups and the community.

The MGV training program adapts over time to meet current needs. Organic vegetable gardening, composting and how to teach children about gardening are examples of popular topics that have become an important part of the curriculum.

Master Gardener Volunteer Jane de Broux, second from right—author of this article—helping out at Urban Horticulture Day at the West Madison Agricultural Research Station.

MOST MGVS ARE NOT professional horticulturists. Ongoing training on a variety of topics is essential, and 10 hours of continuing education are required each year to maintain certification. Horticulture educators like Johnson offer trainings specifically designed to help MGVs in their roles as presenters, speakers and educators. MGVs who have completed an additional Plant Health Advisor (PHA) training qualify to staff the "Horticulture Hotline." According to Johnson, the Dane County hotline alone handles 1,800 to 2,000 phone calls and e-mails each year.

Maddox continues to develop online training opportunities for MGVs across the state. One example last year was a program on vegetable gardening aptly named "A Row to Hoe." Registrants participated in a live virtual classroom format. Those who couldn't make the 11 a.m. time slot for the live class were able to watch the presentations at their own pace on the MGV website. More online opportunities are available and in the works, Maddox notes.

In addition to ongoing training, we also depend on our ability to research questions or pass them on to experts.

MGV Rosanne Horne, working with Johnson, started the Dane County "Ask a Master Gardener" program, which brings an MGV-staffed information table to five farmers markets in Dane County and to other events such as the Association of Women in Agriculture's Breakfast on the Farm, UW Family Gardening Day and open houses at community gardens. Horne, a retired legal researcher, is passionate about exploring every available resource to provide information to home gardeners. And—in keeping with recommended protocol for MGVs—she doesn't hesitate to ask a "higher up" if needed, contacting such experts as Pellitteri or CALS/UW-Extension plant pathologist Brian Hudelson MS'89 PhD'90, director of the Plant Disease Diagnostic Clinic.

While MGVs depend on the professionals at CALS and UW-Extension, Horne notes that the experts also count on us. "We're the eyes and ears and the feet on the ground everywhere," says Horne. "Whether reporting sightings of damaging insects or

Photo by Gerhard Fischer

the appearance of invasive plant species, MGVs are literally in the field and in touch with the public."

We also value the support we find in each other. The love of gardening and learning about horticulture provides an unending stream of topics for spirited conversation. MGV Lori Nelsen BS'03, for example, learned about the program by taking MGV-assisted garden walks at the West Madison Agricultural Research Station and went on to attend other MGV-affiliated events there. "It looked like a different opportunity to learn so much more," she says. "I thought I could meet more people and get out into the community and volunteer."

When I attended a recent annual meeting of the Madison Area Master Gardeners Association (MAMGA), I sat at a table with an old friend and several other MGVs I'd never met. We were eager to hear our speaker, Diane Ott Whealy, a co-founder of Seed Savers. The topic sparked a lively discussion of successes, failures and helpful resources. MAMGA also offers a number of social activities related to gardening for MGVs, from home garden tours to celebrations for MGV graduating classes. We enjoy the community we find there—with classmates, fellow MGVs, experts at UW-Extension and CALS and participants in volunteer projects.

I'm now in my second year as a certified MGV and I am still trying out a number of educational and volunteer opportunities to find where my interests and skills best align. During training I loved volunteering at Sherman Middle School in Madison. I helped students plant their gardens and reveled in their enthusiasm as we watched how quickly they took shape. I also enjoyed answering attendee questions at the MGV table for UW Family Gardening Day, and, on one particularly lovely evening last September, I harvested tomatoes at the West Madison Agricultural Research Station for delivery to the food pantry at the Lussier Community Education Center. It was quiet and beautiful, and the task was like a form of meditation. As the sun began to set, what looked like hundreds of *Hyles lineata*, known as the whitelined sphinx moth, appeared like a show of fairies. It was this kind of experience that drew me to gardening in the first place—beauty, bounty and connection to the earth.

At home, I still enjoy spending a lot of time digging in the dirt. I've raised my first plants from seeds. My perennial garden continues to expand and I've had great success drawing pollinators. It's thrilling to see my neighbor's honeybees buzzing around the garden, and it has been fun and rewarding to grow my own vegetables. Neighbors now come to me with questions about invasive plants, identifying weeds and how to fight them, and, recently, about the emerald ash borer. I am always happy to help them find answers.

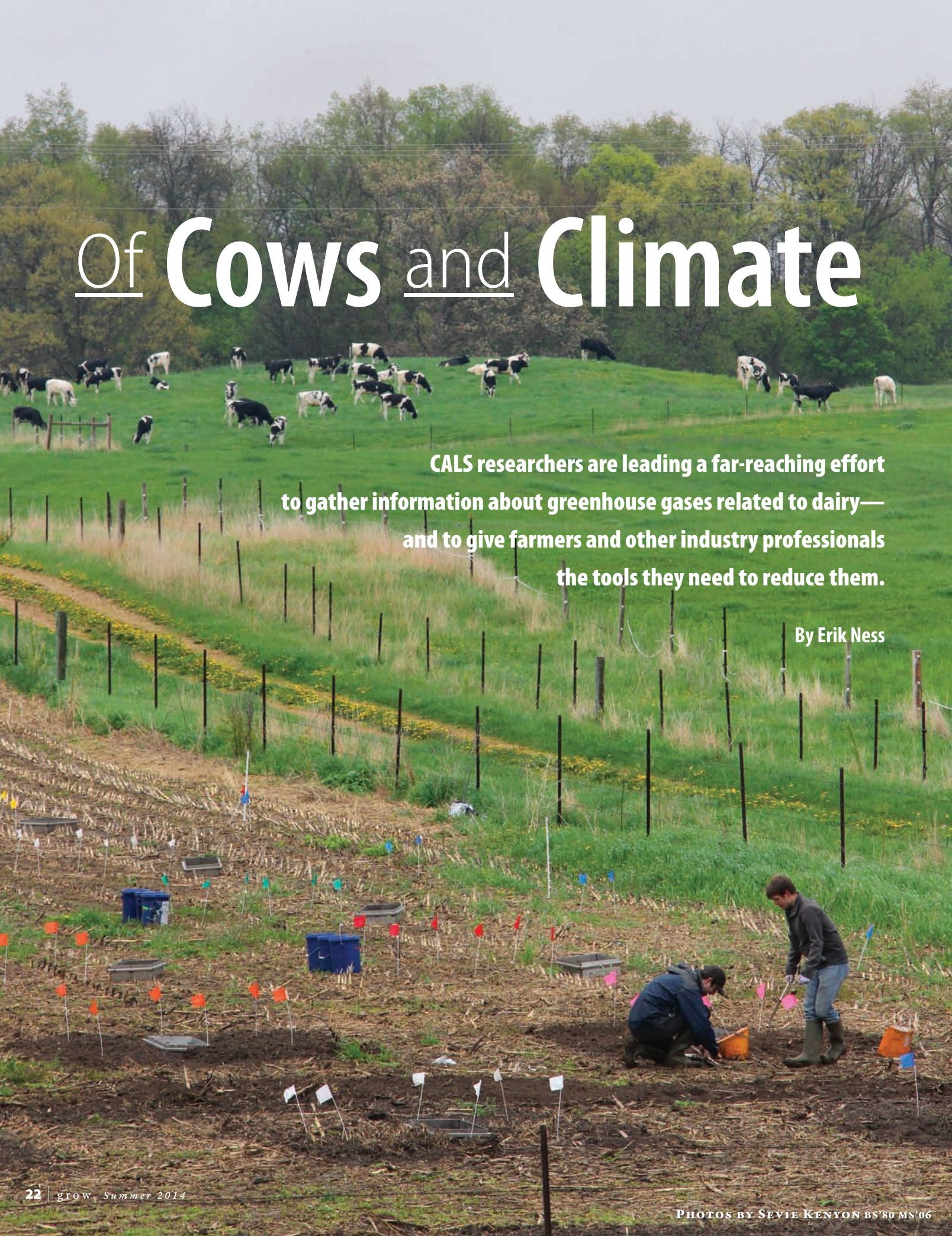
I now wear hats and gloves and even rubber clogs and flowered Wellies, though I still don't grow roses. I understand the privilege and joy it is to be part of the MGV program. For people who are passionate about horticulture, enjoy sharing their knowledge and experience and want to make a difference in their communities, becoming an MGV delivers it all. I highly recommend the program and encourage anyone who is interested to check it out and join us.

Learn more at wimastergardener.org.

Of Cows and Climate

CALS researchers are leading a far-reaching effort to gather information about greenhouse gases related to dairy—and to give farmers and other industry professionals the tools they need to reduce them.

By Erik Ness



Photos by Sevie Kenyon BS'80 MS'06

Experiment in action: Out at the U.S. Dairy Forage Research Center farm, researchers apply manure from cows that were fed three different diets over a three-month period. The manure will be tilled in and greenhouse gases measured every few hours for the first three days. The field will then be planted in corn for silage, and greenhouse gas measurements will be taken every week or two throughout the growing season. Here, researchers take soil samples after manure application.

On a subzero February day, Mark Powell stops his vehicle on the road a few miles outside Prairie du Sac. He's been explaining that cows actually enjoy the polar weather—and as if to prove it, a frisky group in the barnyard across the road turns toward us and rushes the fence.

As a USDA soil scientist and CALS professor of soil science, Powell is focused on the ground beneath their hooves. A few years ago he led a survey of manure handling on Wisconsin dairy farms. He and his colleagues knew how much cows left behind—about 17 gallons a day—but had only educated guesses about the ultimate environmental impact of barnyard design. In open yards like this, says Powell, they found that 40 to 60 percent of the manure ends up uncollected. "It just stays there," he says. In the decade since his survey, the manure challenge has only grown, both in Wisconsin and nationwide. Water quality has been the major concern, but air quality and climate change are gaining.

A few minutes later we turn into the 2,006-acre U.S. Dairy Forage Research Center farm, and the talking points all turn to plumbing. There's an experimental field fitted to track how well nutrients from manure bond to the soil. Parallel to one barn are nine small yards with different surfaces, each monitored to measure gasses emitted and what washes out with the rainwater.

The manure pit is frozen over, but circumnavigating the complex—shared by CALS and the U.S. Department of Agriculture—we arrive at the southern terminus of the barns. Uncharacteristic ventilation ducts adorn the walls and roofline. Inside are four unique stalls that can contain up to four cows each. The manure trough is lined with trays so that each cow's waste can be set aside for further experiments. When the cows return from the milking parlor, airtight curtains will drop, isolating each chamber.

And in a nearby room, sensors sample the air leaving each stall, recording the release of moisture, carbon dioxide, ammonia, nitrous oxide and methane. This data is at the heart of a $10 million, five-year USDA grant to examine climate change and dairying in the Great Lakes region.

In 2009, the dairy industry became the first major segment in the U.S. economy to volunteer a significant cut in its greenhouse gas production, vowing to eliminate 25 percent by 2020. Now in its second year, the project brings together industry, four USDA labs, dozens of researchers from eight universities, and even Milwaukee's Vincent High School. Funded through the USDA's Coordinated Agricultural Projects program, the working nickname is Dairy CAP—pronounced as if it were one word.

To hit that target requires a deliberate look ahead. "What is the climate going to look like in the future?" asks Matt Ruark, a CALS/UW-Extension professor of soil science and leader of the Dairy CAP endeavor. "What is the dairy industry going to look like 10, 20, 50 years from now? And are those two in conflict with each other?"

Sustainable dairying is the ultimate goal, and Molly Jahn, a CALS professor of genetics and agronomy, gives the dairy industry high marks for targeting greenhouse gases. "One thing we know, if you look back over the last 50 years, is that the conditions under which we are dairying are becoming more extreme," explains Jahn, a co-leader on the grant. "Dairying has many benefits to landscapes. As the industry continues to grow, we want to continue to innovate with respect to productivity and quality—and in harmony with our natural resource base."

Dairy CAP will provide not only academic results, but also tools and management practices. "We intend to provide dairy farmers with the resources to make sure they are managing their operations for maximum short-term benefit and for long-term success and resilience," Jahn says.

Living in Wisconsin, you can't help but absorb a few things about dairy, beyond the calcium. You likely know that Wisconsin is America's historic creamery. You also probably know that dairy farms are getting bigger, while other states are challenging Wisconsin's historic primacy. And chances are you also have your own opinions about the advisability of wearing a large wedge of dimpled yellow foam on your head.

But did you know that cows belch, and it's a problem? Cows are ruminants, which means they regurgitate and rechew their food. Combined with microbial action in multiple stomachs, they can break down fiber to get more nutrition out of plants. But these microbes also create methane, the primary component of natural gas.

Soil science professor Mark Powell (right) and research associate Matias Aguerre pose with cows inside a research barn equipped to measure methane released from both ends of the cow—a process made possible by encasing cows behind curtains that will lower to become airtight (middle photo).

(Photo far right) Researchers spread different types of manure on color-coded field testing sites (note the flags of different colors).

In the last decade scientists have become increasingly concerned because methane has more than 20 times the global warming impact of carbon dioxide. New research suggests that livestock sources of methane have been undercounted by as much as half. Overall, agriculture creates 36 percent of human-related methane emissions, followed by natural gas systems (23 percent) and landfills (18 percent), according to a report, "Climate Action Plan: Strategy to Reduce Methane Emissions," released by the White House in March.

Methane isn't the only challenge. Another gas, nitrous oxide, is generated by nitrogen reactions in the soil and by the breakdown of manure. There is less of it, but nitrous oxide has 314 times the warming impact of carbon dioxide.

When this issue first surfaced around the turn of the century, the dairy industry was perplexed. Ruminants have been chewing their cud for millions of years, so wouldn't their impact already have been rolled into natural systems? But as human population has grown, so has the cultivation of animals to feed them. Examining the initial evidence, rough calculations and trends, the dairy industry had to acknowledge that methane and nitrous oxide from agriculture was a real, if poorly quantified, threat.

The industry responded by taking environmental stock. They surveyed 540 farms across the country, scores of processors, and 20 percent of the milk transportation system. Overall, dairy was responsible for 2 percent of total U.S. greenhouse gas emissions. It wasn't a massive number, but then that's the challenge of greenhouse gases: because practically every human activity contributes to the problem, solutions need to be found everywhere.

Just taking stock led to some easy reductions. For example, if you design milk truck routes so that they are always turning right, you'll avoid having those vehicles idling while they wait for traffic to clear. That kind of common sense can be easily implemented.

Methane and nitrous oxide are more intractable. Because this pollution is invisible, poorly understood and hard to measure, the first step is determining how much—and exactly where—it is being produced. Fortunately, the challenge ties deeply into husbandry. Ever since our ancestors milked the first cow, we've been tirelessly working to improve the yield. In part, that's what helped establish Wisconsin as a dairy state: Our climatic sweet spot gave farmers an edge.

Modern dairying has taken productivity much further, drawing upon everything from nutritional advances and facility design to genetics. Most recently, dairies are shifting to thrice-daily milking to maximize production. Add up all of this tweaking, and you'll find the carbon footprint of a gallon of milk has dropped 64 percent since 1946. "That's how we got to this 25 percent goal" for reducing greenhouse gas, says Erin Fitzgerald, the senior vice president for sustainability at the Innovation Center for U.S. Dairy in Chicago. "Sometimes where you've been is also an indicator of where you can go."

From a business angle, there are about 20 major variables that dairy producers follow—everything from energy consumption and manure management to forage formulas and managing herds. These shape the bottom line, but many of them, particularly energy use, also drive greenhouse gas production.

But with so many variables, the problem was too big. "Sustainability is super complicated. If every single producer had to do its own carbon footprint, nobody would have done it," Fitzgerald explains. Dairy CAP will distill that information for producers. "You're working in an industry where there is an incredible ethos to do the right thing. If you can put that information in the right hands, what would they do?"

Marty Matlock's job is to help read the climate crystal ball. A professor of biological and agricultural engineering at the University of Arkansas who's also conducting research for Dairy CAP, he's been thinking about agriculture and climate change since he heard NASA's Sally Ride speak about it in 1996.

A lot of ink has been spilled since then, but the overall picture has not changed. "The evidence is clear that we are seeing more frequent and intense extremes," Matlock explains. "Dryer dries, hotter hots, wetter wets, colder colds." Never mind the politics, farmers understand that they've never seen

weather quite like this. "You have to be able to understand and manage for weather extremes, and be able to explain to your kids how to understand and manage for weather extremes," he says. "And we have to be able to anticipate 20, 30, 50 years from now what our challenges in production are going to be."

Drought and flooding have broadly affected feed price and availability in the last few years. The good news is, under every scenario available from climate modelers, the corn belt will be warmer and wetter, with a net increase in productivity. "What I can tell you is you'll probably be planting your soybeans earlier and earlier," says Matlock.

The bad news is increased intensity and frequency of extreme weather. "We under-predicted how fast change would occur. There was an assumption that the system was more buffered than it is. That's frightening, because that means the rate of change is going to increase," Matlock warns. "That translates to increased risks for the producer."

Dairy CAP should help reduce dairy's contribution to climate change, but Matlock says it will also help dairy farmers adapt. "This is not casting blame, this is improving efficiency. This is improving resiliency of dairy production," he argues. "And our ultimate goal is to give farmers and policy makers the tools to make better policy, to make our dairy producers more profitable, so that we have a viable, profitable dairy industry in 50 years."

Ignore climate change and we will undermine our dairy capacity, a process that may have already begun. "The risk of status quo is chaos, and chaos is bad for an industry that really is generational," he says. It takes a decade or more to build a good herd, and the recent drought and high price of forage have already forced herd reduction. "That means we're losing capacity, we're losing resiliency. It could take a decade to build those herd genetics back up," says Matlock.

"How can I prepare my farm? How can I stay in business given what's likely to be unfolding in the climate?" By now, the wise dairy producer may be asking these questions—and not finding clear answers.

"Dairy production systems in 10 years, and certainly in 20 years, are going to look different than they do now because the climate is going to be different," says Douglas Reinemann, a CALS/UW-Extension professor and chair of biological systems engineering.

This operational challenge is also an intellectual puzzle. Dairy CAP is tackling it through a detailed life cycle analysis—an accounting method that tries to account for the environmental impact of every input, process and emission, from producing the fertilizer to growing the crops to milking the cows and converting it to cheese. The cow itself is part of the model, after cropping and before manure management. Each piece is connected—how we feed a cow influences the nutrients in the manure, and manure application affects the next generation of crops. "And of course, milk production is central to the whole thing," Reinemann says.

Model building is a back-and-forth process: field scientists provide initial measurements and modelers build equations to explain the data. Equations that attempt to model reality are rarely perfect, but as the field scientists and the modelers pass information and questions back and forth, the models get better.

That's where Dairy CAP picks up the torch. Agricultural scientists have been working with local models for decades. Problems develop when you calibrate a model for Wisconsin and then take it to Nebraska. Dairy CAP involves a massive validation effort that will refine and adapt it to different parts of the country.

Farmers need to know how they can adapt, what changes they may need to make to their infrastructure and how, ultimately, climate change might affect crop and milk production. "What are the choices we have to create our future?" asks Reinemann. "We'll be able to give them much better advice than we can now."

Manure is probably dairy's single best opportunity for significant greenhouse gas reduction. When the industry made its reduction pledge, it had its eye on anaerobic digesters to harvest the manure methane, or biogas. It's a double bonus, capturing

(Left) Researchers prepare manure for field application collected from cows fed different diets.

(Right) BSE professor Rebecca Larson uses FTIR spectrometry (in wagon) to measure greenhouse gases being emitted inside the chamber (silver-covered apparatus on the ground). These measurements, along with soil samples, will be taken regularly throughout the growing season.

(Far right) Dairy CAP director and soil science professor Matt Ruark at the Arlington Agricultural Research Station, where some of the project's soil measurement work takes place.

methane that would otherwise enter the atmosphere, but also turning it into energy, preventing further emissions from burning coal or natural gas. "It's one of the largest tools we have to really limit emissions," says Rebecca Larson, a CALS/UW-Extension biological systems engineering professor and biowaste specialist who is leading the Dairy CAP manure team.

A visit to the Dane Community Digester in Waunakee, operated by Clear Horizons LLC, reveals this potential future. Tucked between three dairies in rolling landscape north of Madison, it operates at industrial scale. One steel tank accepts 100,000 gallons of liquid manure pumped daily from nearby farms. Waste from animal bedding goes into what the operator calls the "jacuzzi," a massive liquefying tank, churning and steaming in the cold. A smaller tank stores food waste delivered by local food processors.

All three waste types are mixed together and pumped into one of three 1.25 million-gallon digestion tanks where bacteria do the real work. The methane bubbles up, feeding two generators, each the size of a mobile home. At full capacity, the plant produces two megawatts of power, enough to power about 2,400 homes.

There's more. Each day about one semi-load of spent fiber is filtered from the tanks and sold for use as livestock bedding or soil amendments. Liquid waste is returned to the farmers, who can then use it to fertilize their fields. This facility is also an emergency option for farmers. A local farmer whose retention pond was failing, for example, offloaded 100,000 gallons in one weekend, averting disaster. And the operation is testing increasing phosphorus removal to help with local water-quality problems.

The whole thing may sound like science fiction, but—for the sake of comparison—Germany has more than 6,000 units like this installed, providing power for more than 4.3 million homes. The U.S. has just over 200 operating farm scale digesters, most installed in cooperation with the dairy industry. That should change as part of the new methane initiative announced by President Obama in March. This summer a partnership of USDA, EPA, the Department of Energy, and dairy will release a biogas roadmap, outlining strategies to increase adoption of digester technology and a range of other improvements.

Dairy CAP research will help guide this work, though for now, admits Larson, "It is a data-gathering nightmare." Analyzing manure means knowing where the feed comes from, the inputs into the feed, where and how the manure is processed and land applied, and even how much energy one particular manure pump uses. "You have to understand all the inputs and outputs to the entire dairy system in order to assess impacts and make informed recommendations," she says.

But such detail yields more precise ideas about how to reduce emissions by helping target areas with the greatest potential. Larson is already working on digester additives that might increase gas production and decrease the levels of corrosive sulphur.

Feeding electricity back into the grid is a big financial obstacle, but new technologies may cut that step altogether. For example, biogas can be cleaned and compressed for use as vehicle fuel. Biogas can also be used to make plastic; one company is exploring a system to manufacture plastic from digester methane.

Larson calculates that if digesters processed waste from half of the 1.26 million dairy cows in Wisconsin, it would yield a 6 percent reduction in greenhouse gas from the agricultural sector. Other less capital-intensive processes could yield further reductions when combined with digestion. "Although sometimes the numbers seem low, this is one piece of many that contribute to greenhouse gas emissions," Larson says. "It will be critical as we move forward that we take advantages in all sectors to reduce our overall emissions."

Working alongside climate scientists has opened her eyes to how critical it is to address climate change now—and how behind we really are. "Changes are coming," she says. "We are on the verge of realizing significant impacts from climate change, if not past it."

Back outside the methane monitoring stalls at the U.S. Dairy Forage Research Center farm, Mark Powell is reviewing some of the many scientific questions moving forward. Soil scientists, animal nutritionists and modelers are all looking ahead to the coming spring, planning experiments and anticipating equipment upgrades. Meanwhile, the manure of the future may be aging quietly in a row of blue barrels outside.

Dairy cows can't be accused of leading very interesting lives, but this particular group has a new flavor note in their silage: dried tannins harvested from trees native to Argentina. And everyone is curious to know how this tannin-treated manure affects the nitrogen cycle.

Nitrogen in the soil, whether from manure or synthetic fertilizer or produced by microbes, has to go in one of three directions. The farmer wants it to be taken up by the plants, but when that doesn't happen the nitrates either leach into the water or transform into nitrogen and nitrous oxide in the atmosphere.

Plants use the nitrogen to build protein, which the cows then transform into muscle and milk. Over the last 10 years, we've learned a lot about how feed affects milk production. Based on this research, feed mixtures in Wisconsin and beyond have cut crude protein from 18 or 19 percent down to 15.5 or 16 percent protein, lowering costs.

Measuring the efficiency of protein use allows farmers to finely tune feed mixtures and reduce the amount of nitrogen in the manure. "If we get farmers to reduce the crude protein in the diet, we can reduce on a statewide average ammonia emissions by 30 percent and nitrous oxide emissions by 8 percent," explains Powell. The tannins may further bind up the nitrogen, yielding even greater reductions, but those experiments are just starting.

Other research will assess how dietary changes affect milk production, the manure in the digester and soil resiliency. How does long-term management and crop rotation affect soil properties such as water retention and carbon storage? It was all complicated enough before adding greenhouse gases to the equation.

"We only control a handful of variables in any one study," explains Ruark. His specialty is nitrogen cycling, but he's spent much of the last year learning to speak the many different languages of this transdisciplinary project.

"I was trying to get engineers to talk to dairy nutritionists, and getting physicists to talk to education specialists, getting these diverse people in the same room. We don't necessarily understand each other completely, but we're moving forward," Ruark says happily. "Breaking down the silos, having that direct interaction. It's a unique experience for everybody involved."

Dairy, as noted, accounts for only 2 percent of total U.S. greenhouse gas emissions, and it's clear that getting reductions will be a challenge. It's easy to look at that math and get discouraged. Therein lies the ultimate challenge of climate change.

"We know that developing modern solutions to a changing climate requires a doubling down on collaboration—between farmers, governments, researchers and industry," Secretary of Agriculture Tom Vilsack said last year, soon after announcing the Dairy CAP grant. "We have got to think outside the box, work together and pool our resources to begin developing the next generation of climate solutions for agriculture. This is not a single, one-size-fits-all problem. We need a targeted approach geared to the particular challenge faced by each region."

Over at the Innovation Center for U.S. Dairy, Erin Fitzgerald is upbeat about the challenge. "I really come at it from a business perspective. I'll talk a lot about adaptation, preparedness, risk mitigation, long-range planning, looking for efficiencies," she says. "I haven't found a farmer who doesn't understand it at a more granular definition."

And if there is an underlying strength to Dairy CAP, it's the buy-in from the dairy industry—its realization that not only was climate change a threat to business, it also was part of the problem, and thus part of the solution.

"If we can get the information in the hands of the people who are using it, we think that is what's going to drive incremental improvement," says Fitzgerald. "Stewardship, to me, is a value, it's something that we aspire to. Sustainability is about making it work in your business model."

the mysteries of RNA

For decades DNA has stood in the spotlight of biological research. But scientists at CALS and across campus have also long been intrigued by its chemical cousin, RNA—and are working to shed light on a surprisingly versatile molecule that holds great promise for human health.

By Nicole Miller MS'06

Photo by Sevie Kenyon BS 80 MS 06

Biochemistry professor Aaron Hoskins (left) and graduate student Joshua Larson use lasers to study how cells process messenger RNA.

For people who know about RNA mostly from its place in the central dogma of biology—DNA→RNA→Protein—this story may hold a number of surprises.

That handy equation, taught in Biology 101 courses around the globe, sums up the flow of genetic information in living organisms: how our DNA gets copied into RNA, which then gets converted into proteins, the building blocks of our cells, our bodies.

Originally, the RNA referred to in this equation—messenger RNA, or mRNA, the type that codes for proteins—was the only kind known to science. However, over the years it has become clear that there are many, many other kinds.

"The world of RNA has proven to be a big and fascinating place," says Marv Wickens, a CALS professor of biochemistry and leading pioneer in RNA research. "I've come to think of it as a Fellini movie, full of strange and unexpected characters."

These Felliniesque characters are all the non-coding RNAs that exist in nature—the kinds that don't code for proteins. They go by names like small interfering RNA, piwi-interacting RNA, microRNA, long non-coding RNA, small nuclear RNA—and the list goes on and on. Together they far outnumber messenger RNAs in the cell; while only 3 percent of the human genome gets made into proteins (via messenger RNA), a full 80 percent gets copied into RNA.

What are all of these other RNAs doing? Lots of important and surprising things, scientists are discovering.

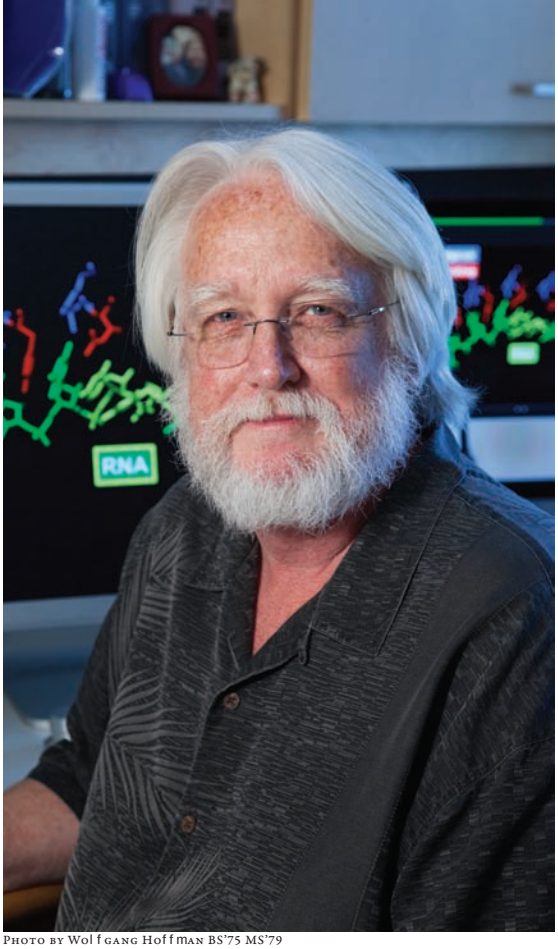


Photo by Wolfgang Hoffman BS'75 MS'79

Biochemistry professor Marv Wickens serves as the hub of UW–Madison's RNA community.

Over the past few decades, RNA, a close chemical cousin of DNA, has proven itself to be a much more versatile molecule than originally thought—far more than just a passive messenger.

The first big surprise came in the 1980s when it was shown that RNA can have catalytic activity, meaning that it can perform chemical reactions inside the cell. Originally assumed to be inert, like DNA, scientists found RNA molecules that could edit their own sequence—expunging a segment of their own genetic code. Later, RNAs were discovered at the heart of important cellular machines, or enzymes, performing critical catalytic reactions, including those at the heart of the cell's information transfer system. Previously only proteins were thought capable of such enzymatic feats.

These findings, it's interesting to note, support the idea that RNA may be the original material of life. With them, RNA has two things going for it: it's made of heritable genetic material and it's chemically active.

"You could imagine you have a little RNA molecule that develops the capacity to copy itself—and now you're off," says Wickens.

More recently, scientists were surprised to discover that microRNAs, which are short pieces of non-coding RNA, play a major role in regulating gene expression. They do so by binding directly to messenger RNAs and altering the amount of protein the messenger RNAs produce. Scientists now believe that microRNAs may be regulating as many as 60 percent of human genes this way.

"It was a revolution. These microRNAs had been completely invisible to us," says Wickens. "We now know that there are hundreds of these RNAs that affect gene expression. They're involved in cancer and in other diseases—they're everywhere."

Yet many RNA mysteries remain. And CALS researchers, as they have been for decades, are at the forefront of efforts to explore these unknowns, working from a variety of angles to shed light—sometimes quite literally, using lasers—on the next big questions in the field.

"For a while, RNA was kind of like the dark matter inside the cell. Everything was below the radar," says CALS biochemistry professor Sam Butcher. "Now we're at the point where we know it's there, and we're working to figure out what's going on."

UW's RNA community

The University of Wisconsin–Madison has a proud legacy of RNA research that goes back to the late 1960s, when members of the so-called "Ribosome Group" began to hit their stride. The group included CALS biochemist Masayasu Nomura, who figured out how to assemble the ribosome—the RNA-powered enzyme that converts messenger RNA into proteins—in a test tube, and biochemist Julian Davies, who discovered that many antibiotics work by interfering with the ribosome. Around the same time, Howard Temin, a professor of oncology in the School of Medicine and Public Health (SMPH) made a breakthrough discovery about how RNA retroviruses work—research that won him a Nobel Prize in 1975.

These figures drew other powerhouses to the UW campus—including RNA researcher Jim Dahlberg, now an emeritus professor of biomolecular chemistry in the SMPH—who then drew others.

"I came to the UW because of the RNA community that existed, because of the virology and the ribosome work being done here. So that's what made the job attractive—and I think we've kept that going," says Dahlberg.

Indeed, UW–Madison's RNA research community is considered among the top in the world. Faculty working in RNA hail from more than a handful of CALS departments, including bacteriology, biochemistry, genetics, nutritional sciences and plant pathology, as well as a number of SMPH units. Many focus on eukaryotic systems, while some stick to bacteria. Some use genetics-based approaches, while others apply the tools of biochemistry, chemistry, biophysics and even physics. Some are lifelong RNA researchers, while others "bumped into" RNA in the course of their work.

It's a very diverse group, yet they don't stick to their silos. Beginning in 1988, they started coming together regularly as members of the RNA MaxiGroup, an organization founded by Wickens to help foster scientific discussion and research collaborations among this far-flung group. Wickens, who is widely seen as the hub of the UW's RNA research community, has been running things ever since.

"He's been the main driver in keeping things going," says Dahlberg.

Through Wickens' vision and effort, the group has helped transform the UW's RNA researchers into a cohesive community. The group gathers for

monthly seminars that draw top RNA researchers from around the globe to speak on campus, bringing in fresh ideas and increasing the visibility of UW research. These gatherings have also helped spark numerous cross-department and cross-college collaborations.

"There's a really wonderful environment here for RNA researchers," says Butcher, who is involved in a long-standing collaboration with an SMPH colleague.

Collectively the group is exploring some of the most pressing questions in the RNA field: how messenger RNAs are regulated; what the spliceosome—the enzyme that edits messenger RNA—looks like and how it works; the phenomenon of RNA interference; the role microRNAs and other non-coding RNAs play in the cell; and others. This work is helping to push back the dark edges in our understanding of RNA and pave the way for important medical breakthroughs down the line.

The following is a selection of exciting RNA projects to emerge from CALS.

Insights into mRNA regulation

Ever since Wickens joined the CALS biochemistry faculty in 1983, he's been in the vanguard of efforts to understand how messenger RNAs (mRNAs) are regulated—how their protein production is controlled—with a particular interest in how that regulation impacts embryonic development, cell growth and memory.

Early on he focused on how the ends of mRNAs are formed, which at the time was largely a mystery. His team made a major discovery about the poly(A) tail, the long string of adenine ("A") residues at the end of mRNA molecules (see Figure 1). They found that cells can tack on more "A" residues to the end of the poly(A) tail to ramp up an mRNA's protein output, and then remove them to dial things back—and that animal embryos regularly rely on this trick during early development to quickly boost production of important proteins at key moments.

Next, Wickens began exploring another regulatory region found in mRNA molecules known as the 3′ untranslated region—or 3′ UTR—which is full of binding sites for regulatory proteins and non-coding RNAs that impact protein production. Wickens started hunting for these binding sites—and their corresponding binding factors—but was frustrated by the lack of tools available to do this kind of work. So he helped devise one: the Yeast Three Hybrid System, a powerful test that is now widely used in labs around the world and has facilitated a string of major discoveries.

Simplified structure of a typical human protein coding mRNA, including the untranslated regions (UTRs)

Figure 1
mRNA Structure

Wickens and University of Washington biologist Stan Fields came up with the idea over dinner one evening. The test, in which a motley assortment of molecules must line up to give a positive result, gives researchers a way to find out which proteins bind to a particular piece of RNA, or vice versa.

"It seems so Rube Goldberg, and it's kind of preposterous that it works—but it does," says Wickens. "And all you want to know is if these two guys—an RNA molecule and a protein—interact."

One early and high-impact use of the Yeast Three Hybrid System took place in the form of a collaboration between Wickens and CALS stem cell researcher Judith Kimble, even though—at the time—working together was something that both Wickens and Kimble, who are married, had hoped to avoid.

"I was over at Bock Labs running my lab, completely separate from Marv," explains Kimble. "As a woman professor, it was important to be independent, especially of my husband, but then my group stumbled into an interesting 3′ UTR, and Marv was the 3′ UTR expert."

Kimble's team had found what they believed to be a key binding site in the 3′ UTR of an mRNA that was important in cell fate decisions in the worm *C. elegans*. Kimble wanted to figure out what protein was binding to the site and collaborated with Wickens' group to fish it out using the Yeast Three Hybrid System. The test identified FBF, a member of the now widely studied PUF family of proteins.

Although they made this discovery in *C. elegans*, PUF proteins have turned out to play important roles in organisms from yeasts to humans. It's now clear that these proteins, which bind to and regulate a broad spectrum of mRNAs, are important in early development, stem cell maintenance, and even learning and memory. Groundbreaking work in this area by Kimble and Wickens has helped spark interest among other scientists.

"Now there's a little cottage industry of people trying to figure out what these proteins do," says Wickens.

Cracking the spliceosome

One holy grail for the international RNA community is to crack the spliceosome—to figure out what it looks like and how it works. Two CALS scientists are participating in this effort.

The spliceosome, the enzyme responsible for editing messenger RNA (mRNA), is an amazing cellular machine. Its job is to process "pre-messenger RNA" into "mature" mRNA. To do so, the spliceosome removes unwanted segments in the pre-messenger RNA, called introns, and stitches together the keepers, called exons. The enzyme, remarkably, is able to mix and match the exons. So, from the same gene, it creates different mRNA products in different tissues, as called for (see Figure 2). This process, known as alternative splicing, is extremely prevalent in humans, affecting more than 90 percent of our genes.

This phenomenon is partly responsible for making humans the complex creatures that we are, notes Aaron Hoskins, a CALS professor of biochemistry. While humans don't have all that many more genes than *C. elegans* or fruit flies, he points out, "One thing we do a lot more than any of those organisms is edit our RNA."

The spliceosome itself is a massive structure, with small nuclear RNA (snRNA) at its catalytic core performing the splicing reaction. It's composed of five major subunits that assemble step-wise to form a whole, functioning enzyme. Once assembled, the spliceosome performs a single splicing reaction and then falls apart.

Although the spliceosome is a large enzyme, it's still too small to see with a microscope. And because it's in constant motion—building up and falling apart—it's proven to be very difficult to study, particularly for scientists who'd like to crystallize it and figure out its three-dimensional shape, known as "solving" its structure.

But CALS structural biologist Sam Butcher is undeterred. He's tackling the challenge one piece at a time. As part of a long-standing collaboration with SMPH biomolecular chemistry professor David Brow, the two recently crystalized and solved the 3-D structure of U6, the snRNA believed to be the spliceosome's key catalytic component, bound to a nearby protein (see Figure 3).

Figure 3
3-D Structure of U6*
(RNA shown in red)

"It's a beautiful crystal that we're really excited about," says Butcher. "And we found something about the structure that we never expected, that no one has ever seen before, in fact—the RNA and the protein are intimately entwined."

Down the line, explains Butcher, this section of the spliceosome could be combined with other sections—like pieces of a puzzle—to assemble a full picture of the enzyme.

"The idea is if we can finally see it, then we can start asking better questions about how it works," says Butcher.

For his part, Hoskins is shedding light on how the spliceosome assembles—quite literally—by zapping it with lasers. Hoskins uses an approach he helped develop called co-localization single molecule spectroscopy (CoSMoS) and was the first to apply it to complex cellular machines such as the spliceosome.

The approach involves attaching fluorescent dyes of various colors to molecules of interest—such as spliceosome subunits and RNA molecules—and then watching them interact by shining lasers on the sample. Different lasers—blue, green, red and orange—cause the

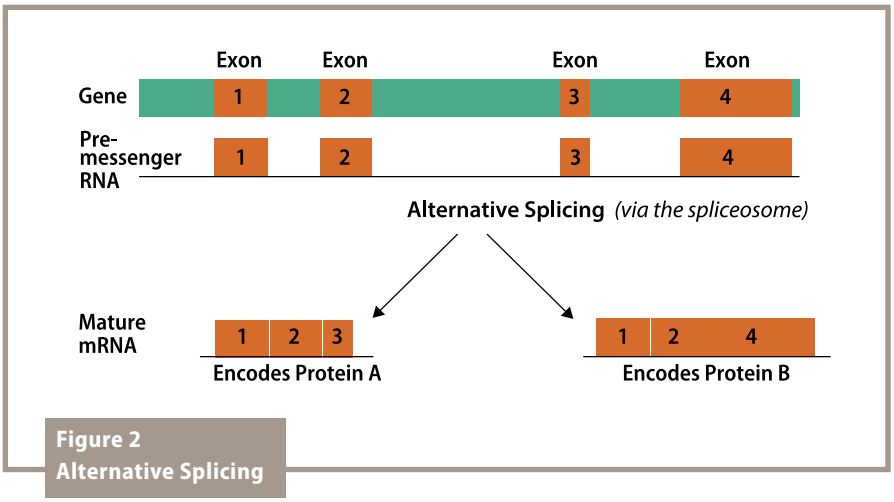
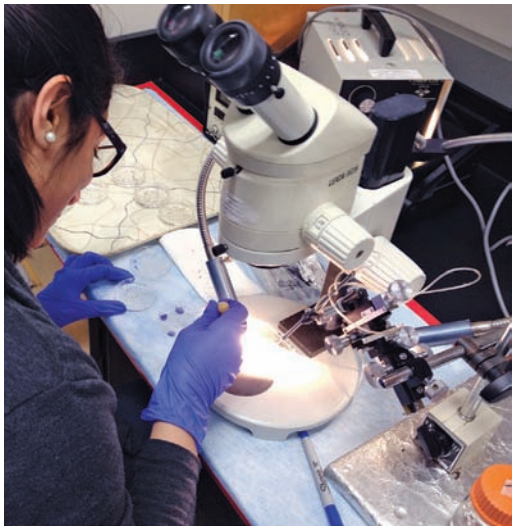
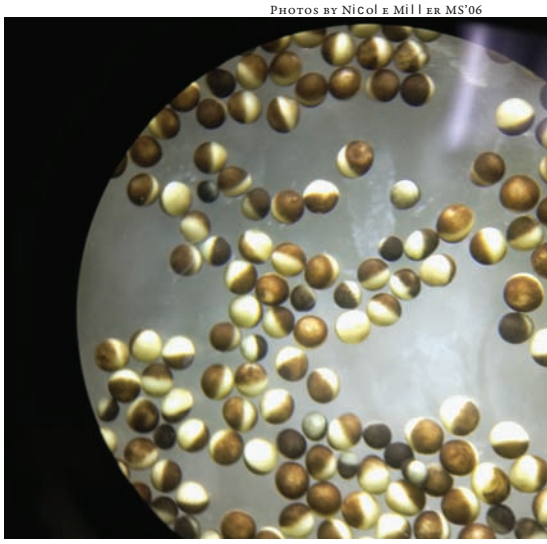


Figure 2
Alternative Splicing

*Montemayor, E.J., Curran, E.C., Liao, H.H., Andrews, K.L., Treba, C.N., Butcher, S.E. and Brow, D.A. (2014). Core structure of the U6 snRNP at 1.7 Å resolution. Nat. Struct. Mol. Biol., Epub ahead of print, http://dx.doi.org/10.1038/nsmb.2832. This structure is a CALS/SMPH collaborative project between the labs of Sam Butcher and David Brow.

Photos by Nicole Mill | ER MS'06





In biochemistry professor Marv Wickens' lab, graduate student Shruti Waghray injects RNA into frog eggs to study the workings of the poly(A) tail.

different dyes to emit light. The way it works, Hoskins' team can actually focus in on a single molecule at a time and get a kinetic picture of how it's interacting with the other dye-labeled molecules. This research is revealing valuable information about the order of splicing events and how the spliceosome "knows" which mRNA to make. Understanding how this process occurs is essential for understanding how one version of an mRNA can be produced in lung tissue, for instance, and a different form in heart tissue, despite both RNAs originating from the same gene.

"We're using this approach primarily to study how all the pieces of the spliceosome come together at the right location at the right time," says Hoskins, who is also developing methods to perform similar experiments inside live cells in real time. "That's where this project is going."

Applications in human health

It's not hard to imagine that many basic RNA research projects could one day lead to medical breakthroughs—and in many cases, including on the UW campus, they already are doing so.

We live in a time when antibiotics are losing their power, and new ones are desperately needed. This could come from the kind of work being done by CALS bacteriology professor Karen Wassarman, who studies a small RNA in bacteria known as 6s RNA. Wassarman figured out how 6s protects bacterial cells from stress, helping them slow their growth and conserve energy during times of nutrient scarcity. The work, which revealed a novel mechanism of action for bacterial small RNAs, is just about as basic as it gets, notes Wassarman—yet it could one day reveal entirely new classes of RNA-based targets for antibiotics.

"Lots of small RNAs in bacteria are involved in stress response, which is exactly the type of thing we would want to exploit," she says.

There's also the prospect of capitalizing on RNA interference, the phenomenon where the introduction of small interfering RNAs (siRNAs)—which are a type of short, double-stranded RNA—into a cell causes the cell to "turn off" the expression of genes that look similar to the inserted siRNA.

"These siRNAs could be extraordinarily useful. Say someone has a disease that's caused by having too much of gene X. Well, if you could give them a little RNA trigger to turn off gene X—problem solved," says SMPH genetics professor Scott Kennedy, who studies the heritability of RNA interference. "siRNAs could be very potent drugs. That's something people are working on right now."

MicroRNAs, on the other hand, are already starting to prove themselves useful in diagnosing, understanding and monitoring cancer. In limited cases, doctors have begun screening cancer biopsies for their microRNA profile, looking for information about the nature of the cancer, including where it originated in the body, its aggressiveness and whether it's responding to treatment.

And this heralds a much larger medical advance on the horizon: the screening of a person's transcriptome, the full complement of RNAs in their various tissues. While genome sequencing tells a person what genes they have, the transcriptome could reveal much more, including information about what forms of messenger RNA are being made from a given gene in various tissues (via alternative splicing) and how that expression is being regulated.

Closer to home, a number of UW labs have made RNA-related discoveries that are being developed into commercial products by biomedical companies. CALS biochemistry professors Laura Kiessling and Ron Raines founded Quintessence in 2005 to develop a cancer-fighting compound. The drug candidate, an altered enzyme, preferentially destroys RNA in cancer cells, killing the cells. Phase I clinical trials of the drug recently wrapped up, with promising results.

Companies that have arisen from RNA discoveries made in SMPH labs include Third Wave Technologies, which was co-founded by Dahlberg in 1993—and later bought by Hologic in 2008—to commercialize a method for quantifying microRNAs. Another is PTC Therapeutics, a New Jersey-based company that's developing basic discoveries made in a UW oncology lab by alumnus Stuart Peltz into drugs that target RNA to treat a wide range of diseases.

And, across campus, there may well be more.

It's impossible to know when the next big RNA discovery or medical application will occur—or what it will be. But as long as our scientists continue to probe the remaining dark matter of RNA, we can rest assured that more discoveries and more applications will come.

in the field


Chris Barrett


Jessica Bateman


Rogier van den Brink


Diana Fletschner


Joseph Glauber

Chris Barrett PhD'94 Agricultural and Applied Economics • In January Chris Barrett began a new position as the David J. Nolan Director of Cornell University's Charles H. Dyson School of Applied Economics and Management, whose undergraduate and graduate programs rank in the top five nationwide. Barrett takes on that leading role in educating applied economists at a crucial time for the field, he says, citing global challenges posed by the rapid growth in demand for food, feed, fuel and fiber. As a CALS graduate student Barrett found a collaborative network of scholars and practitioners who have been formative in his success as both a teacher and a scholar. Among Barrett's experiences as a CALS student, he fondly remembers enjoying Babcock ice cream with his children while watching the UW Marching Band practice.

Jessica Bateman BS'05 MS'11 Agricultural and Applied Economics • Jessica Bateman's experiences at CALS, which included a health and nutrition study abroad program in Uganda and a course called World Hunger and Malnutrition, were formative in her decision to pursue a career in agricultural economics. Today Bateman is the nutrition technical quality coordinator for Mawa, a USAID-funded Feed the Future project with roots in Zambia. Collaboration with her Zambian colleagues and interacting with communities in the field are the most rewarding aspects of her career, she says. Bateman's role in developing community-based approaches to improving nutrition allows her to witness small changes that greatly benefit the health of children, in particular. Those approaches include promoting consumption of locally produced foods, cooking demonstrations and training field staff in nutritional lessons for community outreach.

Rogier van den Brink PhD'90 Agricultural and Applied Economics • As a Washington, D.C.-based lead economist with the World Bank in the department of poverty reduction and economic management, Rogier van den Brink works on economic policy and related concerns with a number of countries in Southeast Asia, his region of interest. Recently he helped establish a multimillion-dollar budget in support of relief operations following Typhoon Haiyan in the Philippines. Now a Distinguished Alumni Lecturer with UW-Madison, van den Brink became aware of the "special powers" of agriculture in reducing poverty while a student at CALS, he says, a lesson that his career continues to affirm. When he's not working, van den Brink pursues music production, an interest he discovered at Amy's Cafe and Bar in Madison. Sometimes he mixes work and pleasure, most recently when he recorded an album, "Zsa Zsa Exactly," while in Mongolia. Proceeds from the album will go to Typhoon Haiyan relief efforts.

Diana Fletschner MS'95 PhD'02 Agricultural and Applied Economics • China, Colombia, Russia, Peru and Uganda are just some of the places in which Diana Fletschner has had the opportunity to work. Fletschner serves as senior director of research, monitoring and evaluation for the Seattle-based NGO Landesa, which works to secure land rights for the world's poorest populations. Fletschner's role includes evaluating projects, fostering a network of professionals aimed at strengthening women's land rights, and supporting national and international advocacy of land issues. For Fletschner, being a CALS student served as a platform for exploring new experiences from around the world as well as the opportunity to build formative relationships with "mentors with a capital M," as she puts it.

Joseph Glauber PhD'84 Agricultural and Applied Economics • Henry C. Taylor, the first chief economist with the USDA, was a Badger—and today another alum, Joseph Glauber, holds that title. Glauber's duties include preparing the department's agricultural forecasts and projections as well as advising the Secretary of Agriculture on the economic implications of agricultural legislation. Time spent around the chalkboards discussing and debating economic issues belongs to Glauber's fondest memories of CALS. He will also forever value the Department of Agricultural and Applied Economics for its diversity and an open climate that facilitated forming lifelong friendships. In his free time Glauber bikes 3,500 to 4,000 miles a year, including commuting to work—a hobby, he explains, that balances his love of food.

David Kaimowitz MA'86 PhD'87 Agricultural and Applied Economics • Challenges facing marginalized rural groups—including chronic poverty, competition over land and environmental degradation—are just some of the issues that David Kaimowitz addresses as the Ford Foundation's director of sustainable

Alumni from Agricultural and Applied Economics

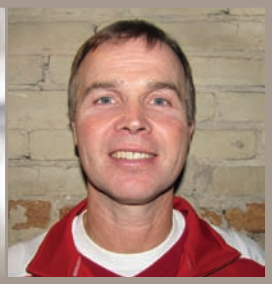
—By Claudia Roen


David Kaimowitz


Bruce Larson


Jerry Steiner


Thomas Wegner


David Welsh

development. His efforts include negotiating grants, designing strategies for meeting the needs of particular groups, and monitoring the effectiveness of those strategies. The importance of institutions and property rights was instilled in Kaimowitz during his time at CALS and has proven relevant in nearly every economic problem the world faces, Kaimowitz notes. Kaimowitz misses the "luxury," he says, that came with being a CALS student—being able to explore new ideas and theories, hear from professors who are leaders in their fields and browsing endlessly through the library stacks. On that wistful note Kaimowitz encourages current students to take full advantage of the enormous opportunity they have at CALS.

Bruce Larson MA'84 PhD'87 Agricultural and Applied Economics • Bruce Larson, a professor of international health at Boston University's School of Public Health, considers his research on HIV/AIDS and improving health delivery and services in Africa to be among the most rewarding achievements of his career. His experiences in the field also have demonstrated the global presence of CALS. While on sabbatical in Kenya investigating a particular course of treatment for HIV-infected adults, nearly 20 years after leaving Madison, friends he had met while at CALS were living in Nairobi and were instrumental in Larson's transition to life in Kenya.

Jerry Steiner BS'82 Agricultural and Applied Economics • Until retiring in 2014, Jerry Steiner served for a decade as the Monsanto Company's executive vice president of sustainability and corporate affairs. His goal was to help farmers produce more food while conserving valuable resources throughout the dozens of countries in which Monsanto conducts business. His work involved ensuring that farmers had the opportunity to choose new technology, including genetically modified seeds. One of his proudest moments was forging partnerships with the Gates Foundation that led to delivering drought-tolerant corn to African farmers. Steiner worked with CALS faculty to co-found Field to Market, an NGO that brings together farmers, agribusinesses, and food and fiber companies to promote sustainable production. Now based in St. Louis, Steiner returns to Madison every year for Badger football.

Thomas Wegner BS'81 MS'83 Agricultural and Applied Economics • Thomas Wegner currently serves as director of economics and dairy policy for Land O'Lakes, Inc., a position that calls for him to monitor national, regional and state regulatory issues affecting dairy farmers and Land O' Lakes as a member-owned cooperative. Wegner works alongside cooperative marketing agencies and strives to keep members informed of changes in federal and state milk marketing regulations. While at CALS Wegner developed an economic analysis approach that has proven invaluable as he evaluates the costs and benefits of federal agriculture policies from the perspectives of a farmer-member, a food processor and a government administrator. In his free time Wegner enjoys walking his dog and patronizing the burgeoning microbreweries of Minneapolis.

David Welsh BS'90 Agricultural and Applied Economics • As a corn specialist for Crop Production Services, David Welsh works directly with farmers in Wisconsin in an effort to maximize their corn yields and profits. Welsh's time at CALS proved integral to his future success. While a student, he was able to participate in two internships that helped jump-start his career, in addition to providing him with invaluable work experience. Welsh also was active in Alpha Gamma Rho, a professional agricultural fraternity. Today Welsh enjoys coaching his children in youth athletics and giving back to CALS through his service with WALSAA.

About *In the Field*

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

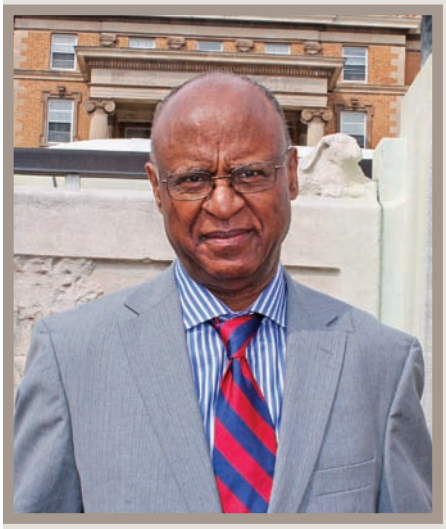
Know a CALS grad whose work should be highlighted in *Grow*? E-mail us at: grow@cals.wisc.edu

Next issue: Alumni who are making their mark in plant breeding.

Catch up with …

Kifle Gebremedhin MS'75 PhD'78 Agricultural Engineering*

As a professor of agricultural and biological engineering at Cornell University for more than three decades, Kifle Gebremedhin is in a prime position to offer young people advice about the field. His contributions have been wide-ranging, particularly in the areas of animal thermal stress physiology and design of post-frame buildings. Two of his findings have become the basis for national standards set by the American Society of Agricultural and Biological Engineers.



But Gebremedhin is in a good position to offer life lessons as well. He recently visited the CALS campus to give two technical presentations—and one, for BSE students, that served to inspire. His talk, titled "Be the Best You Can Be," emphasized hard work, persistence and flexibility—values that have served him well through many challenges.

Gebremedhin grew up on a family farm in Eritrea, a small country in the Horn of Africa. Although he was gifted academically, his parents could only afford to send him to a vocational high school rather than a university prep school because it offered room and board. That put him on track for a diploma program rather than a more prestigious degree program in college, which he attended in Ethiopia. An uncle who had earlier settled in Wisconsin helped him relocate and eventually attend the University of Wisconsin–Platteville, where he earned a B.S. in civil engineering. For graduate study at UW-Madison, however, he was able to get financial support only if he switched to agricultural engineering—a field for which he developed a great passion.

• What made you fall in love with biological systems engineering?

It was through my research. I was working with animals in the Biotron [a controlled environment facility for biological research]. I raised three calves from their first week to eight weeks of age inside a chamber I'd built, measuring how much heat they produced. It was from that relationship that I came to love biological systems—the interface between the biological object and the engineering becomes very interesting. I'm still working on thermal stress physiology of animals.

• You have some pretty funny stories about your first day in Wisconsin.

I came here in January. I had no idea about snow. The only thing I knew was hail. When I was leaving the plane, the flight attendant said, "You can't go out like that. It's cold outside. Why don't you take a blanket and throw it around you?" I said, "Don't worry." When I got out, it was so cold, I went back to get the blanket. The flight attendant said, "I told you so."

• How does it feel to be back here?

So many firsts happened to me in Wisconsin. My first experience with snow, I got married here, my first child was born here, I got my first degree at UW–Platteville, my master's and Ph.D. at UW–Madison, and I started my academic career here. So this is my second home. I have a fond relationship with Wisconsin.

• Your talk for students emphasizes global challenges (adequate food, water and energy supplies, clean air, soil health, etc.). Why?

I want them to think globally—and to think about how biological systems engineers can help meet those challenges, from the smallest to the largest ecological systems.

—Joan Fischer

* Now Biological Systems Engineering (BSE)

Honoring Our Teachers

Robert R. Spitzer in his home in Burlington. Books and essays he authored, along with notes, awards and memorabilia from his business and service travels around the world, are being given to the Wisconsin Historical Society, which a few years ago honored him with the Charles Van Hise Award for Distinction in Education.

Photo by Andrea Engebretson BS'96, MS'99

Robert R. Spitzer BS'44 MS'45 PhD'47 has held such positions as president and CEO of the agribusiness firm Murphy Products, president of the Milwaukee School of Engineering and head of the U.S. State Department's Food for Peace program.

But as the son of hardworking tenant farmers in rural Wisconsin, he understands the value of financial support. When Spitzer went off to study at UW-Madison in 1940 he received a $100 scholarship from Sears, Roebuck & Co.

"That $100 was a big number back when tuition was very modest," says Spitzer. "I felt from day one that I owed a lot of people."

During his time at CALS, where he eventually earned a bachelor's degree in agriculture and master's and Ph.D. degrees in biochemisty and animal nutrition, Spitzer learned from some of the college's most illustrious figures. "I worked in a lab next to Harry Steenbock," he says. "Conrad Elvehjem was one of my teachers." Other early influences included E.B. Hart, Henry Ahlgren and Mike Foster.

"All these men happened to be not only good scientists but people of breadth and vision," recalls Spitzer. "The teaching was not only about dairy chemistry or organic chemistry—it was teaching about culture, and about obligation and opportunity."

The importance of good teaching stayed with him. "When I got out in industry I saw research recognized and I got the feeling that the teaching end of things needed more light on it," he says. "And so in 1968 we established an outstanding teacher award at my company."

When the company was sold, Spitzer stepped up to personally ensure that the award continued by establishing a fund at the UW Foundation and designating a portion of his estate to benefit future generations. The Spitzer Excellence in Teaching Award each year provides recognition and $1,000 to a worthy CALS educator.

"It's motivational," says this year's winner, Ronald L. Russell, a senior lecturer in animal sciences. "It drives me to want to do an even better job on the teaching front."

Spitzer continues to serve in various civic organizations and on corporate boards—for example, he's a director and senior mentor with Kikkoman Foods, Inc.—and, with his wife, Delores, advocate for the things he cares about.

Ensuring an adequate food supply for all—the subject of his book, *No Need for Hunger*—is one of his most abiding passions.

"To me the true avenue to peace in the world is agriculture training and agricultural independence so that people have enough to eat—and the pride that goes with that kind of life," he says.

—Joan Fischer

For information about establishing funds, designating a portion of your estate, or making a gift to CALS now, please contact Sara Anderson at the UW Foundation, tel. (608) 263-9537, e-mail Sara.Anderson@supportuw.org.

nextSteps

CELEBRATE AG AROUND THE STATE at Agricultural Research Station events for the public. Here's a partial list to get you started:

Arlington: Agronomy/Soils Field Day, **August 27.** ***Hancock*** Wisconsin Potato and Vegetable Grower Field Day, **July 22**, Albert Horticulture Garden Open House, **August 5**—also see WALSAA Farm Tech Days Picnic below. ***Kemp:*** "Turning Wood into Art" workshop, **July 8–12.** ***O.J. Noer:*** WI Turfgrass Association Summer Field Day, **July 29.** ***Peninsular:*** The Garden Door Open House, **July 12,** Taste of Garden Door, **September 6.** ***Spooner:*** Sheep Day, **August 16,** Twilight Garden Tour, **August 19.** ***West Madison:*** Urban Horticulture Day, **August 9.** For more information, visit **http://ars.wisc.edu/**

GET YOUR STATE FAIR ON with CALS at UW Day on **Wednesday, August 6**. Festivities include hands-on scientific demonstrations, performances, games and, of course, the pep rally and parade. More information at **statefair.wisc.edu.**

VISIT US at **Wisconsin Farm Technology Days,** this year taking place in Portage County at Blue Top Farms & Feltz Family Farms **August 12–14**. More information at **wifarmtechnologydays.com**. And be sure to attend the **WALSAA Farm Technology Days Picnic** on **Wednesday, August 13**, 3:30-7:30 p.m., at the Hancock Ag Research Station. Entry is $15 per person, which includes picnic dinner, beverages and tours.

BACTERIOLOGY'S 100th anniversary will be marked on **Saturday, August 30,** to include food, presentations, tours and other events. More info at **bact.wisc.edu**.

MARK YOUR CALENDARS for **Football Fire-Up** on **Saturday, September 6**, before the game against Western Illinois. Location: Parking lot of the University of Wisconsin Foundation, 1848 University Avenue. Time TBA. New this year: guests will be able to register and pay online. More information at **walsaa.org**. Also mark your calendars for **CALS Honorary Recognition** on **Thursday, October 16,** as well as **"The Science of Supper Clubs,"** a special CALS presentation at the Science Festival on **Friday, October 17** More info at **wisconsinsciencefest.org** and **cals.wisc.edu/honorary.**

For more information, go to:
www.grow.cals.wisc.edu

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Agricultural and Applied Economics

1. Name a market structure in which there are a small number of sellers:

a) monopsony
b) oligopoly
c) oligopsony
d) monopoly

Horticulture

2. The two environmental factors most often associated with floral induction are:

a) water and temperature
b) temperature and nutrients
c) temperature and light
d) water and light

Entomology

3. Where do Monarch butterflies from Wisconsin spend the winter?

a) Florida
b) The Gulf of Mexico
c) Costa Rica
d) Mexico

Community and Environmental Sociology

4. Fertility rates in China had their most rapid decline:

a) in the 1970s, before mandatory family planning policy was implemented
b) in the 1980s, immediately following the introduction of mandatory family planning
c) in the 1990s, after initial problems in implementing family planning were overcome
d) in the 2000s, as growing affluence led Chinese people to voluntarily limit reproduction

Animal Sciences

5. "Zoonosis" is:

a) zoo animal science
b) the study of disease in zoo animals
c) animal disease
d) human disease
e) human disease that is specifically transmitted from "lower" animals

LAST ISSUE: Answers were 1: C, 2: C, 3: E, 4: E, 5: F. Congratulations to Shana Lavin PhD'07, who was randomly selected from four people who correctly answered all questions. She wins a Babcock Hall cheese box.

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BUSY BEE

Congratulations to Mike Geiger, a graduate student in the Department of Horticulture, who was among 12 winners of this year's campus-wide Cool Science Image Contest. His photo shows a bumblebee alighting on borage, also called starflower. See all contest winners at http://whyfiles.org/2014/2014-cool-science-image-contest-slideshow/.