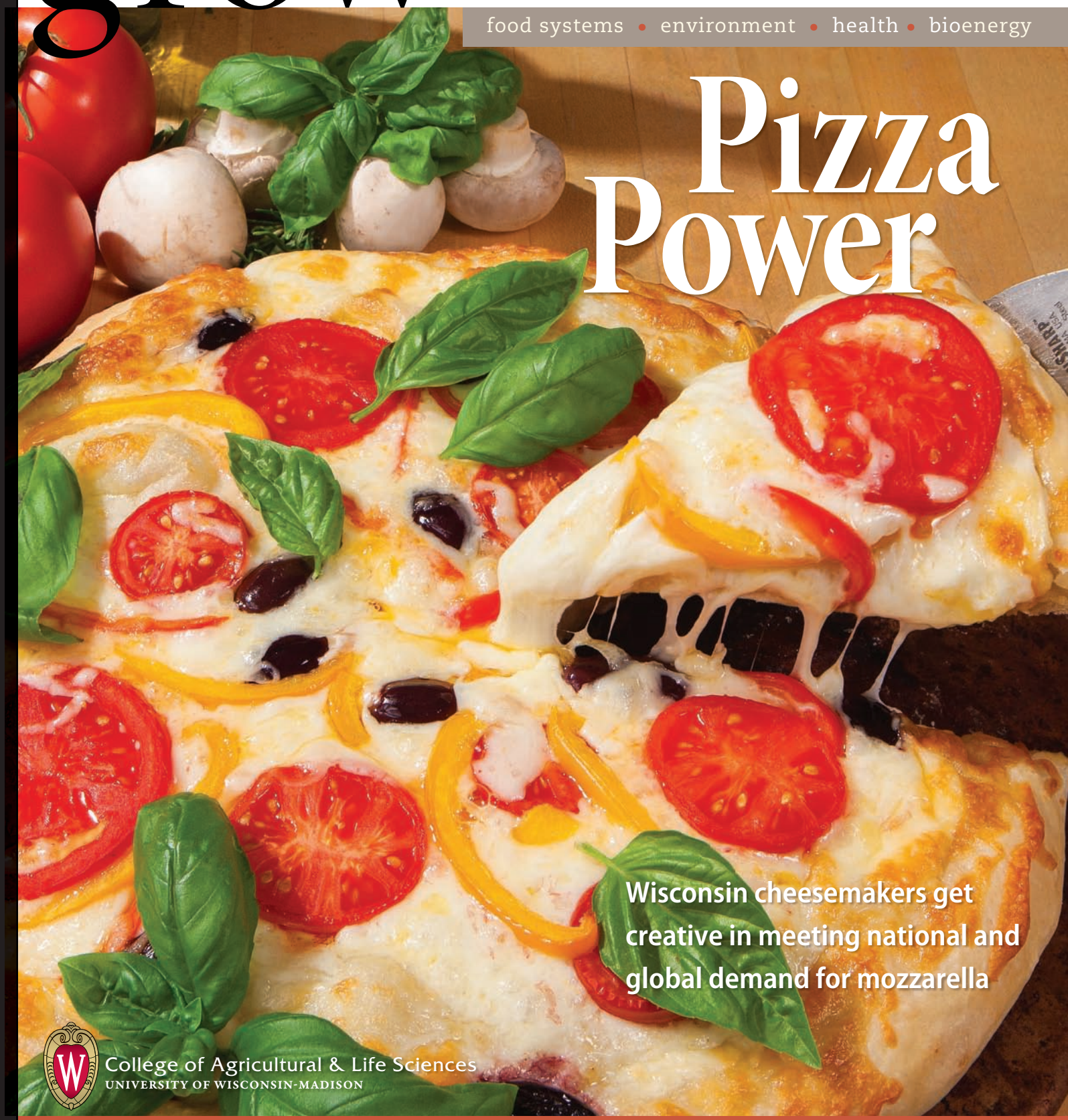
grow

Wisconsin's Magazine for the Life Sciences • Fall 2013

food systems • environment • health • bioenergy

Pizza Power



Wisconsin cheesemakers get creative in meeting national and global demand for mozzarella

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN-MADISON

MICROBES AND HUMAN HEALTH • SCIENCE MEETS TROLLS • FIGHTING SEPTIC SHOCK

A cow nuzzles her newborn at CALS' Marshfield Agricultural Research Station.

Volume 7, Issue 1 • Fall 2013

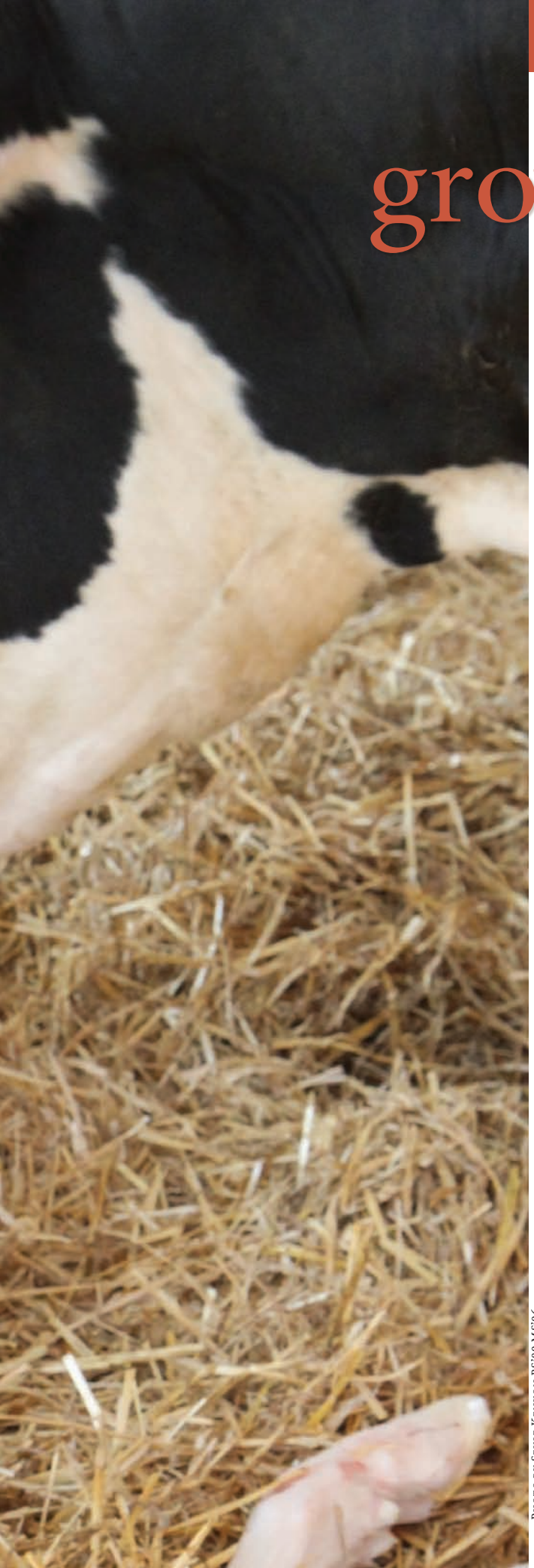


Photo by Sevie Kenyon BS'80 MS'06

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Wisconsin's Magazine for the Life Sciences

Cover Photo by Wolfgang Hoffmann BS'75 MS'79

Dean Kate VandenBosch

Growing Our Future

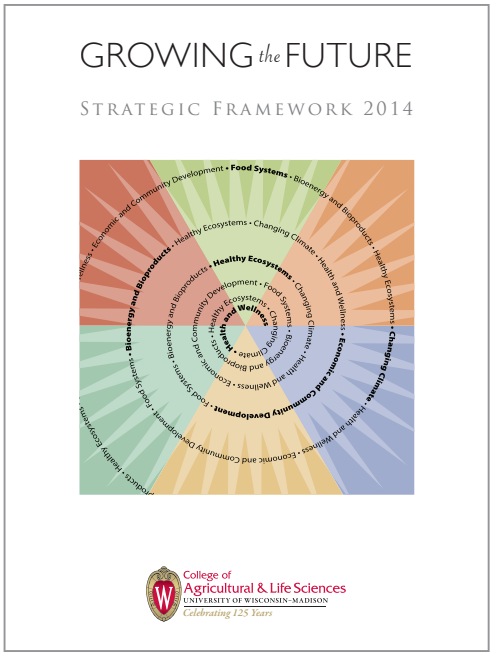
As you read the feature stories in this edition of *Grow*, I invite you to consider how they reflect the mission, vision, guiding principles and priority themes for our college as we've identified them in our strategic planning.

The enormous potential of microbes for enhancing human health—reflecting our priority theme of health and wellness—is sure to be a predominant area of research in the next decade as new tools continue to improve our understanding of how microbes work with us as human hosts as well as in the environment.

Our cover story on pizza cheese exemplifies our work in food systems (a priority theme) and crosscuts into another theme, economic and community development. Food development is one of the things CALS does best, and I look forward to seeing what unimagined products will result from our new dairy research facility—which, thanks to the hard work of so many members of the CALS community, is included in the 2013-2015 state budget.

As for our third feature, knowing how to communicate science effectively is a science in its own right. We speak to the overarching importance of science communication in the eighth of our guiding principles—and we are fortunate to have excellent national leadership in this area on our life sciences communication faculty.

> "As we map our future, the approaching year of 2014 offers an important occasion to reflect on our past."



Visit cals.wisc.edu/stratplan *to learn more.*

These stories reflect the cutting-edge activities we've been talking about this past year as we've discussed how CALS can best grow the future, as our new tagline states. The publication resulting from that work is posted at cals.wisc.edu/stratplan. We invite you to take a look!

As we map our future, the approaching year of 2014 offers an important occasion to reflect on our past. It's CALS' 125th anniversary, or "quasquicentennial." This milestone will give us a chance to celebrate our college's many achievements, which we plan to highlight throughout the year at such events as CALS Week and Honorary Recognition as well as in news stories and a social media campaign involving alumni and friends of CALS from Wisconsin and around the world.

What do you consider to be CALS' shining moments, past or present? And—to connect this milestone to our strategic planning—what activities should we pursue to ensure that the next 25 years will be as vibrant as the last? What do you think will be our next big ideas or breakthroughs? We're eager to hear your thoughts at CALS125@cals.wisc.edu.

grow
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Meat, With a Touch of Fruit

Protecting organic meats from deadly bacteria calls for developing new antimicrobial agents from natural sources

Photo by Wolfgang Hoffmann BS'75 MS'79

Kathy Glass and Jeff Sindelar seek to ensure the safety of organic meats by developing antimicrobials from fruits and vegetables.

When Jeff Sindelar talks about the ingredients he's working with, you'd think he was making juice. Not quite. He's adding things like cranberry concentrate, cherry powder, lemon extract and celery powder to meat.

But Sindelar, a CALS professor of animal sciences and a UW–Extension meat specialist, is not adding them for flavor. He's looking at ways to ensure that meat products labeled "organic" and "natural" are safe to eat.

Sales of organic and natural foods are booming, with double-digit percentage gains almost every year. As more and more food processors scramble to meet that demand, they're encountering a special challenge. Because they must process these meats according to organic and natural label requirements, they are unable to use the vast majority of antimicrobial agents employed in standard meat processing.

"Most ingredients and technologies that serve as antimicrobials—ingredients that can improve safety by either suppressing, inhibiting or destroying any pathogenic bacteria—are not able to be used in products labeled 'natural' and 'organic,'" Sindelar says.

The trick is to find alternative materials and processes that deliver safety—and also offer the look and flavor that consumers value.

Sindelar has identified some options. "A number of different natural-based organic acids offer a significant improvement to food safety," says Sindelar, who is working in partnership with Kathy Glass, associate director of the CALS-based Food Research Institute. "We have tested a number of different ingredients such as cranberry concentrate, grape seed oil and tea tree extract."

Some compounds from natural sources work as well as such standard preservatives as sodium nitrite, sodium lactate or sodium diacetate, to name a few. But it can take heavy doses of some natural ingredients to provide equivalent results—causing some undesirable side effects.

"Cranberry concentrate is a very effective natural antimicrobial," says Sindelar. "But if you use the amount needed to significantly control the growth of bacteria, the meat turns cranberry red."

Part of the researchers' work involves "challenge testing"—adding pathogenic microbes to the meat to make sure that a given ingredient prevents the growth of bacteria throughout processing and storage. If substantial numbers of microbes grow, that ingredient is ruled out as being an effective natural antimicrobial.

Successful tests have already led to new products. Cherry powder combined with celery powder, for example, "is already being adopted by processors because of how effective these ingredients are in improving meat safety and quality," notes Sindelar. And the search for other natural additives continues.

Both researchers are certain they'll find success—particularly as they continue working in partnership with producers in the field.

"Collaborative research between the university and industry is essential to understand the synergistic effects of these ingredients—and to ensure the safety and quality of natural and organic meats," says Glass.

—Cathy Day

Tasty Solution

A CALS–medical school partnership leads to better, safer beverages for people who have trouble swallowing

After having a stroke in 2008, Jan Blume lost the ability to swallow for two full years. As she slowly regained that vital function, she faced a new challenge: drinking the thickened beverages that are recommended for people with swallowing problems, or dysphagia. She found the drinks almost intolerable.

"They taste bad and the texture is so weird," recalls Blume, a retired nurse living in Appleton who can now eat and drink whatever she wants. "At some point, I would have just stopped using them—and either done okay or developed problems."

Fortunately there may soon be a better beverage option for people with swallowing problems, thanks to collaboration between a dysphagia specialist at the UW–Madison School of Medicine and Public Health—and a candy expert at CALS.

It started by chance when JoAnne Robbins, head of the medical school's Swallowing, Speech and Dining Enhancement Program, asked CALS food scientist Rich Hartel if she could borrow his viscometer, a device that measures viscosity, or the thickness of fluids.

"After learning that one of Rich's areas of expertise was chocolate, I mentioned that there are all these awful-tasting drinks made for people with swallowing problems, and nothing in chocolate," recalls Robbins, a professor of medicine with an affiliate position in the CALS nutritional sciences department. "So we decided to develop a thickened chocolate drink together."

The biomechanical events of swallowing are complex, involving 40 sets of muscles. Many things—including injury, illness and natural muscle atrophy due to aging—can cause dysphagia, which afflicts some 18 million adults in the United States.

The condition can be embarrassing. Some people with dysphagia simply stop going to restaurants or even eating with their families at home due to the struggle to swallow or the length of time it takes them to finish a meal. "This can have a devastating impact on social structures," says Robbins.

But it's more than just a quality-of-life issue, notes Robbins. Dysphagia can cause dehydration, hunger and malnutrition. Worse, if people with dysphagia aspirate liquids or food into their lungs, it can lead to pneumonia—and possibly death.

Many patients with dysphagia are advised to drink thickened beverages, which tend not to leak into the airway. But these products often leave much to be desired, and not just because of a bad flavor.

"The commercial products that are out there don't match the diagnostic standards. So people

Photos by Sevie Kenyon BS'80 MS'06

Toasting success: CALS food science professor Rich Hartel and JoAnne Robbins of the School of Medicine and Public Health are working to develop a tastier, more effective beverage for people with swallowing disorders. Here they sample their work with research assistants Kathryn Henry (standing) and Emily Daw.

Goes down easier, tastes better—this one is pink lemonade flavor (and notice the viscosity).

think they're buying a 'nectar thick' beverage, which is supposed to be a certain viscosity, but it'll turn out that it's not even close," says Hartel.

That's where Hartel and Robbins figured they could help: by developing what they call "biophysically based fluids" that match the diagnostic standards—making them safer for patients to drink—and that also taste good.

With the support of a U.S. Department of Agriculture grant, Hartel analyzed 15 thickeners and developed beverages using a handful of them. Robbins tested the drinks for safety in her patients, and a third team member, University of Minnesota researcher Zata Vickers, gathered key sensory data.

Ultimately the team gave up on chocolate after reading a number of studies showing that citrus flavors elicit a faster, better swallow. They are in the process of patenting their beverage technology through the Wisconsin Alumni Research Foundation, and are excited for the day when people who must drink thickened beverages—as Jan Blume did—will have a safer, tastier option.

"I'm in this to make my patients feel better," says Robbins. Of her CALS collaborator Robbins says, "Rich is a very good partner. He was open to expanding the focus of his research program. He liked the idea of helping people directly."

—Nicole Miller MS'06

Gut Feeling

STUDENTS at a Chicago public high school got some hands-on—and hands-in—experience with two cannulated cows that CALS dairy science management instructor Ted Halbach and dairy science PhD student Shane Fredin brought down to the Windy City.

Although the Chicago High School for Agricultural Sciences (CHSAS) is a magnet school for ag and life sciences, its urban location limits student opportunities to get up close and personal with farm animals. The cows were part of a workshop teaching students how feed is digested in the four compartments of a dairy cow's stomach.

"The students were stunned that they got to put their arm in a cow," notes CHSAS instructor Maggie Kendall. "After the first brave soul, they all lined up with gloves, eager to follow suit. They were enthralled and it was organized in a way that kept their attention. They had just enough time at each station to absorb the material and ask questions."

CALS regularly recruits students from CHSAS, sparking interest and cultivating relationships through such activities as workshops and frequent visits by Tom Browne, CALS assistant dean for minority affairs. Currently five students from CHSAS are undergrads at CALS.

Photo Courtesy of Ted Halbach

Reaching in for the first time: Students at a Chicago high school got a whole new perspective on cows.

Making It Personal

A CALS capstone class in genetics encourages students to explore their own genomes

It was one of the strangest homework assignments Erin Syverson had ever had. The senior genetics major was asked to open a small vial and start spitting.

"I would much rather have gotten my blood drawn, but it's a simple, effective way to collect DNA at home without a medical professional," notes Syverson, who submitted her saliva to 23andMe, a private company that analyzes a person's DNA—all 23 pairs of chromosomes, hence the name—for $99.

Those benefits are being cited all around the nation as more and more college genetics courses encourage students to get tested. They were confirmed by a recent study in the journal *PLOS One* showing that 70 percent of students who underwent personal genome testing self-reported a better understanding of human genetics on the basis of having undergone testing. They also demonstrated an average 31 percent increase in pre- to post-course scores on knowledge questions, which was significantly higher than students who did not undergo testing.

Photo by Sevie Kenyon BS'80 MS'06

Presenting their findings on genetic disorders: Some students gained a better understanding of genetics through an analysis of their own DNA.

Syverson underwent the analysis as part of Genetics 677, Genomic and Proteomic Analysis. While DNA testing is not required for the course, professor Ahna Skop encourages her students to undergo it. Students may use their own results as the basis of their individual semester-long class project, which requires doing in-depth research about a particular genetic disease or disorder and presenting findings in class and on a website the student creates.

"Because they have a vested interest in their project, they are emotionally engaged and seek out answers from me, their classmates and beyond the classroom—for example, from doctors and their families," says Skop. "The payoff I see in my course is deeper, longer-lasting learning due to this emotional investment."

Syverson didn't end up basing her research project on her own results, but she still found the testing worthwhile. "Through learning to interpret my own results and scrutinize them, I have learned a lot about not only the diseases they tested me for, but also how to think critically about genetic results," she says. "I've also learned a lot about the state of the field and how to explain it to others, which will be very helpful for my future career as a genetic counselor."

The course will be offered again next spring. Student presentations are posted at http://gen677.weebly.com/projects.html.

—Joan Fischer

Targeting a Killer

CALS researchers are making important advances in detecting and treating septic shock, which is responsible for more than 200,000 deaths a year

By the time doctors diagnose septic shock, patients often are on a knife's edge. At that point, for every hour that treatment is delayed, a person's risk of death rises an alarming six percent.

Time is of the essence. And CALS animal sciences professor Mark Cook was part of a team that developed a breath biomarker technology capable of detecting septic shock 12 to 48 hours earlier than standard methods. This powerful device, which was patented in 2008 and is making its way through clinical trials, creates an exciting opportunity for new, life-saving medical interventions.

"If you can detect septic shock earlier, then you can begin to explore ways of treating it earlier," says Cook, who already is in the process of developing a promising antibody-based treatment.

Septic shock—or severe sepsis—affects approximately 750,000 people in the United States each year, taking more than 200,000 lives and costing around $17 billion in treatment.

It occurs when a person's immune system, spurred by a bacterial infection or serious physical trauma, launches a massive inflammatory response that can lead to a drop in blood pressure, multiple organ failure and death.

The gastrointestinal tract is believed to be the primary site of this runaway response. Because of that, some scientists call the gut "the motor for sepsis," says Cook. So it's no surprise that Cook looked to the gut for a solution.

With funding from a Robert Draper Technology Innovation Fund grant from the UW–Madison Graduate School, he began working to interfere with the activity of a protein called $sPLA_2$, which is part of the chain of events in the gut that drives septic shock. It is a dual-purpose protein that can act as both an enzyme and a signaling molecule, so it wasn't initially clear which of the protein's roles—enzyme, signaling or both—were involved.

Cook and Jordan Sand, a scientist in Cook's lab, decided to first try blocking the gut protein's ability to signal, guessing that this would calm the immune response. So Sand made a series of antibodies that inhibited $sPLA_2$'s signaling function—but not its enzyme function—and then tested them in a mouse model of septic shock.

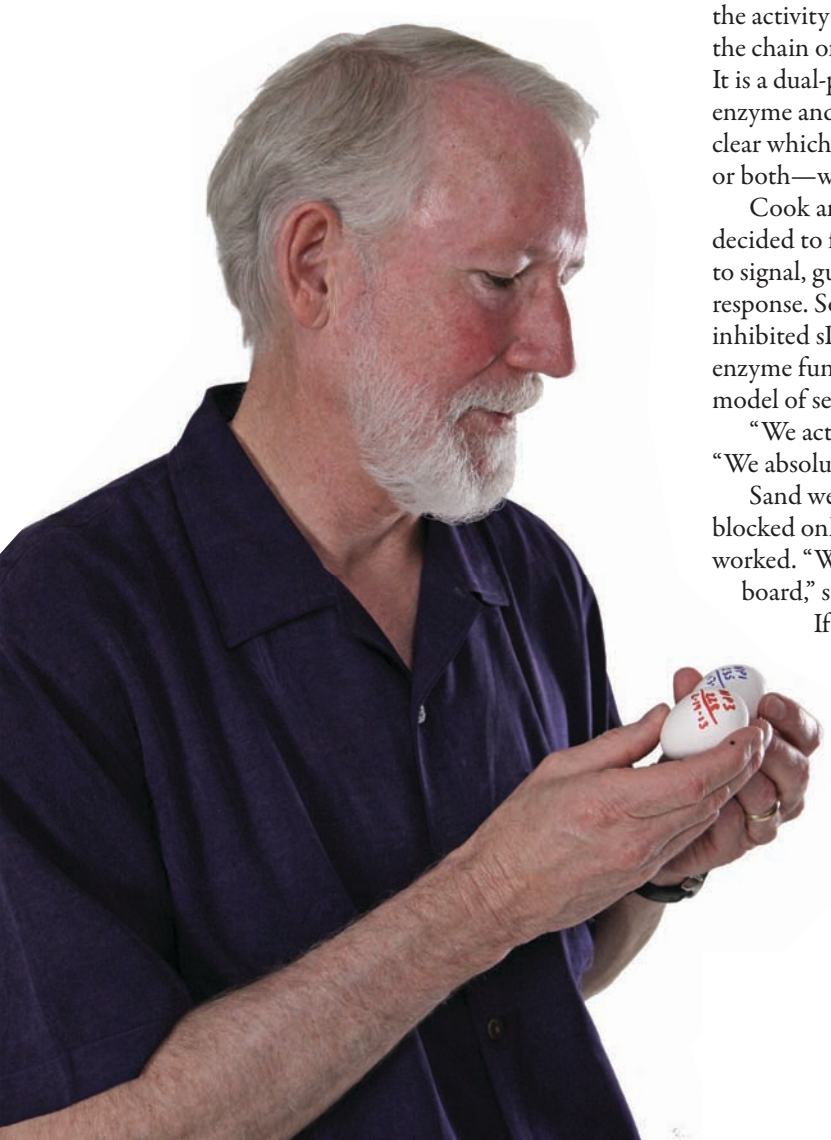
"We actually made it much worse," says Sand. "We absolutely failed. There's no other way to say it."

Sand went back and made antibodies that blocked only the protein's enzyme function. Those worked. "We had 100 percent survival across the board," says Sand.

If the antibody approach also works in people, this treatment could help patients with septic shock stay alive while they wait for antibiotics and other standard treatments to kick in.

Cook and Sand have filed a patent on the technology. But, Cook notes, "There are still a lot of steps to get this into human medicine."

—Nicole Miller MS'06



Animal sciences professor Mark Cook (photo left) and researcher Jordan Sand are developing antibodies that could slow the pace of deadly septic shock. The antibodies come from the eggs of laying hens.

Photo by Sevie Kenyon BS'80 MS'06

classAct

Patricia Paskov

The Big Picture on Food

Paskov posing with a guinea pig, a popular food in Peru.

She's picked vegetables on West Coast farms, worked to improve health, education and housing in immigrant communities on the Texas-Mexico border and, most recently, spent a semester in Peru, where she attended Pontificia University and worked with a non-governmental organization on food security.

As a double major in agricultural economics and Latin American studies—with an academic record that led to a recent Outstanding Sophomore Award from the Wisconsin Agricultural and Life Sciences Alumni Association—Patricia Paskov is trying to get the big picture on food.

It all started with a little story. "My grandfather, an immigrant from a tiny island in Croatia, claims to have survived the earliest years of his childhood on the milk of one goat," says Paskov. "I, on the other hand, grew up in suburbia and probably spent most of my childhood believing that food grew on grocery store shelves."

As a young adult, Paskov resolved to learn more about where food comes from. A "three-week, no-frills farm experience" in California, as she describes it, gave a new focus to her life. "I began to understand that food is an undeniable social, economic and political force," Paskov says.

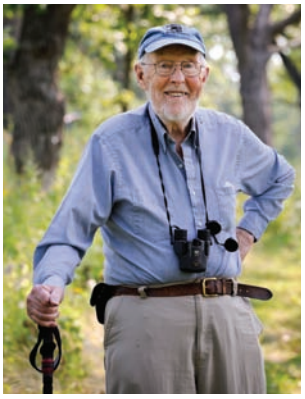
Her interest in food policy grew during an internship with the Oakland-based nonprofit Food First, which conducts global work on food systems and is located near a part of the city that at the time had 30,000 residents but no grocery stores. "It's almost as if this reality has prompted the community to take some of the most progressive steps forward in food justice," Paskov says. "Community development programs, NGOs, and farm-to-plate programs abound in Oakland, igniting a role of agency amongst everyone."

Paskov sees her life's calling as helping to make the world a better place food-wise. "I see myself working in the public or third sector, contributing to international decisions regarding food, agriculture, national resources and rural development," she says. "In the upcoming years, population growth and climate change will largely affect how the agricultural market functions—and food policy will be a more important field than ever."

—Joan Fischer

HONORED BY CALS for their contributions to Wisconsin agriculture and agricultural science: **Roger Blobaum**, **Pam Jahnke**, **John Ruedinger** and **Allan Schultz** (Honorary Recognition Award); **Henry Fribourg** (Distinguished Alumni Award); and Professor Emeritus **Warren "Buck" Gabelman** (Distinguished Service Award). These awards are the highest honors bestowed by CALS.

PRESENTED WITH the Albert Lasker Award for Basic Medical Research—a prize often called "the American Nobel"—**Richard Scheller BS'74** (biochemistry), for his work explaining how messenger chemicals move between nerve cells. Scheller is executive vice president for research and early development at Genentech, a medical biotechnology firm in California.



CONFERRED a Golden Goose Award, Professor Emeritus **Thomas Brock** (bacteriology), whose study of microbes in the thermal springs of Yellowstone National Park helped pioneer the study of life in extreme environments—and yielded discovery of an enzyme central to the technology for amplifying DNA. The Golden Goose is awarded by several organizations, including the American Association for the Advancement of Science, for federally funded research that has led to "demonstrable, significant human and economic benefits."

CELEBRATING 100 years, the **Wisconsin Seed Potato Certification Program**, launched as a partnership between UW–Madison and the state's farmers to reduce pests and diseases in seed crops and help ensure overall quality and reliability.

Number Crunching

252 BIRD SPECIES COUNTED

Greater Prairie Chicken

in the Great Wisconsin Birdathon, which engages volunteers in tallying species all around the state and, through donations and team sponsorships, raises money for bird conservation (more than $55,000 this year). CALS/UW–Extension faculty, staff, students and alumni participated in the event last May, including the Northern Highlands team (with Scott Craven, Jamie Nack and David Drake from forestry and wildlife ecology) and the student chapter of the Wildlife Society at UW–Madison.

Five things everyone should know about . . .

Industrial Hemp

By Irwin Goldman

1 | **It's a booming industry.** The American hemp industry generates sales of $450 million a year, according to the Hemp Industries Association—about a quarter from food and body care products and the rest from a wide array of goods, including clothing, auto and airplane parts, building materials and more. But since the cultivation of hemp is illegal in the United States under federal anti-drug laws, all hemp and hemp parts (fiber, oil, seed) used to make these products have to be imported.

2 | **It's cannabis, but not the narcotic kind.** Hemp is of the same plant species as marijuana, *Cannabis sativa*, but it is bred and cultivated quite differently. Cannabis bred for narcotic use is high in tetrahydrocannabinol (THC), the plant's main intoxicant, while in hemp THC content is far lower, not nearly enough to produce a high. Also, hemp can be grown densely since the fibrous stalk is the main harvest, while marijuana plants need room to spread out and grow buds, which contain the most THC.

3 | **It's been with us a long time.** Hemp was cultivated in China more than 4,000 years ago, making it one of the oldest domesticated crop plants. It originated in Asia, spread to Europe, and came to the U.S. with the first European settlers. Primarily a fiber crop, hemp also was used for food and medicine. Many of the earliest domesticates had multiple uses in human societies, and hemp is an excellent example. Over time and geography, hemp cultivars found separate, specialized uses for fiber production and medicinal purposes.

4 | **It was huge in Wisconsin.** Farmers were growing hemp in Wisconsin before it was admitted as a state, but true hemp glory came during World War II, with high demand from the military for such hemp-based products as rope and twine (eventually some 146,000 acres of hemp were harvested nationwide). The biggest growing areas were in Fond du Lac, Green Lake, Dodge and Racine counties. An article in the Madison-based *Capital Times* in 1941 noted that Wisconsin produced more than 75 percent of the hemp raised commercially in the United States, and Wisconsin was referenced several times in the 1942 government-produced film "Hemp for Victory." At one point Waupun-based grower and mill owner Matt Rens was known as "America's Hemp King." But after the war the crop lost much of its value, especially with the rise of synthetic fiber, and in 1970 federal drug law classified plants with any THC as an illegal substance.

5 | **There's a growing push to change that.** The Industrial Hemp Farming Act of 2013, introduced in both the House and Senate, would amend federal drug law to legalize growing cannabis that contains less than 0.3 percent THC. It enjoys the support of Senate Minority Leader Mitch McConnell (R-KY) and Senator Rand Paul (R-KY), among others.

Irwin Goldman is a professor and chair of the CALS' Department of Horticulture. He is the nation's only publicly supported beet breeder.

PERU

Potato Exchange Benefits Peruvians

In the growing region around Puno, Peru, farmers hedge their bets.

Located 12,000 feet above sea level, on the side of an Andean mountain, Puno has a growing season that's short, cool and prone to frost. The staple food of the area is potato, and local farmers plant dozens of different varieties on their plots—some that they relish for their flavor, as well as some less palatable, frost-tolerant types.

Photos courtesy of Alfonso del Rio

CALS scientist Alfonso del Rio (left) and horticulture professor Jiwan Palta (right) consult with a research partner in Peru. They are part of a team creating new varieties of frost-tolerant potatoes in Peru (top photo).

In good years everything grows well and families have plenty to eat. In bad years—when there is an unseasonable or particularly hard frost—their preferred plants fail, and they must rely on the small, bitter potatoes produced by the hardy survivors.

Soon, however, they will have a better option. For the past two growing seasons, farmers near Puno and in three Peruvian highland villages have participated in a project to grow and test frost-tolerant versions of their favorite local varieties, with great success.

These special potato plants were developed in Wisconsin by a team of CALS plant scientists and plant breeders using germplasm stored in the U.S. Potato Genebank, located in Sturgeon Bay.

"I think this is the first case where a potato developed in the U.S. has been accepted by local farmers in these communities in the Andes," says project coordinator Alfonso del Rio, an associate scientist in the lab of John Bamberg. As an employee of the USDA's Agricultural Research Service, Bamberg serves as director of the U.S. Potato Genebank. He is also a professor of horticulture with CALS.

The plant materials used for the project, like the vast majority found in the U.S. Potato Genebank, were brought to the United States from the Andes, the potato's site of origin. This makes the project a special opportunity for potato breeders in the United States to give something back.

"We're interested in returning the benefits of our genebank to Peru and the broader Andean region because that's the area that supplied our country with germplasm," says Bamberg, who led the project's breeding effort. Earlier work by CALS horticulture professor Jiwan Palta, the third member of the team, made modern marker-assisted breeding for frost tolerance possible.

To make the new potato lines, Bamberg took an exceptionally frost-tolerant wild relative of the potato family—a weed, basically—and crossed it with seven popular native Peruvian potato varieties to generate frost-tolerant versions of the native potato plants.

Although the new potato lines were originally meant to be added to Peru's national potato breeding program as germplasm for further breeding, the farmers who were involved in the trials are eager to start growing some of them right away. And no wonder. This past growing season in Puno, after a late, hard frost, a few of the new frost-tolerant lines far outperformed the local varieties, yielding twice as many pounds of potato per plot.

The CALS team hopes these more dependable potato plants will help bolster Peru's vulnerable rural communities.

"If the farmers could send part of their harvest to market, even 10 or 20 percent, they could have some money to invest in community development—in things like clinics, schools and libraries," says del Rio.

—Nicole Miller MS'06

KENYA

Certified Seed Potatoes for Kenya

When scientists in Kenya needed help developing a certification program for seed potatoes, a CALS plant pathologist stepped up to the task.

The new program is run by Kenya's Agricultural Development Corporation (ADC), a government-controlled agency charged with improving agricultural programs throughout the nation.

"They were looking for somebody to help improve their certification program. Since it's my job at the UW to do this kind of thing, I applied," says Brooke Weber, a scientist with the CALS-based Wisconsin Seed Potato Certification Tissue Culture Laboratory, which helps produce certified disease-free seed potatoes for Wisconsin growers.

A nonprofit agency called CNFA, which supports economic growth in the developing world by empowering the private sector, selected Weber for the position, paying for her flight to Nairobi as well as her three-week visit to the ADC Molo Seed Potato Complex in Kenya's Rift Valley Province.

On her first day at ADC, Weber went straight to the tissue culture laboratory and greenhouse facilities to learn about ADC'S main areas of concern and to discuss how to make her trip as productive as possible. From there, Weber launched into training ADC scientists how to run various diagnostic tests for plant-associated microorganisms at the tissue culture and greenhouse level.

It didn't take long for her to experience one of the obstacles her peers in Kenya regularly face. "The electricity cuts in and out. If you are working in a sterile hood, the fan will go out and there's nothing you can do about it. It takes a few minutes for the backup generator to kick in," says Weber. "Still, I was really impressed by how well their tissue culture lab worked, considering the less-than-ideal conditions."

Due to limitations associated with the available diagnostic tests, Weber recommended that ADC implement a broad pathogen eradication procedure for all of the company's potato lines. "It's very expensive to initiate numerous diagnostic tests, so a lot of times when you don't know what microorganisms are present, it's better to assume everything is infected and put all plants through a curing process," she says.

Weber was also able to share some helpful tips to improve the company's tissue culture media, increase lighting in the growth rooms and optimize the nutrient solution sprayed in the aeroponic systems used to grow mini-tubers.

Since returning to Madison Weber has stayed in contact with ADC scientists, exchanging e-mail correspondence regularly. She plans to assist with the pathogen eradication procedure from Madison, offering advice and answering questions via e-mail and Skype as needed.

"It is an ongoing project," Weber says. "That has been the most rewarding part of this experience."

—Nicole Miller MS'06

CALS' Brooke Weber (fourth from left in top photo and on the right in bottom photo) is helping scientists in Kenya develop a seed potato certification program, working in lab and greenhouse facilities run by the nation's Agricultural Development Corporation.

Photos courtesy of Brooke Weber

Will Dead Species Live Again?

It sounds like science fiction—but it could happen in real life. **Stan Temple** describes "de-extinction" and its promise for conservation.

Interview by Sevie Kenyon BS'80 MS'06

Photo by Jeff Miller/UW Communications

STANLEY A. TEMPLE is the Beers-Bascom Professor Emeritus in Conservation in forest and wildlife ecology at CALS and a former chair of the conservation biology and sustainable development program at the Gaylord Nelson Institute for Environmental Studies. For 32 years Temple occupied the faculty position once held by Aldo Leopold, and while in that position he received every University of Wisconsin teaching award for which he was eligible. Since his retirement from academia in 2008 he has been a Senior Fellow of the nonprofit Aldo Leopold Foundation. He and his 75 graduate students have worked on conservation problems in 21 different countries and have helped save some of the world's rarest and most endangered species. Last spring Temple gave a TED talk at a special event devoted to de-extinction, a concept that has captured the imagination of scientists and the general public alike.

What is "de-extinction"?

De-extinction is a recent term that involves bringing back an extinct species using DNA that's been recovered from preserved material. There are two ways that it can be accomplished: one would be cloning to produce a copy of an extinct individual's genome. The second way is through genetic engineering to re-create a close approximation of what the extinct species' genome might have once been. The reality is that it's no longer science fiction. We're getting close to being able to revive extinct species from recovered DNA.

This must make for some unusual scientific partnerships.

It's an interesting synthetic endeavor that matches the biotechnologists in the laboratory with conservationists in the field. The biotech crowd will be responsible for recovering DNA from an extinct species and through either cloning or engineering turning that DNA into individuals. But once they've done that, the next step involves people like myself who know how to recover endangered species by taking a small number of individuals and turning them into a viable population and getting them back into the wild.

What opportunities might this technology present to conservation efforts?

On the plus side, obviously, it would be exciting to bring back a species that human beings drove to extinction. But even if we weren't able to do that, the technology presents an appealing opportunity to recover DNA from preserved specimens of an endangered species and use it to enhance the genetic diversity of the surviving population.

Can you please elaborate on that?

Conservationists have recovered many endangered species from very low population levels and saved them from extinction. The problem is, they're often genetically depauperate, or lacking in genetic diversity. If we can recover some of the lost genes from preserved specimens collected before the population crashed, we might greatly improve the species' prospects for long-term survival.

How would a conservation biologist go about actually applying this?

De-extinction is still an unproven concept, but it's likely that sometime in the coming decades it will happen. Once they have revived individuals of an extinct species in the lab, then conservation biologists could try to recover the species by captive breeding and reintroducing the species to the wild. But conservation biologists get concerned about some of the details: Which species are going to be revived? Are they the right species? Are they the species that have the best chances for long-term survival in the world today? Are they species that might actually enhance the ecological health of the ecosystem that they were once part of, like the wolves reintroduced to the Yellowstone ecosystem? These are all questions of setting priorities for which species to actually revive.

How would you recommend setting priorities?
As a conservation biologist I would certainly look first at recently extinct species that were affected by a threat we've now overcome. Not only are those the ones for which we're likely to have good quality DNA, but their ecological niche in the wild hasn't been vacant for very long. And as a result, the ecological community that they were once part of has not readjusted itself to their absence, and might once again easily accommodate the species in its midst. On the other hand, if you're dealing with a species that's been extinct for a very long period of time—centuries or even millennia—the ecosystem that they were part of has moved on, and a species like that, once back in the system, could essentially be the equivalent of an invasive species. It might disrupt the system and threaten extant species.

Let's visit the process of extinction a little more generally. What does it mean to us?
One of the catchphrases is "extinction is forever." And for three and a half billion years of life on this planet, that has been true. No species that has gone extinct has ever come back. So de-extinction would be an unprecedented biological event.

But extinction—the death of the last individual of a species—is of course a natural process. It eventually happens to all species in the course of their evolution. But we have greatly accelerated the rate of extinction in recent times because of human activities, so that compared to the long history of life on this planet, we're in what is often referred to as a period of "mass extinction," in which extinction rates are many orders of magnitude higher than they would normally be. And that is why the modern conservation biology movement has made such a push to make society aware of the fact that we are in a crisis right now of losing species from this planet—and, biotechnology notwithstanding, those that are being lost are gone forever.

> "No species that has gone extinct has ever come back. De-extinction would be an unprecedented biological event."

How would you like to see this development proceed?
Considering the timeline that we probably have years or even decades to do this right—I and other individuals and groups that are thoughtful and somewhat skeptical about this would like to see a very broad discussion of the implications. We would like to see a lot of input in deciding the priorities about which species to bring back. We would not like to see this done in secret, which, unfortunately, is where this seems to be heading. This very expensive work is not receiving government funding and doesn't have any sort of public oversight. Hence, privately funded biotech labs seem to be focusing on reviving spectacular extinct species, like mammoths and other Ice Age animals, rather than species that have a real chance of surviving in today's world.

What would be an important takeaway point for the general public?
De-extinction doesn't mean we can ignore the significance of extinction—to think, "Oh well, we can let species go extinct because we can always save some DNA and bring them back later." This would just be an open door for activities that have been constrained by concerns for biodiversity and basically give the green light to go ahead and precipitate extinctions of species that are already with us.

You've worked with species that were close to extinction. Do you have a story about your favorite one?
Early in my career, on the island of Mauritius in the Indian Ocean—the former home of the extinct dodo—the Mauritius kestrel, a small falcon, was down to four individuals. As a young conservation biologist, capturing some of the last remaining individuals and bringing them into captivity, I knew that if something went wrong and the species went extinct, I would carry it with me throughout my career. Fortunately, things went well. There are now several hundred Mauritius kestrels. The same is true of the California condor, which dropped to 22 birds when my students and I worked with them. Now there are several hundred. So by and large, if we decide we really want to save a critically endangered species, we've generally been able to pull it off. The problem is, there are so many endangered species out there that need to be saved that we simply don't have the resources to save all of them.

A CALS podcast with Stan Temple is available at **http://go.wisc.edu/qgt6h8**

His TED talk is posted at **http://go.wisc.edu/0xh379**

The Power of Pizza

The pie's ever-growing popularity has made mozzarella the big cheese in Wisconsin. CALS researchers are helping state cheesemakers feed and grow that demand by developing new varieties for specialized and international markets.

By Bob Mitchell BS '76

The busloads of schoolkids who visit Jauquet Dairy each year have lots to talk about when they get home—from the really cute newborn calves to the really big cows and the really cool machines that milk them.

Dave Jauquet gets a kick out of all that, but he wants them to remember something else as well: The link between his farm and what they eat. And he has a good way of getting that across.

"I tell them that the milk from these cows ends up on pizza. I like to tell them that because they can connect it all the way from standing here, seeing a lot of cows eating food, to something they actually have for supper," Jauquet says. "Because pretty much every kid eats pizza."

And so do their parents, friends and neighbors. In the myriad menu items that make up American cuisine, pizza is as close as you get to a universal food. Ninety-seven percent of U.S. consumers had some at least once last year, and 41 percent of us eat it once a week.

That matters in a very big way to people like Jauquet and his partners—his wife Stacy and brother Jeff. Virtually every pound of milk produced on their Kewaunee County farm is made into six-pound loaves of mozzarella and sleek "salamis" of provolone. Like the people who buy that cheese—mostly independent Italian eateries—the Jauquets, their dozen employees and 600-plus Holsteins are in the pizza business.

That's the case for somewhere around a quarter of Wisconsin's 1.25 million dairy cows—the working girls in an industry that generates 150,000 jobs, half of the state's farm revenue and $26.5 billion in economic activity. At least 85 percent of the state's milk goes into cheese, a third of which is mozzarella, the vast majority of which ends up on pizza.

Photos by Wolfgang Hoffmann BS'75 MS'79


Pizza cheese gets evaluated for stretch, melt, blistering, color and 11 other characteristics by scientists at the CALS-based Wisconsin Center for Dairy Research. (*In photo opposite, left to right:* Carol Chen, Maya Warren and Liz Miller.)

"As pizza goes, so goes the dairy industry," says John Umhoefer, executive director of the Wisconsin Cheese Makers Association.

Forty years ago, cheddar was the state's big cheese. Mozzarella was a specialty cheese, made by firms that specialized in Italian varieties sold primarily to Italian American customers. Since 1970, Wisconsin's mozzarella production has increased tenfold—it surpassed cheddar in 2000. So has U.S. per capita consumption. "That's all pizza," Umhoefer says.

In a nation with 70,000 pizzerias and pizzas sold in every bowling alley and convenience store, it's hard to imagine a time when pizza wasn't part of the broad cultural landscape. But it wasn't until after World War II that pizza went mainstream. Cultural historians attribute the shift to American G.I.s who acquired a taste for it while serving in Italy. It also meshed with trends of the time: Informal dining, ethnic foods, eating by the TV, and lots of cars to facilitate takeout, delivery and road food.

If you want to get a feel for how pizza transformed Wisconsin's cheese business, a good person to talk to is Roger Krohn, master cheesemaker at the Agropur facility in Luxemburg. Krohn is in charge of turning milk from Jauquet Dairy and 150 other area farms into pizza cheese. His family began making cheese at this site in 1892, and when they sold the business 108 years later, Roger Krohn stayed on to oversee cheese production. It was in his DNA. He grew up next door to the cheese plant and began making cheese there at age 14.

For the first 68 years, like most Wisconsin cheese firms, the Krohns made cheddar. In 1960, that changed. "I think my dad was looking to branch out into something a little less competitive—a new niche market," Krohn says. "An Italian gentleman encouraged him to get into mozzarella, because he foresaw the pizza industry really taking off."

It was a leap of faith—"Pizza was not a real big deal in 1960, at least not in the Midwest," Krohn says—but a smart one. The mozzarella making began modestly—two guys kneading and stretching the curd by hand—but never stopped expanding. By next year, when a major expansion is done, the plant will be using 2.4 million pounds of milk from 28,000 cows to produce about a quarter of a million pounds of pizza cheese—every day.

As pizza picked up, more Wisconsin cheddar plants followed suit, says Dean Sommer of the Wisconsin Center for Dairy Research (CDR), a CALS-based dairy foods research and education program.

"They read the tea leaves," says Sommer, who in 1986 took a job at Alto Dairy (now Saputo foods) in Waupun—then the nation's largest cheese plant—to help the firm expand into mozzarella. "Consumption of pizza was on a double-digit increase every year, and the margins of making mozzarella were higher than for cheddar cheese. They could see that with the growth of pizza and the growth of mozzarella, and the profitability, this was a better place to be."

Pizza is a simple food, but

when it's being made in thousands of kitchens by thousands of chefs, things get complicated. Ovens change, tastes change, and everyone has a different idea of the perfect pie. To keep everybody happy, cheesemakers must be nimble.

For more than a century, Wisconsin cheesemakers have been enlisting help from CALS scientists to improve and troubleshoot their products. That's how the first pizza cheese research at UW happened, says CDR scientist Carol Chen. Decades before Domino's folded

its first box, Wisconsin's Italian cheesemakers tried shipping their traditional pizza cheese, a fresh mozzarella, to the East Coast. "But by the time it got there it was spoiled," Chen says. "Fresh mozzarella has a very short shelf life." So one of those cheesemakers teamed with CALS food scientist J.L. Sammis to invent a new mozzarella—a firmer, drier cheese better suited to transport and cooking. Now known as low-moisture part-skim mozzarella, it's the most commonly used pizza cheese in the world.

As the pizza business grew, so did mozzarella research, recalls Norm Olson, a CALS professor emeritus of food science who served as CDR's first director.

"When I started on the faculty in 1959 there was very little mozzarella for pizza made in the state, and what was made was virtually all molded manually—a bunch of women and men around the hot water tank molding the cheese into its final shape," says Olson, who had never tasted pizza when he took the job. "We worked with the cheese companies and equipment manufacturers to mechanize the process. That had a huge impact on the price and availability and economics of mozzarella cheese."

Roger Krohn recalls another challenge: Hotter, faster ovens. "It used to be you'd go out for pizza and wait 35 or 40 minutes, because it took that long to bake. Now they're done in five minutes," he says.

"A lot of pizzerias were having issues with the new ovens in the '80s," says Mark Johnson, another CDR scientist. "The cheese melted too much, it didn't string, it burned." The researchers explored that and all manner of other factors—from the milk to the microbes that make the flavors—that affect how the cheese performed.

Two decades later, the focus has shifted. In 2012 the USDA proposed new rules for school lunches: No more than 10 percent of total calories from saturated fat and no more than 200 milligrams of sodium. That put pizza in the crosshairs.

"They looked at removing it from the school lunch program," Johnson explains. "And there goes a lot of nutrition—there's a lot of calcium, protein, phosphate in the cheese. Sure, it's also in milk and yogurt, but kids prefer pizza. So you're seeing a lot of research now about reducing the fat level by half and also reducing the sodium content by at least 25 percent."

It's not just the government that wants a healthier pizza. Consumers are opting for healthier foods, notes a 2012 report by Packaged Facts, a research firm. The main message to pizza makers is to boost the overall healthfulness of their product and experiment with options that provide more "clear-cut healthfulness without sacrificing taste," said the firm's research director.

It's not that hard to make a low-fat pizza cheese. The trick is to make one that anyone would want on a pizza. And it's not just a matter of taste, says CDR director John Lucey. "Without much fat in the cheese, the pizza surface tends to dry out, leading to excessive browning and blistering," he explains. "And low-fat cheese is higher in protein, and the greater protein content makes a tougher cheese with less melt unless the cheesemaker corrects for this difference. Low-fat cheese also usually appears translucent."

Lucey has applied his expertise in the chemistry and physics of cheese to create a low-fat, low-salt mozarella with pizza-worthy qualities: It melts and stretches nicely, doesn't blister and burn and has an appealing white color. Now researchers are focusing on how it tastes.

"We're mixing and blending cheeses to improve the flavor," says Johnson. "We start with the low-fat cheese and blend in enough of a higher-fat, more flavorful cheese—say a Muenster—to bring the fat content up to 10 percent, which is where the school lunch

program wants us to be." The resulting blend will still have half the fat and less than half the sodium of a low-moisture part-skim mozzarella, he says. The researchers are also looking beyond the cheese, finding ways to reduce sodium levels in the sauce and crust.

Does a cheese have to be salty to be flavorful? That has a lot to do with context, CDR sensory research suggests. If consumers sample a reduced-sodium cheese along with a conventional version, the saltier version wins out. But if they're not tasting the two side by side, they're fine with the lower-salt version.

The cheese industry pays a lot of attention to sodium these days, and not just for U.S. markets. Asian consumers want low-sodium cheese. And Asia represents a huge new market for dairy products—and pizza.

While the pizza business isn't booming in the U.S. like it was 30 years ago, it's enjoying double-digit growth elsewhere, especially in Latin America and Asia. That's where U.S. companies that sell pizza and its ingredients are looking to grow.

"It's easy to see the attraction," notes *PMQ Pizza Magazine* editor-at-large Liz Barrett in her 2013 state-of-the-industry report. "In a different country, you're the new guy in a fairly new industry. It's similar to opening a pizzeria in the States back in the 1970s—before the market became saturated and everyone was excited to discover what you had to offer."

"We'd love to tap into the Asian market, obviously, because of the number of people who live there," says Roger Krohn. "They're starting to get a hunger for our mozzarella and our pizzas." But it's going to take a different kind of product to succeed there, he adds. "They like a totally different mozzarella."

China, not surprisingly, is getting a lot of attention. U.S. chains are active there—Pizza Hut alone has 500 stores—and China has its own chains as well as independent operators. But with an expanding middle class and a population four times that of the U.S., the market is barely tapped.

In June 2012, the farmer-funded U.S. Dairy Export Council sent Mark Johnson to Shanghai to get the Chinese view on what makes a good pizza cheese. He helped bake pizzas in 10 pizzerias—a Domino's, a Pizza Hut, and eight small independents—to see how U.S. cheeses stacked up against the competition, which was mostly from New Zealand.

"I think U.S. cheese tasted better," he says. "But when I asked them what was most important—a great flavor versus appearance—appearance is what they wanted."

Color was a big issue. While U.S. mozzarella is white, New Zealand's is yellow because it's made from milk from cows that are always on pasture. New Zealand was first in the market, so the Chinese expect yellow cheese. Nor is there detente on the appropriate color

(Left) Roger Krohn, master cheesemaker at Agropur, Inc.'s plant in Luxemburg, demonstrates mozzarella's signature stretch. His family shifted from cheddar to mozzarella in 1960, just as pizza was rising in American cuisine.
(Center and above) Mozzarella cooling in brine and stacked for shipping. When a plant expansion is completed next year, Agropur will produce a quarter million pounds of pizza cheese per day.

of a baked pizza. Consumers in the U.S. expect the cheese on their pizza to look a bit toasted. "But when I show a browned pizza to people in China," Johnson says, "they think it's burned."

They also want their cheese to stretch—a lot. "When they advertise pizza on TV, they lift a piece from the pie and it has this really long stretch. They show cheese dripping off the slice. They love that," says Johnson.

Cheesemakers in the U.S. can make a mozzarella that looks and acts like New Zealand's, Johnson says, but he also thinks there's an opportunity to offer Asian consumers something different.

"Let's be innovative," he says. "There are other cheeses you can put on a pizza. So instead of copying somebody else's cheese, you introduce a Muenster as a cheese for pizza, or a Monterey jack—different varieties. And different condiments that work with our cheeses. Let's not just add pepperoni and sausage."

The CDR kitchens are experimenting with condiments suited to emerging markets. A good example is kimchi, the super-pungent Korean dish made with fermented vegetables.

"We add kimchi to a Muenster cheese. We baked a pizza using this cheese for a Korean group that came here," Johnson says. "They were all going 'I want to be the first to import this cheese.' Boy, they loved it. They just loved it."

Wisconsin does not make

the most pizza cheese in the U.S.—California ranks No. 1 in mozzarella—but it makes most of the best.

"Most Wisconsin companies sell a higher-priced but higher-quality cheese," explains CDR's Dean Sommer. "It's a different market—smaller pizza chains and mom-and-pops that don't try to compete on price with the big guys, whose customers prefer to sit down to enjoy a hand-crafted pizza rather than eat it quick and run."

It's a great fit for Wisconsin's mid-sized firms, which can custom-tailor a product for every end user, says John Umhoefer of the Wisconsin Cheese Makers Association: "We don't have giant box factories working 24/7 making one product. We've got people who have the expertise and time and energy to experiment."

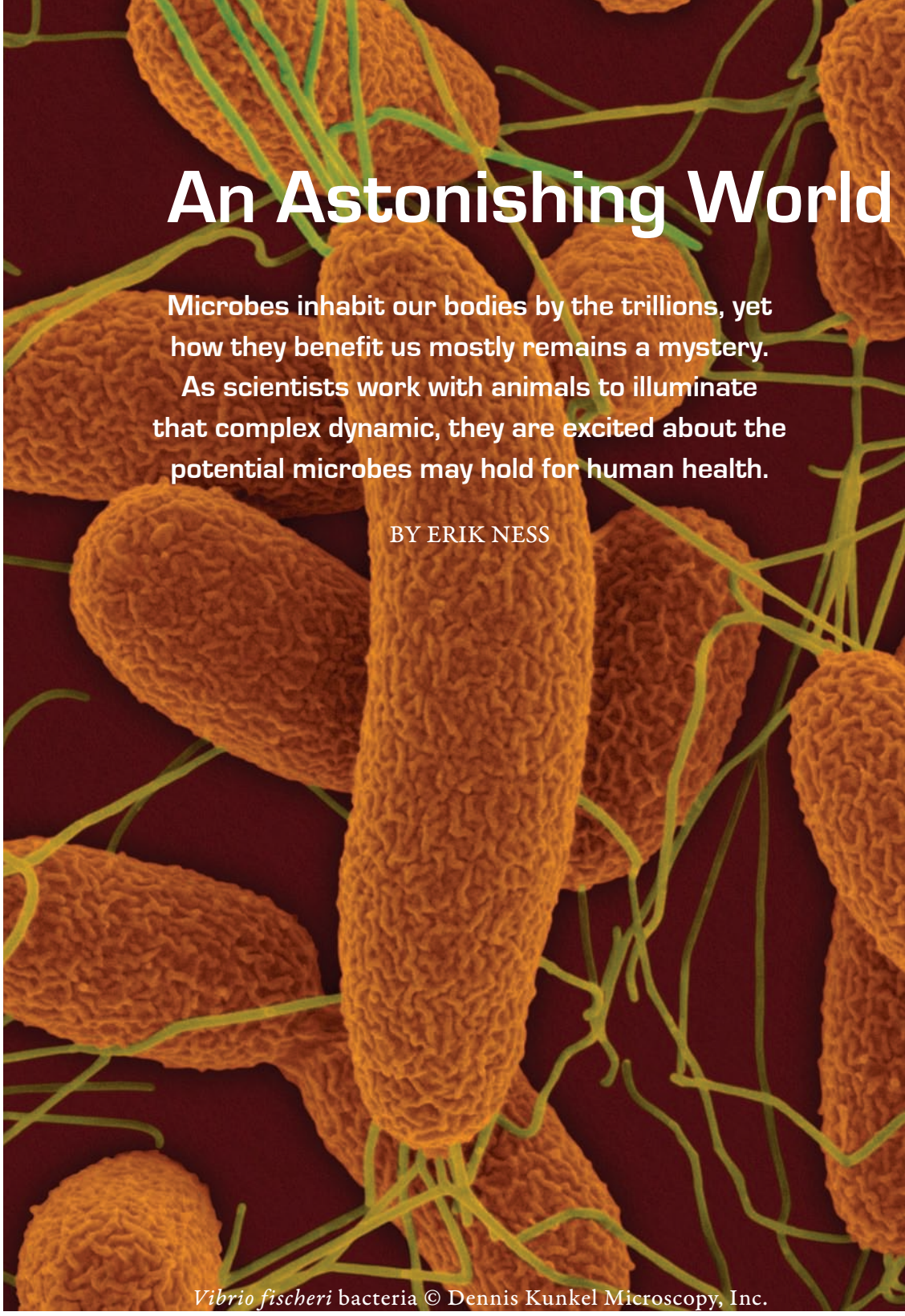
Roger Krohn follows that model at Agropur. Every so often he heads east to visit pizzerias that use his cheese. "We'll go into the kitchens and bake pizzas with the cooks. A lot of them, especially in New York, came over from Italy, so I get quite an education every time I talk to them. They'll tell me exactly what they want on their pizzas."

Dairy farmer Dave Jauquet stays out of the kitchen when his family goes out for pizza, but he still feels like he's part of the business. "I think we're thinking about it a little differently than somebody sitting at the next table. It's not just another ingredient. It's something that you could almost say you made."

An Astonishing World

Microbes inhabit our bodies by the trillions, yet how they benefit us mostly remains a mystery. As scientists work with animals to illuminate that complex dynamic, they are excited about the potential microbes may hold for human health.

BY ERIK NESS



Vibrio fischeri bacteria © Dennis Kunkel Microscopy, Inc.

Jim Steele used to be one of the skeptics. He'd be at a conference, listening to early research on the health benefits of probiotics. Steele scoffed at the small experiments. "We would literally try not to laugh in the audience, but we'd laugh pretty hard when we went out that night," he admits.

But slowly the punch lines gave way to revelation. Steele, a professor in CALS' Department of Food Science, conducts research on lactic acid bacteria, with a focus on *Lactobacillus* species. They're important for human gut health, critical for the production of cheese and yogurts, and are the most common probiotic genus. He knew how incredibly useful they were, but still watched with a humbling disbelief as the data on the health potential of these microbes kept getting broader, deeper and more intriguing.

Our microbiota—what we call the totality of our bacterial companions—is ridiculously complex. Each human harbors a wildly diverse ecosystem of bacteria, both in the gut and elsewhere on the body. They have us completely outnumbered: where the typical body may contain a trillion human cells, your microbial complement is 10 trillion. They have 100 times more genes than you, a catalog of life potential called the microbiome. (The terms "microbiome" and "microbiota" are often used interchangeably in the popular press.)

While our initial, germaphobic impulse may be to freak out, most of these bacterial companions are friendly, even essential. On the most basic level they aid digestion. But they also train our immune system, regulate metabolism, and manufacture vital substances such as neurotransmitters. All of these things happen primarily in the gut. "In many ways the gut microbiota functions like an organ," says Steele. "It's extraordinarily important for human health," with as much as 30 percent of the small molecules in the blood being of microbial origin.

Revealed

Early research has suggested possible microbiota links to protecting against gastric cancers, asthma, numerous GI disorders, autoimmune disease, metabolic syndrome, depression and anxiety. And the pace of discovery seems to be accelerating; these headlines broke in just a few months last spring:

- Mouse studies suggested that the microbe *Akkersmania muciniphila* may be a critical factor in obesity;
- Kwashiorkor, a form of severe malnutrition that causes distended bellies in children, was linked to a stagnant microbiota;
- Risk of developing Type 2 diabetes was linked to an altered gut microbiota.

The catch: For all the alluring promise of microbes for human health—and it's now clear they're critically important—we have almost no idea how this complex system works.

The human gastrointestinal (GI) tract is a classic black box containing hundreds or thousands of species of bacteria (how many depends on how you define a species). There are viruses, fungi and protozoans. Add to that each person's distinct DNA and their unique geographic, dietary and medical history—each of which can have short- and long-term effects on microbiota. This on-board ecosystem is as unique as your DNA.

Beyond these singularities, the action is microscopic and often molecular, and even depends on location in the GI tract. Most microbiota studies are done with fecal material. "Is that very informative of what's going on in the ileum?" asks Steele, referring to the final section of the small intestine, which is thought to be the primary site where immunomodulation occurs. "From an ecosystem perspective, fecal material is many miles away from the ileum. Is it really reflective of the ileum community?"

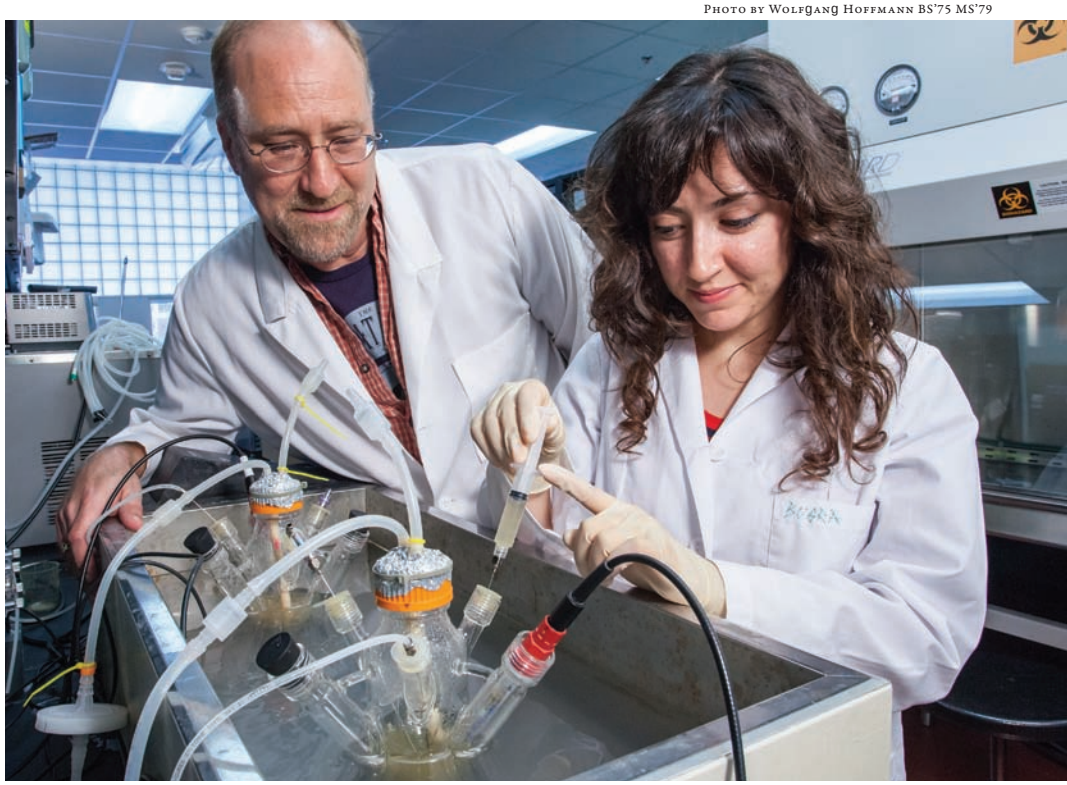
Developing the tools to unlock this black box begins with simply accepting the idea that these bacteria—*germs*!—are part of us. It's a fundamental shift in how we think about health, which has evolved for centuries around the prism of disease development, or pathogenesis. For centuries we had no idea that microorganisms caused plague, cholera, and dozens of other debilitating diseases.

"Because we couldn't know who they are and what they're doing, we focused on pathogenesis," explains Margaret McFall-Ngai, a professor in the Department of Medical Microbiology & Immunology at the UW–Madison School of Medicine and Public Health. Once we knew that bacteria existed and developed the germ theory, modern medicine grew by leaps and bounds. "Pathogenesis has had such a profound effect on human history," she notes.

Except that's not how the world normally works. McFall-Ngai studies mutualism, where microbes and their host organisms scratch each other's backs. For the last 25 years, she and colleague Ned Ruby have been untangling the elegant relationship between the Hawaiian bobtail squid and its luminescent bacterial symbiont *Vibrio fischeri*. She argues that these collaborative relationships are far more important than we realize—that instead of viewing the world through the framework of disease, biology needs to be understood through the prism of beneficial microbes.

"I think we are in a revolution," McFall-Ngai says. She recently was lead author—Ruby was one of 25 others—of a major *PNAS* review. They argued that new technologies have "revealed a bacterial world astonishing in its ubiquity and diversity" and that the resulting relationships in symbiosis and in larger

Photo by Wolfgang Hoffmann BS'75 MS'79



Food science professor Jim Steele and research assistant Busra Aktas working with their GI passage model, which simulates the GI tract and allows them to test the survival of bacteria in the presence of various digestive and other chemicals.

Photo by Chris Frazee/UW-Madison School of Medicine and Public Health

The Hawaiian bobtail squid uses bacteria (*Vibrio fischeri*) in its light organ to erase its shadow, thus protecting it from predators. The squid-vibrio relationship offers "a way to understand how bacteria talk to animal tissue," says Margaret McFall-Ngai, a professor of medical microbiology and immunology.

ecosystems are "fundamentally altering" our biological understanding. "All biologists will be challenged to broaden their appreciation of these interactions and to include investigations of the relationships between and among bacteria and their animal partners as we seek a better understanding of the natural world," the authors state.

Model species like yeast, mice and fruit flies are common workhorses for scientific discovery. By exhaustively breaking down and manipulating these organisms in the lab, scientists have been able to decode a huge array of biological puzzles.

Studying symbiosis—two organisms intertwined, often in a mutually beneficial relationship—adds a layer of complexity to these models. Since the 1960s scientists have been working with *Steinernema*, a large family of very small worms—nematodes—and their symbiont, *Xenorhabdus* bacteria. When Heidi Goodrich-Blair joined the CALS bacteriology faculty in 1997, she had already begun unraveling how the worms and their symbionts communicate on a molecular level.

Steinernema are a popular organic control for greenhouse pests. Just a couple hundred microns in length—about 250 million fit in a cup—they prey on insects in their larval stage, entering their target through natural body openings. Creepy, but it's their bacterial symbionts that do the killing. *Xenorhabdus* live in the intestinal tract of *Steinernema*—the worm protects them from ultraviolet radiation. *Xenorhabdus* infect the insect host when they're excreted and cause a raging infection that kills the insect, setting up a perfect incubator that can produce more than a million *Steinernema* offspring.

So how can this worm and its virulent symbiont help us understand human microbiota? The two biggest inquiries are which bacteria are present, and how they contribute to our health. The *Steinernema*/*Xenorhabdus* relationships don't give us direct answers, but they help us refine the questions.

Current techniques for analyzing gut bacteria decode DNA and its related compounds. Genomics identifies all of the genes present, but a lot of DNA is not used regularly, if at all. It's like drawing conclusions about your diet by analyzing your cookbook library. Genomics shows everything you could possibly create—but not what you actually make. "All we're doing is sequencing the potential," says Goodrich-Blair.

Transcriptomics, on the other hand, decode what genes are active by recording the RNA messages from the genes actually in use. But with so many species present in the gut, it's not possible to link microbes to genes.

These tools provide a lot of information, but how do you make sense of it? "That's where model systems come in," says Goodrich-Blair. "We have the ability to tease cause and effect out of our systems. We can inactivate specific genes in specific microbes, and then we can ask, 'What impact does that have?'"

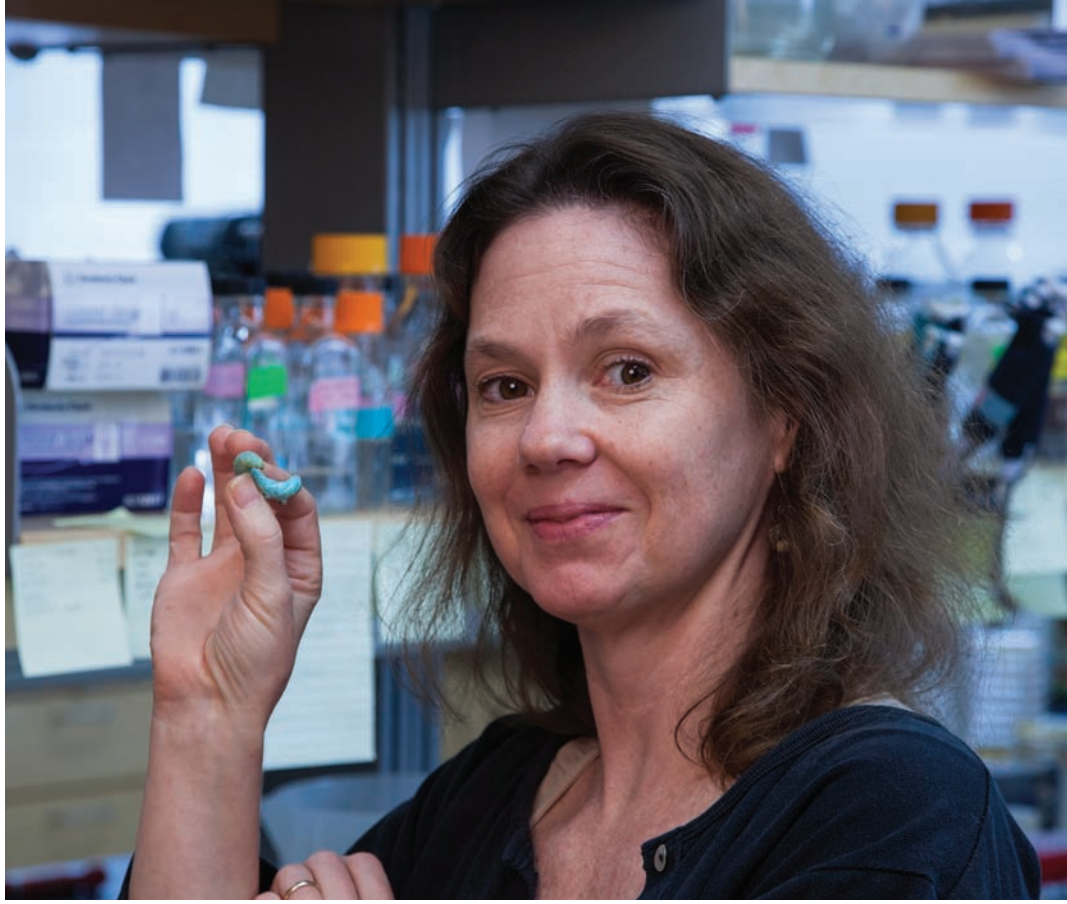
With a good model, nature has done some of that genetic engineering already. It's often reported how close human genes are to those of evolutionary cousins like chimpanzees (98 percent identical). Bacteria have fewer genes overall but are far more diverse. In *E. coli*, for example, nearly 40 percent of the gene content is variable within that species. To make things even more confusing, bacteria can even transmit DNA horizontally, across species barriers.

"It's very difficult to define what a species is in bacteriology," explains Kristen Murfin, a fifth-year grad student in Goodrich-Blair's lab. Her work with animal-associated microbes focuses on variations in strains, a level *below* species.

Murfin is testing how important strains are by examining a group of closely related *Steinernema* worms. In nature each subspecies has its very own *Xenorhabdus bovienii* strain for a symbiont. In the lab she can cross worms with various bacterial strains to see if the worms' fitness—their ability to find and infect prey, and how much (if any) offspring are produced—suffers.

"Strains are so different," explains Murfin. "Arguably, who the microbes are is important. But what they can do is maybe more important because if you have two strains of the same species that can do two different things metabolically, they are going to have very different impacts on the host."

If strain matters in these very simple models, the implication is that we probably need to be looking at a finer



Bacteriology professor Heidi Goodrich-Blair holding a tobacco hornworm, a pest that is preyed upon by very small worms called *Steinernema*—or, more accurately, by the bacteria that live inside them.

Photo by Wolfgang Hoffmann BS'75 MS'79

scale in the human gut. "You would not be able to distinguish the difference between these strains using the technology that we currently have and at the level we're looking in the human gut," says Goodrich-Blair. "If some strains of bacteria are better for us than others, then it matters which strain we have in us. So we will have to dig down to a deeper level of bacterial identity than we have been."

When choosing a model organism, one could do worse than the Hawaiian bobtail squid—*Euprymna scolopes*. (Imagine punctuating the grad school grind with occasional collection trips to Paiko Lagoon on Oahu.) But that's not what led microbiologist Ned Ruby and invertebrate zoologist Margaret McFall-Ngai to the squid in the first place. What makes these mollusks special is their light-emitting bacterial ally, *Vibrio fischeri*. The squid live in the shallows and spend their days buried in the sand. At night they hunt—and are hunted. Under the bright tropical night, the squid would cast a faint shadow on the ocean floor. The squid use the bacteria in their light organs to erase their shadow, so predators can't triangulate their position.

This unique biology makes the squid-vibrio relationship incredibly useful. In a lot of animal-microbe associations, animals are born with their symbionts. For example, if you want a mouse without microbes, you have to deliver it via caesarean section. With the squid, you just have to let it hatch in water without *V. fischeri*. Because *V. fischeri* glow, you don't have to kill the squid to find out if it's been colonized—another challenge with many symbiosis models. And because *V. fischeri* provide light instead of the more common nutritional assistance, you can deprive the squid of its symbiont in the lab without affecting its health or ability to survive.

But perhaps the biggest benefit is that *V. fischeri* live in direct contact with the squid's epithelial cells, similar to the cells that the human body presents to the microbial world. Humans have 10 organ systems, and eight have epithelial and mucosal surfaces that interact with the external environment and maintain communities of beneficial bacteria. The squid-vibrio system offered "a way to understand how bacteria talk to animal tissue," explains McFall-Ngai.

A young squid has a juvenile light organ that filters *V. fischeri* from the vast array of species available at sea—the first communication between the symbionts. Once the squid has captured its *V. fischeri*, the filtering organ isn't needed anymore, and within four days it's gone. This development is triggered principally by exposure to two compounds excreted by the *V. fischeri*, lipopolysaccharide and peptidoglycan, that are commonly associated with bacterial pathogenesis. In addition, the light of the symbiont itself participates in triggering these changes.

In the lingo of pathogenic microbiologists, these compounds are pathogen-associated molecular patterns (PAMPs). But in a paper in *Science*, McFall-Ngai argues that they would more accurately be called microbial-associated molecular patterns (MAMPs). These substances may have been discovered while unraveling a few virulent pathogenic processes, but in fact many species of bacteria in your gut create—and communicate with—the same substances.

It's an attempt to wrest scientific lingo from the pathogenic worldview. Sometimes these bacterial products are benign. Sometimes they're necessary in the gut, but they're bad actors in the bloodstream. "I see them as a language. It's not just what you say, it's how you say it," explains Elizabeth Heath-Heckman, a senior graduate student in the McFall-Ngai lab. "It's a difference between talking to someone in a normal tone and yelling or swearing at them. It can be the same word, but it's a completely different context."

Getting back to the squid, the discovery that MAMPs trigger the loss of parts of the juvenile light organ has important implications. It's been known for a long time that the mammalian gut and its associated immune tissue requires interaction with gram-negative bacteria for proper development. "Nobody could ever figure out why," says McFall-Ngai. This suggests

(Photo below) Travis De Wolfe, a graduate student in Jim Steele's lab, is using mice and pigs to help build a model of the human gut.

that the cellular language that animals use to communicate with bacteria is deeply embedded in our genetic code. "Of course it's doing a different thing, but in animals as divergent as mice and squid it's the same simple molecules," she says. "We know that animals have been associating with bacteria since the beginning of their evolution," she explains. "It allows you to look at the experiments that nature has done through evolution to try to gain insight into how these things work at a basic level."

Recently McFall-Ngai's lab has linked microbial symbionts to another hot field, circadian rhythms. *V. fischeri* produce the same blue light that plants and animals use to tell that it's daytime. Circadian circuitry controls far more than bedtime; its malfunction could underlie a wide variety of problems with immunity, metabolism and mental health.

Photo by Wolfgang Hoffmann BS'75 MS'79

Heath-Heckman wanted to know if the *V. fischeri* bacteria helped the squid tell time. Using genetically modified *V. fischeri* to turn off light production, she deduced that light alone couldn't keep the squid on a circadian cycle: it also needed circadian feedback from the bacteria to tell time.

Her paper, published in April, was the first to link microbiota and circadian rhythms. Just two months later, another group reported that in mice treated with antibiotics, the circadian rhythms in the gut subsided—suggesting that, like the squid, the bacteria and their chemical language might be necessary for maintaining those rhythms.

"If it only happens in the squid, then it's only cool in one dimension," says Heath-Heckman. But if microbes are major players in timekeeping in general, the microbiologists have just opened a new frontier in circadian biology. "This may be a shared trait among animals and their bacterial symbionts. That's part of the power of our system," she concludes. "It really can tell us things about how bacteria associate with animals."

Jim Steele's lab primarily works on *Lactobacillus casei*, and its diversity is a testament to the power of just one microbial species. One of Steele's projects focuses on cheese flavor; another is tweaking strains to enhance ethanol production for use as a biofuel; and yet another works on the utility of this species as a probiotic.

Recently, Steele's graduate student Travis De Wolfe got his first real data, and he can hardly sit still. Now entering his second year in the lab, he is helping to build a model of the entire human gut, using both mice and pigs. Steele's goal is to figure out how to use probiotics to treat *Clostridium difficile*, a nasty human diarrheal illness that is associated with antibiotic usage. De Wolfe eagerly pulls up a chart breaking down the microbes in two mice: one treated with 1 million colony-forming units (a measurement of living bacteria) of *Lactobacillus casei* strain 32G and one treated with 100 million of the same organism.

Two interesting things appeared in the data. One was that, despite the massive infusion of *Lactobacillus casei*, none were detected in the cecum, the region midway through the gastrointestinal tracts that De Wolfe sampled. The other was that the higher dose of probiotic significantly reduced another bacterium, *Lachnospiraceae*. That's the same order as *C. difficile*, their ultimate target. Both findings suggest complex ecological relationships.

"It's pretty astounding for preliminary data," De Wolfe says, then cautions that it means nothing by itself; they're just trying to get their methods down. "We need to pull it apart."

A probiotic is defined as a live microorganism which, when consumed in an adequate amount, confers a health benefit on the host. It's implied in the definition that the microbe matters, and that the dose matters. But there's a caveat, says Steele: "Weirdly, we're this deep into the research ... and no one's actually proven those two very basic tenets of probiotic therapy."

That there are benefits of taking probiotics is clear. Steele describes a famous study that looked at preschoolers in China. One group received a single strain of probiotics, another received two different strains, and the third received placebos. Over six months, the groups that got probiotics missed a lot less school and had fewer symptoms of upper respiratory infection. And the kids who received two strains did the best, though ultimately the difference between receiving one or two probiotic strains wasn't statistically significant.

The benefit of the probiotics was clear, but how did it work? Was the children's immune system on alert because of exposure to a bolus of probiotics? Did the probiotics trigger a change in the microbial ecosystem in the ileum that in turn resulted in upregulating the immune system? "We don't know the mechanism," states Steele. "If scientists are going to take probiotics and dietary interventions to the next level, we've got to understand the underlying mechanisms. If you don't understand the

Photo by Wolfgang Hoffmann BS'75 MS'79

Professors Margaret McFall-Ngai and Ned Ruby inspecting the squid tanks in their lab.

mechanism then you simply can't optimize and control the health outcome."

A large number of people already take probiotics and follow special diets, and scientists are trying to capture some insights from that real-life experiment. Steele needs a middle ground between this complexity and the stripped-down systems like the squid-vibrio.

Pigs are favorite model systems because they so closely mimic human systems. Steele has already fed pigs a humanized diet and found that he can get reasonably close to re-creating the human GI tract. "I'm willing to have a smaller *n* and to pay more to utilize a model that more closely mimics humans for some experiments," he says (*n* referring to the number of experimental subjects). But with yards of intestinal tract, pigs are still unwieldy. He's hoping to use mice in parallel with pigs to shorten the experimental cycle.

There is vast experience in translating mice to humans, but Steele is still uncomfortable with the trade-offs. For example, mice have a foregut colonized by *Lactobacillus*—an organ with an obvious role in defining the gastrointestinal microbiota, but missing from humans altogether. But by extrapolating between mice and pigs he hopes to make the translation to human health. "There is just no other model system that allows us to economically get the *n*," says Steele. "We have to utilize model systems where we can have greater control, run a larger number of samples—and mice give you that opportunity."

On his office door, Steenbock Professor of Microbiological Sciences Ned Ruby has posted a *New York Times* article about a do-it-yourself fecal transplant. The writer's friend had ulcerative colitis, and early research suggested that implanting microbes from a healthy gut might help defeat this difficult disease. But new guidelines from the federal Food and Drug Administration had curtailed the willingness of physicians to perform the experimental procedure.

Instead the procedure was guided, long-distance, by a physician. The overall logic about why it might work was sound. But exactly why it worked could remain a mystery for years. In a nutshell, that's the promise and peril of microbes in human health.

Ruby has worked with McFall-Ngai on the squid-vibrio system for the last 25 years, and the accelerating proliferation of ideas and evidence around microbes is exciting. "The field is opening up beautifully," he says. "It's like you're just coming over the horizon and you're beginning to see the tops of a town. You can't see the whole town yet, but you're beginning to see the tops of the buildings. It's pretty clear there is going to be a town down there."

For all the excitement, Steele thinks the data on the health impacts of probiotics is probably going to get more confusing before it becomes clearer. The answers will come from complex mathematical analysis, crowd-sourced epidemiology, happy accidents and dogged insight. But without the model systems being built at UW and beyond, we'd never unlock the box.

"The importance of studying model systems cannot be overstated, in my opinion," concludes Goodrich-Blair. "You can't study one thing and get a paradigm. You have to study a whole bunch of different things to get the paradigm."

"It is a huge black box," Steele notes. "The tools we have today are not going to be the last tools that we employ to look at this system."

A GROWING FIELD AT CALS

Two faculty members new to CALS this fall are exploring the links between microbes and human health.

J.P. Van Pijkeren, joining food science, studies how intestinal bacteria interact with their host. He is particularly interested in the design and development of lactic acid bacteria to prevent and treat acute and chronic human diseases, including cardiovascular disease.

Federico Rey, joining bacteriology, focuses on gut microbes that metabolize dietary compounds modulating the development of atherosclerosis, a deadly disease. The lessons from these studies, he says, will have implications for therapeutic manipulation of gut microbiota to enhance host health.

communicating science
in the digital age

Web-based science news has placed a higher burden on scientists to more effectively share their discoveries with the public—a challenge that CALS life sciences communicators are ready to help them meet.

By Dennis Chaptman

Photo by Michael Kienitz

Two months after retiring from the Madison-based *Wisconsin State Journal*, where for 34 years he'd reported primarily on science and the environment, Ron Seely splays his hand on the table and points to a small knot of flesh on his palm.

It's from how he cradled his iPhone, his physician told him, especially when Seely was constantly tweeting live from such events as legislative hearings on mining in Wisconsin.

"It was exhausting," says Seely, who like many journalists balanced the new duties of tweeting and other social media tasks with researching and writing his stories, all while meeting daily deadlines. "It's a vicious cycle: You create the expectation that people will have news instantly."

Seely began his career in daily journalism with hot type and ended it with hot tweets. And his career—which includes serving as a teacher of life sciences communication at CALS—reflects the seismic changes that have jolted science journalism.

Take it from anyone who has ever struggled through freshman biology or o-chem: science news was hard enough to understand before the collapse of traditional media. Then Twitter and other social media exploded, blogs proliferated, reader comment sections swelled—and the science got even more complex.

Dominique Brossard, professor of life sciences communication

> "We used to believe that if we only explained to people what the science is about, they would understand and support it."

It's no longer just the newspaper plopping on your doorstep—the science journalism of years past, when discoveries were presented in one-way fashion by writers with science expertise and passively consumed by a trusting public. Science reporting was hit hard by the economic collapse of traditional media, with many science reporters laid off or not replaced upon retirement (example: the *New York Times* closed its environment desk early this year). As science journalism migrated online, web technology blurred the lines between professionally trained journalists, bloggers and other commentators, the public and, most notably, the scientists themselves, who face new and evolving challenges in understanding science communication.

Today, coverage is tweeted, retweeted, "liked" on Facebook, interpreted and reinterpreted by any willing participant—and is the target of instant and often rude, politically tinged reader commentary. With one in seven people actively using Facebook and Twitter users posting 340 million tweets daily, understanding the interaction between science news and readers is crucial.

In short, science communication is being reborn while the media reinvents itself online. That collision raises concern about how society views the science that can solve energy problems, mediate climate change, improve health and feed a hungry planet.

Stem cells, genetically modified organisms, nanotechnology, bioenergy and other complex advancements have all poured down on an American public ill prepared to understand even basic science. The National Science Board, for instance, in 2010 reported that only 73 percent of U.S. adults were able to answer correctly that the earth revolves around the sun; only 52 percent could say how long that takes. And a recent survey by the Pew Research Center for People and the Press found that only 47 percent of respondents knew that electrons were smaller than atoms.

That lack of knowledge, combined with built-in attitudes about science among much of the public—often rooted in religious or political beliefs—makes groundbreaking discoveries difficult to grasp or embrace.

"We're no longer just using microscopes. We're using scanning, tunneling nanoscopes that go into 1,000 times more detail," notes Dietram Scheufele, a CALS professor of life sciences communication. "The science is more complex, and just as complex is the question of what we want to do with that science."

Small wonder that when the public turns to the media, it is often flummoxed, whipsawed by Internet trolls' nasty comments and unsure what to think of the science's legal, social and ethical implications. In the process, is innovation handcuffed by public opinion at just the moment when society needs it most?

Against that backdrop, Scheufele and his colleague Dominique Brossard are in the vanguard of researchers who are trying to understand the emerging media landscape and its volatile dynamics.

"We used to believe that if we only explained to people what the science is about, they would understand and support it," says Brossard, professor and department chair of life sciences communication at CALS. "Today, it's not just about the communication—it's about how the communication takes place."

Notes Scheufele: "Global climate change is not just a political problem or a communication problem or an oceanic and atmospheric problem. It's all of the above—it's science meeting society."

Science carries ethical, legal and social implications that demand reasoned, informed debate. If scientists botch communicating the importance of their work, they can end up saddled with unwelcome consequences, Brossard and Scheufele agree.

In a commentary they co-authored in the journal *Science* early this year,

Dietram Scheufele, professor of life sciences communication

"We are creating an environment where the facts are reinterpreted based on how loudly we yell at each other."

the pair concluded: "Without applied research on how to best communicate science online, we risk creating a future where the dynamics of online communications systems have a stronger impact on public views about science than the specific research that we as scientists are trying to communicate."

The fallout from a poorly

informed debate can be costly, says Molly Jahn, a CALS professor of agronomy and genetics. Genetic modification of foods has been one of science's biggest PR battlegrounds in recent years. Jahn says it's important to understand the dialog between scientists and the public—and its consequences.

"One side yells, 'It's safe! It's safe!' And the other yells, 'We hate big corporations!' Because of that, we don't get anywhere for decades," Jahn notes wryly. "That's where the barriers occur in delivering on the promise of the technology. And those failures often affect people who are not principals in that debate, such as food-insecure people in other parts of the world who could benefit."

As a result of a complex dynamic of corporate decisions, government regulation—and public outcry—there are a "host of plant species and traits that might never be developed," Jahn says.

Science communication research, Jahn says, is crucial to helping scientists dispel public fears about innovation. "Scientists tend to underestimate the extent to which any innovation tends to create consequences in politics and business."

Public attitudes can directly affect researchers' ability to conduct their work. Chris Kucharik BS'92, PhD'97, a CALS professor of agronomy and environmental studies whose research focuses on connections between climate and agriculture, has experienced that on the ground. On occasion, farmers who are wary of his motives or of climate change itself have refused to cooperate with graduate students gathering data. But hardened attitudes seem to be mellowing as people gain more knowledge, he observes.

As a way of addressing the problem, Kucharik emphasizes public outreach as part of his work. At a beer-and-bratwurst meeting at a town hall in southern Wisconsin a couple of years ago, Kucharik mingled with 75 people before stepping up to give a talk about climate change in Wisconsin and its impacts on agriculture.

Not everyone was buying it. In the front row sat a woman, arms folded and offering an occasional, high-arching eye roll as the soft-spoken and measured researcher spoke. Afterwards she challenged him on the existence of long-term climate change. He did his best to explain, but the woman would not be persuaded. The next day, a frustrated Kucharik found that she had blogged about his appearance, claiming that he'd predicted "Armageddon was coming and that everyone had better watch out." He had not. Yet her online verdict was likely to reach more people than his personal appearance.

Such experiences raise questions about the value and nature of online coverage of science. Some science journalists insist that online coverage and commentary provides more information and greater accountability. Others say that the Internet give-and-take can bring down the quality of discussion.

Ron Seely noticed the damaging effects most when covering such polarizing topics as climate change. "With electronic and social media coverage, the differences became the story because controversy plays better on social media. It hurts the science," Seely says.

Exactly how much and what kind of damage may online debate be doing? Dominique Brossard, Dietram Scheufele and several colleagues coauthored a study early this year zeroing in on the effects of nasty online comments by Internet "trolls"—people who comment on news stories with malicious intent, sometimes for pay—on the way readers perceive news stories.

The study, which garnered international attention and coined the term "the nasty effect," asked 1,183 people to read a carefully balanced story about a type of nanotechnology offering such potential benefits as antibacterial properties and such risks as water contamina-

tion. Half of the sample was exposed to civil reader comments at the bottom of the story and the other half saw an uncivil back-and-forth.

The results, Brossard says, were disturbing. "Just the tone of the comments can polarize readers," she says. People who read uncivil comments became more entrenched in their views of the science than those who read civil comments. Those who began with a negative view thought the technology was even riskier after reading disparaging uncivil comments, and people who started off with a positive view became even more convinced when they read a comment like "If you don't see the benefits ... you're an idiot."

"You notice the words 'fool' and 'idiot' and make quick judgments," says Brossard. "That is what we found most troubling."

The study—the first to examine the potential effects of online comments on public perceptions of science—prompted vigorous discussion about the value of moderating online comments and removing off-topic or uncivil screeds. The managers of PopularScience.com cited the study in their decision to discontinue the site's comments section.

Meanwhile, the debate continues. Los Angeles–based science blogger and author Jennifer Ouellette is concerned that communication can be smothered by rudeness.

"Sometimes it seems that those who comment are the least informed, the most biased—when they're not inane," says Ouellette, who has a personal science-and-culture blog at *Scientific American* called "Cocktail Party Physics." "I find myself deleting many comments when I moderate. Maybe that's how it should be—commenting as a privilege, not a right."

Advocates for various causes see the power of online comments. Last spring the Climate Reality Project, a group overseen by Al Gore, created a website that automatically searches for comment opportunities and provides its followers a way to weigh in.

"We are creating an environment where the facts are reinterpreted based on how loudly we yell at each other," Scheufele says. "Scientists cannot engage in that kind of arms race because we will be outspent and outcommunicated—and we will lose every time."

Brossard, coming out of a one-semester sabbatical she used to develop a new course on science and social media, is working on more research that assesses the effects of re-tweets and has trained computers to analyze more than 200,000 tweets on nanotechnology.

"Let's say you blog and you have a great story," Brossard says. "I re-tweet it and change or repurpose it. How does that change how people perceive that story? We need to find out."

What are some paths

toward improving our science discourse? To start with the basics, nearly everyone observing the field agrees that better science education for Americans is essential. Educators this spring unveiled sweeping new science teaching guidelines called the Next Generation Science Standards, developed by state governments, scientists and teachers. They include recommendations to teach climate change and evolution, a hot-button issue for some religious conservatives.

But those changes will take years, and crucial science debates are happening now. There is much that scientists and communicators can do—and still much more to be learned—to promote a more evidence-based, respectful discourse.

Five Surefire Strategies *for* Communication Failure

1. Be reactive rather than proactive, i.e., start going public only after a crisis hits.

2. Address only issues and ignore values, emotions, etc. that people bring to the table.

3. Assume that scientific facts will triumph over everything else (including how they're initially framed in public discourse).

4. Assume that new and social media don't matter as much as traditional media.

5. Assume that public communication is an art rather than a science, i.e., rely on intuition rather than communication experts.

—Dietram Scheufele

Engaging with the public in person is one option. A number of CALS scientists feel they can change minds and solve problems by going into the community and discussing their work, as the Wisconsin Idea intends.

Through that process, agronomist Chris Kucharik has learned to be a better communicator. Experiences such as his town hall beer-and-brat gathering have helped him hone his presentations, framing them with an eye toward public opinion and how his messages will be perceived. "I'm adapting the ways I deliver this information, always finding ways to improve it," says Kucharik.

Describing how he interacts with his audience, Kucharik says, "I always encourage a meaningful back-and-forth discourse. It is the only way to educate the public on new research and consider their experiences as well."

And when things don't go so smoothly? "It is upsetting when personal attacks occur and my words are twisted,"

Comments *about* Comments

A *Milwaukee Journal Sentinel* story about the effect of online comments on science literacy—based on a study by CALS researchers Dominique Brossard and Dietram Scheufele—drew a spicy selection of comments, thus (however inadvertently) helping to illustrate the researchers' point.

Health News

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Online comments hurt science understanding, study finds

By Mark Johnson of the Journal Sentinel Jan. 3, 2013

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A new obstacle to scientific literacy may be emerging, according to a paper in the journal Science by two University of Wisconsin-Madison researchers. »Read Full Article

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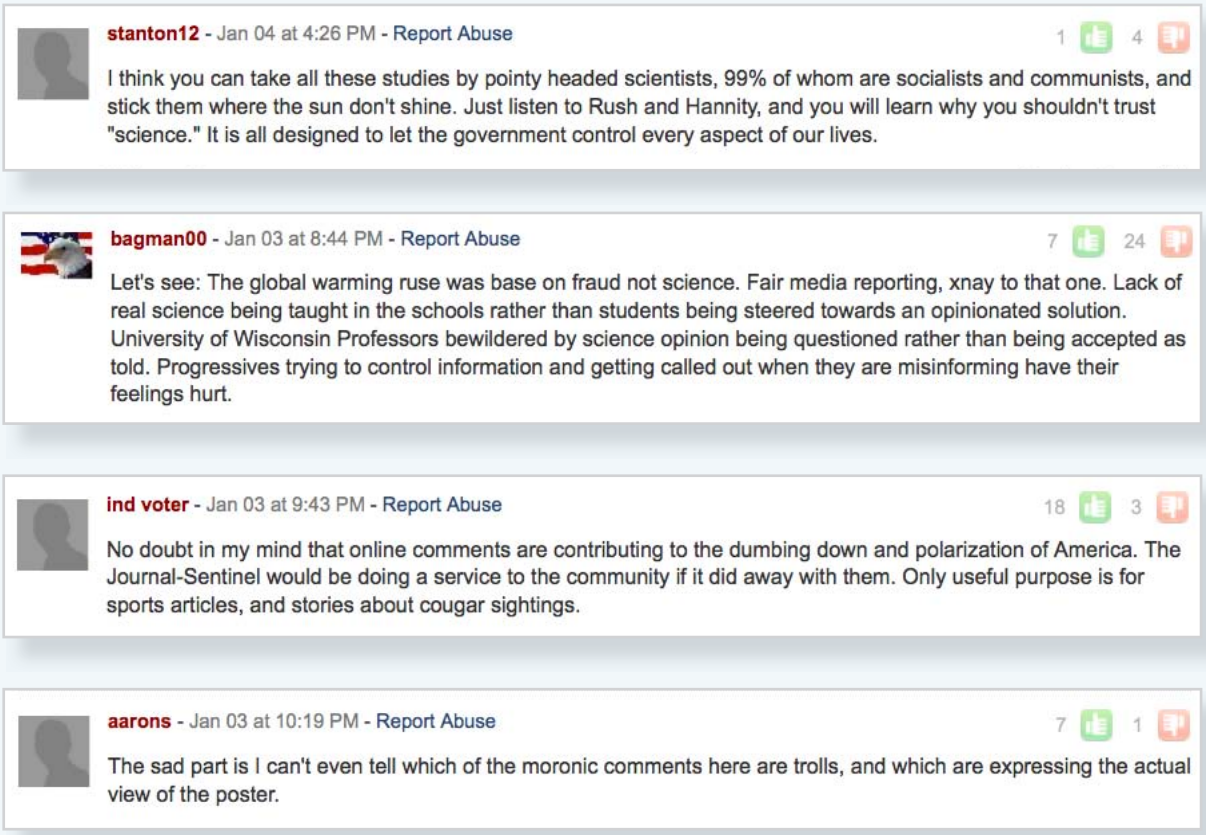


stanton12 - Jan 04 at 4:26 PM - Report Abuse 1 4

I think you can take all these studies by pointy headed scientists, 99% of whom are socialists and communists, and stick them where the sun don't shine. Just listen to Rush and Hannity, and you will learn why you shouldn't trust "science." It is all designed to let the government control every aspect of our lives.

bagman00 - Jan 03 at 8:44 PM - Report Abuse 7 24

Let's see: The global warming ruse was base on fraud not science. Fair media reporting, xnay to that one. Lack of real science being taught in the schools rather than students being steered towards an opinionated solution. University of Wisconsin Professors bewildered by science opinion being questioned rather than being accepted as told. Progressives trying to control information and getting called out when they are misinforming have their feelings hurt.

ind voter - Jan 03 at 9:43 PM - Report Abuse 18 3

No doubt in my mind that online comments are contributing to the dumbing down and polarization of America. The Journal-Sentinel would be doing a service to the community if it did away with them. Only useful purpose is for sports articles, and stories about cougar sightings.

aarons - Jan 03 at 10:19 PM - Report Abuse 7 1

The sad part is I can't even tell which of the moronic comments here are trolls, and which are expressing the actual view of the poster.

—Excerpts from JSonline.com

he says. "At that point, I still try and educate. That's what I'm here for, right?"

Agronomist and geneticist Molly Jahn, too, has found that one of the best ways to dispel skepticism about science is by facing skeptics. As criticism of plant genetics mounted, Jahn engaged with both critics and supporters. "I talked to the people I was supposed to be innovating for instead of assuming I knew the right answer," she says.

Seely notes that scientists today have an unparalleled chance to make their case. "It's more important than ever for scientists to communicate science clearly, and to take on some of that responsibility themselves," he says. Moreover, they should consider taking their communication online. "The scientist who doesn't blog today is missing out on a great opportunity."

The key is learning to do it right—and that's where life science communicators offer help. Brossard, mindful of her study on Internet trolls, warns that scientists untrained in communication could venture into blogging and get more trouble than they bargained for. Brossard argues for scientists to be trained in communication, preferably early in their careers. Otherwise, she says, "We may hurt the cause without knowing it."

When communicating scientific advances, framing the issues is key, Scheufele says. Framing is based on the assumption that we all make sense of new information by attaching it to our existing frames of reference. "It's about presenting issues in a way that connects with what people already know and what's relevant to their daily lives," he says.

As an example he points to the power of the environmental group Greenpeace's "Frankenfood" campaign last decade, an effort that helped demonize genetically modified food by linking it, with a catchy name, to a concept we already found frightening: scientists overstepping ethical bounds to create something monstrous.

Framing is based on the assumption that we all make sense of new information by attaching it to our existing frames of reference.

Framing is about understanding and teaching, not marketing, Scheufele insists. "If I have the feeling that you don't understand something I'm trying to explain, I will try to find different analogies or ways of describing the same issue that resonate better," he says.

Learning to do that is a crucial task—and it's a central goal of efforts to increase collaboration between scientists and science communication researchers, Scheufele says. Such efforts could lead to a better understanding of how science communication works and help scientists more effectively build bridges to various audiences. Schools of agriculture and the life sciences, as natural "hotbeds" of the kind of research that can draw controversy, are well positioned to foster that work, he says.

The process is gaining momentum. Organizations such as the American Association for the Advancement of Science, the National Science Foundation and many universities have begun programs to teach scientists how to interact with journalists and non-academic audiences.

Scheufele and Brossard have emerged as national leaders in the effort, presenting their findings ("The Science of Science Communication") at such highly visible venues as the Arthur M. Sackler Colloquia with the National Academy of Sciences and writing articles for (and being quoted in) a number of popular and academic science publications. Scheufele serves as co-chair of the National Academy of Sciences' Roundtable on Public Interfaces of the Life Sciences, which is devoted to collaboration among scientists and social scientists and convenes workshops to explore needs, challenges and opportunities for public communication about the life sciences.

On a more hands-on level, in the CALS' life sciences communication (LSC) department Seely has started teaching a course in communicating science to a lay audience, aimed specifically at graduate and postdoctoral scientists. The course is popular enough to have a waiting list. He's also been conducting one-semester seminars on writing and communicating science with other UW departments, including botany and chemistry. "It would be nice to think that at some point in the future, science departments would all require the completion of at least one science communication course for graduation," says Seely.

And a new LSC course titled "Science, Media and Society" focuses on the complex relationship between science and the public, emphasizing that beyond teaching scientists to write for a lay audience, scientists also must learn the mechanisms behind science–public interactions. The course drew more than 100 students when it debuted last spring.

In the meantime, Scheufele and Brossard are carrying on with their research. More is needed, they say, to help identify solutions even as communication technology changes at a blinding pace.

"We're trying to fix a car while we're going 70 miles per hour down the highway. We're not in the parking lot and there's not going to be a rest stop anytime soon," says Scheufele. "The opportunity is that here in CALS we have just about every piece of expertise on board."

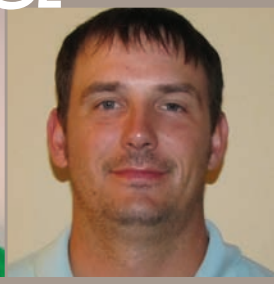
in the field


David Arndt


Brian Brown


Samantha Starich Frei


Karen Kelley


Justin Powell

David Arndt **Farm and Industry Short Course** • For David Arndt, Farm and Industry Short Course (FISC) is a family affair. His father attended FISC in 1948 and strongly encouraged his son to go, too. "It was one of the best decisions of my life," Arndt says. "It got me away from home and started me on a road to being much more independent and inquisitive. I had grown up in a rural community and most of my experiences were in a 100-mile radius of Janesville. It improved my leadership skills, my public speaking skills and my learning skills."

Today Arndt owns and runs Arndt Farms along with two brothers, two nephews and his youngest son. They raise 2,700 acres of crops including corn, seed corn, soybeans, sweet corn, peas, green beans, peppermint and alfalfa and feed 1,600 beef cattle per year. "Crop production is what makes me tick," says Arndt. "I try to give each acre exactly what it needs when it needs it. One of my greatest joys is watching water fall on our irrigated crops. It gives me much pleasure to know that I can give them what Mother Nature sometimes cannot."

Brian Brown **Farm and Industry Short Course** • Brian Brown and his wife Yogi own and operate Sunburst Dairy in Belleville. Sunburst is often cited as a model of successful growth. Sixteen years ago the couple gave up their old stanchion barn and expanded to a freestall barn and parlor, a move that allowed them to double their herd to 300 cows and hire employees. Six years ago they added a second barn and grew to 500 cows.

"I'm involved in overall management of every aspect of the dairy, but most of my focus is on animal nutrition, genetic selection, herd health and reproduction, and crop production," says Brown. Beyond the farm, Brown serves as chairman of the board of directors at Accelerated Genetics and as a dairy leader for the local 4-H club.

For Brown, the Farm and Industry Short Course tradition encompasses three generations—both his father and his son Cory, who now works with him at Sunburst, are FISC alumni. Brown says the course provides a lifelong value. "The professors pushed us to challenge ourselves and go after new opportunities," says Brown. "To this day, 30 years later, I am still using what I learned in short course. It is useful, practical knowledge. Short course is a program that will benefit future generations in agriculture."

Samantha Starich Frei **Wisconsin School for Beginning Dairy Farmers** • Samantha Frei is a self-described "city girl" from Madison who found her passion in farming through 4-H club, where she learned to show dairy cattle, and by working on dairy farms during summers while in high school. She originally planned to go into veterinary medicine, but an encounter at World Dairy Expo changed her mind. "It wasn't until I was standing in front of the UW–Madison FISC booth and the School of Veterinary Medicine booth that I considered going through short course instead of a full bachelor's degree plus vet school," she says.

That was in 2007. Frei enrolled in short course and never looked back, taking classes in crop management, soil science, dairy herd health, dairy reproduction, food processing and grass-based dairy business. She met her husband, Don, shortly after graduating, and together they transitioned his family's 30-cow, 180-acre conventional dairy farm in Argyle to an organic dairy, Morning Dew Dairy. They currently farm 500 acres and milk 60 cows.

Karen Kelley **Ice Cream Short Courses** • Karen Kelley had long loved ice cream and she'd long loved dairy farming, her profession for more than two dozen years. But she first brought the two together in 2010, the year she launched Kelley Country Creamery right on her family's 200-acre dairy farm in Fond du Lac. Her creativity shines in a list of more than 200 flavors ranging from traditional to adventurous (examples of the latter: Acai Blueberry, Chai Tea and Jalapeño).

Thanks to short courses in the Babcock Hall dairy plant, Kelley did not have to make the business leap alone. Two ice cream courses—Ice Cream Makers Short

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: Alumnae who became Alice in Dairyland

John Vosters

Ilan Weiss

Matt and Sarah Winnie with their children

Alumni from CALS Short Courses

—*Natalie Hinahara*

Course and Batch Freezer Workshop—helped her learn the art of "cream-smithing," as she calls it, and offered her a start in networking with other ice cream professionals. She went on to attend regional and national ice cream conferences and seminars and became a member of the National Ice Cream Retailers Association and the Great Lakes Ice Cream Association. After some four years of research and development she was ready to launch her business, which she now runs with the support of her husband and five children.

Justin Powell BS'06 Dairy Science, Farm and Industry Short Course • Justin Powell, DVM is the herd veterinarian for River Valley Dairy in Tremont, Ill., and the owner of Twin River Veterinary Service, where he focuses on embryo transfer work and in vitro fertilization. He was moved to enter this specialized field because of a lifelong love of cows and, as an undergrad, dairy cattle genetics. Powell grew up and remains active on his family's Holstein farm in central Illinois. Powell attended short course prior to earning his four-year degree in dairy science. "It allowed me to make some important connections. I met people who really helped me when I came back for the four-year program," he says. Between those enrollments he worked on a 300-cow dairy in Wisconsin. "It was a good experience to work on a farm that was different from the one I'd grown up on," he says. In his free time Powell enjoys boating, fishing and showing cows.

John Vosters Farm and Industry Short Course • John Vosters is co-owner of Milk Source LLC, which operates a number of dairies in Wisconsin as well as a calf farm and heifer-raising facility. Milk Source's roots date back to 1965, when Voster's parents started a small dairy farm near Kaukauna. In 1999 Vosters partnered with Jim Ostrom and Todd Willer, also veteran family farmers, to form Milk Source. They moved into large-scale farming as a way to escape the 24/7 duties of a traditional farmer and divide labor among a workforce that could be offered insurance and paid time off.

In his role as livestock director, fostering that workforce has been one of Vosters' biggest pleasures. "The biggest driver for our success is the development and growth of our managers," he says. "They've been with us from three to 20 years. Many of them started as a milker, feeder or in maternity and have grown with us. We need to invest both personal and professional time in our employees in all levels of management. An engaged employee is an extremely valuable asset."

Ilan Weiss Resident Course in Confectionery Technology ("Candy School") • Ilan Weiss is a senior food scientist with SunOpta in Edina, Minn., where he conducts research and development on roasted snacks: sunflower seeds, soybeans and corn. That includes coming up with new products and processes. "Several of our snack items go into the school feeding program," says Weiss. "This makes me feel good because our snacks are filled with protein, fiber and healthy fats. That really sets our products apart from other options in school programs."

Why go to candy school? "I wanted to better understand what options we have for making different snacks. I was looking to see what concepts could be used in our product line." Not only was the course a great refresher in carbohydrate chemistry, says Weiss, but he was able to make important contacts in many different industry sectors.

Matt and Sarah Winnie Wisconsin School for Beginning Dairy Farmers • When Matt Winnie arrived on the CALS campus some 10 years ago for his short course, he was hoping to broaden and deepen his skills in dairy farming, not necessarily find a wife. He ended up doing both. On the second day he fell into conversation with Sarah Knorn, who'd grown up on Green Valley Farm, which had been founded by her great-grandparents near Rib Lake. Winnie admits it was love at first sight: "Right away I felt a connection with her. We seemed to hit it off, and I guess she kept me ever since." Romance seems to be an added benefit for other short course participants as well—the Winnies can name two more couples who met that way.

The course, Winnie said, helped him build a business plan for a dairy operation, which he had long wanted to establish. As for Sarah Winnie, since childhood she'd wanted a farm of her own. In 2008 the couple purchased Green Valley from Sarah's parents, becoming the fourth-generation owners. Modernization efforts since then include adding another silo, putting comfort tie stalls in the barn and building a milking parlor. They've gone from 64 to 110 cows and doubled the number of acres farmed. And they're growing their family as well. Matt and Sarah have two boys and two girls—and another baby is due this winter.

Catch up with …

Barbara Heindl BS'09 Wildlife Ecology

As a double major in wildlife ecology and biological aspects of conservation, Barbara Heindl dreamed about one day helping to save a species from the brink of extinction. Now she's pursuing her passion as a field crew leader for the Kaua'i Forest Bird Recovery Project, a mostly government-funded effort facilitated by the University of Hawaii.

Kauai, known as "the garden isle," is the oldest Hawaiian island and one of the wettest spots on earth, a paradise noted for spectacular mountains, canyons, waterfalls—and an array of rare native birds.

Even in the context of Hawaii, which leads the nation with 35 birds on the endangered species list, Kauai stands out. Only eight of the island's original 13 forest birds still exist—and six of them are found on Kauai and nowhere else. Three of them are on the verge of extinction. Heindl's organization focuses on those three federally endangered species: the akekee, the akikiki and the puaiohi (in photo left).

- **What do you love about your job?** The areas where we work are absolutely gorgeous, though very challenging to work in. I often describe the forest as a literal jungle gym, and more often than not it's raining, which can make conducting surveys a mental and physical challenge—but I love it. To top it off, getting to go through all of the data we collect and using that to help inform conservation efforts is really rewarding, enough so that I don't mind going back into the forest to get roughed up again.

- **What are the main threats to the three birds you are working to save?** The tricky part about Hawaiian avifauna is that they are affected by many threats that all work together. The main ones are predation by non-native rats on nestlings and nesting females and diseases such as avian malaria, which is spread by non-native mosquitoes. That, in turn, has secluded native forest birds to high-elevation forest where mosquitoes are less prevalent, thus limiting the birds' range. Native forest destruction (and increasing mosquito habitat) caused by non-native ungulates like pigs and goats, whose wallows make excellent mosquito breeding areas, is also a significant problem.

- **What are your team's main activities?** Primarily we are doing surveys to better understand the relationships between these birds and the native forest, as well as surveys to get better estimates on current population sizes and their threats. Right now we're doing a lot of nest monitoring, vegetation surveys and rat work. All of our work then influences the five-year recovery plans for these birds.

- **Why is the survival of these birds important?** These birds are found nowhere else in the world and are highly adapted to the forests on Kauai. In particular puaiohi are the only remaining native frugivore (fruit-eater) on the island and are important seed dispersers for the native forest. Akikiki and akekee are primarily insectivores and are excellent indicators for ecosystem and forest health. Other native birds provide services by pollinating specific plants that have no other pollinators. Not to mention the cultural uses by native Hawaiians. The loss of any of these birds would be tremendous both culturally and ecologically.

—Joan Fischer

Learn more at http://kuauiforestbirds.org/

Photo by Mark Hoffman/Milwaukee Journal Sentinel

Taking orders: Bucky's Butchery offers hams and prime rib for the holiday season.

BUY HOLIDAY GOODS ON CAMPUS—not only are they high quality, but proceeds benefit CALS student clubs and organizations as well as the university's teaching and research.

Christmas Tree Sale: The 40th annual Christmas Tree Sale takes place **December 6–8** in the UW–Stock Pavilion. Tree species include Fraser fir, balsam fir and white pine as well as Fraser fir wreaths. Proceeds support student educational opportunities within the Department of Forest and Wildlife Ecology.

Hams and Prime Rib Sale: Bucky's Butchery, located in the Meat Science and Muscle Lab building (1805 Linden Drive), starts taking orders for Christmas hams and prime rib right after Thanksgiving. Orders must be placed by **December 17**. More information at **http://go.wisc.edu/y7399m**.

SHARE THE WONDERFUL by donating to CALS as part of the all-campus annual campaign (see page 38). You can make a gift to the **CALS Annual Fund**, which allows the college to allocate your support where it is needed most. Visit **http://sharethewonderful.org/give?to=cals** to donate any amount—even small gifts add up and make an enormous impact.

This year's Share the Wonderful includes a crafty online feature called **Words On, Wisconsin** that allows you to create and share your memories of campus using word strips and photos. Visit **sharethewonderful.org/words/** and get creative!

GET THE LATEST information about Wisconsin's $60 billion ag industry at the **Wisconsin Agricultural Outlook Forum** on **Wednesday, January 22, 2014** at the Pyle Center (702 Langdon Street). The event is held by CALS and UW–Extension. More information available soon at **news.cals.wisc.edu**.

UWMadisonCALS

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

give

Supporting Food Safety

When Kikkoman wanted to establish a naturally brewed soy sauce plant in Walworth, Wisconsin—an operation that was to become the world's largest—the company had a top-notch consultant at CALS to help them out.

That expert was professor Edwin "Mike" Foster, a noted bacteriologist who was the first director of the Food Research Institute (FRI) and the person responsible for FRI moving to UW–Madison from the University of Chicago in 1966.

"Mike was invaluable in offering guidance on how to address and validate regulatory issues related to the safety of soy sauce as Kikkoman went through the process of gaining FDA approval," says FRI director Charles Czuprynski. Over the years UW–Madison has continued to play a role in testing potential new uses of sauce and products derived in the fermentation process, he notes.

Dr. Edwin (Mike) Foster

Out of long-standing gratitude, the Kikkoman Foods Foundation has named a new scholarship fund in Foster's honor. The "Kikkoman Scholarship in Honor of Dr. Edwin (Mike) Foster," as it is called, will be awarded by the FRI each year "to a deserving undergraduate student with a demonstrated interest in food microbiology and food safety," says Czuprynski. The award amount will be in the range of $1,000 to $1,200.

Czuprynski regards the Kikkoman plant as a remarkable Wisconsin success story—and a tribute to Kikkoman's long-range leadership vision, supportive relationship with their workers and cooperation with local businesses and communities. "This scholarship is just one example of their generous support of UW–Madison and the UW System," Czuprynski says.

The UW Foundation maintains more than 6,000 gift funds that provide critical resources for the educational and research activities of CALS.

Contributions to the Kikkoman Scholarship in Honor of Dr. Edwin (Mike) Foster fund are welcome at ***http://go.wisc.edu/08c3m5****.*

If you wish to establish your own scholarship fund, contact Sara Anderson at the University of Wisconsin Foundation, sara.anderson@supportuw.org, (608) 263-9537.

To make a more general contribution to scholarships at CALS, visit the Agricultural and Life Sciences Scholarship Fund at ***http://go.wisc.edu/3q63sr****.*

Together, We Make a Difference

Your gift, big or small, makes all the difference in ensuring that a world-class intellectual environment and a campus life that's the envy of the Big Ten will be available to a new generation of Badgers.

Designating your gift to the College of Agricultural and Life Sciences allows us to:

- Offer hands-on learning experiences for students, whether in classrooms, campus labs or faculty-led field courses in Wisconsin and around the world
- Support programs, lectures and tours organized by the 35 student organizations housed in CALS
- Enable advances based on scientific discovery in such areas as food systems, health and wellness, bioenergy and ecosystem management

For more information about giving to the College of Agricultural and Life Sciences through the Share the Wonderful Annual Campaign or to learn about other giving opportunities, please contact Sara Anderson at the UW Foundation (608-263-9537 or Sara.Anderson@supportuw.org).

SHARE THE WONDERFUL

UNIVERSITY OF WISCONSIN ANNUAL CAMPAIGN

sharethewonderful.org

Photo: Wolfgang Hoffmann BS'75 MS'79

Take the Final Exam!

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

Food Science

1. The foodborne pathogen responsible for the largest number of outbreaks is:

a) *Escherichia coli*
b) Norovirus
c) *Campylobacter* spp.
d) *Salmonella* spp.
e) *Toxoplasma gondi*

Animal Sciences

2. What was the typical number of hours hunters and gatherers searched for food per day?

a) 3 hours
b) 9 hours
c) 15 hours
d) continuously

Horticulture

3. The factors of plant growth are:

a) genotype, nitrogen, plant disease, temperature, and light
b) genotype, nutrients, water, light, gases, and temperature
c) nitrogen, phosophorous, potassium, and trace elements
d) genotype, phenotype, light, temperature, and water

Agricultural and Applied Economics

4. What are the three main anthropogenic greenhouse gases?

a) Carbon dioxide, methane, nitrogen oxide
b) Carbon monoxide, ozone, nitrous oxide
c) Carbon monoxide, ozone, nitrogen oxide
d) Carbon dioxide, methane, nitrous oxide

Agronomy

5. Which of the following is an advantage of growing soybeans?

a) It produces oil.
b) It produces high-protein animal feed.
c) It is useful in controlling soil erosion.
d) All of the above.
e) a and b
f) b and c

LAST ISSUE: Answers were 1: D, 2: B, 3: D, 4: D, 5: C. Congratulations to Chris Latimer, a PhD student in wildlife ecology, who was randomly selected from the six people who correctly answered all questions. He wins a gift certificate to Babcock Hall.

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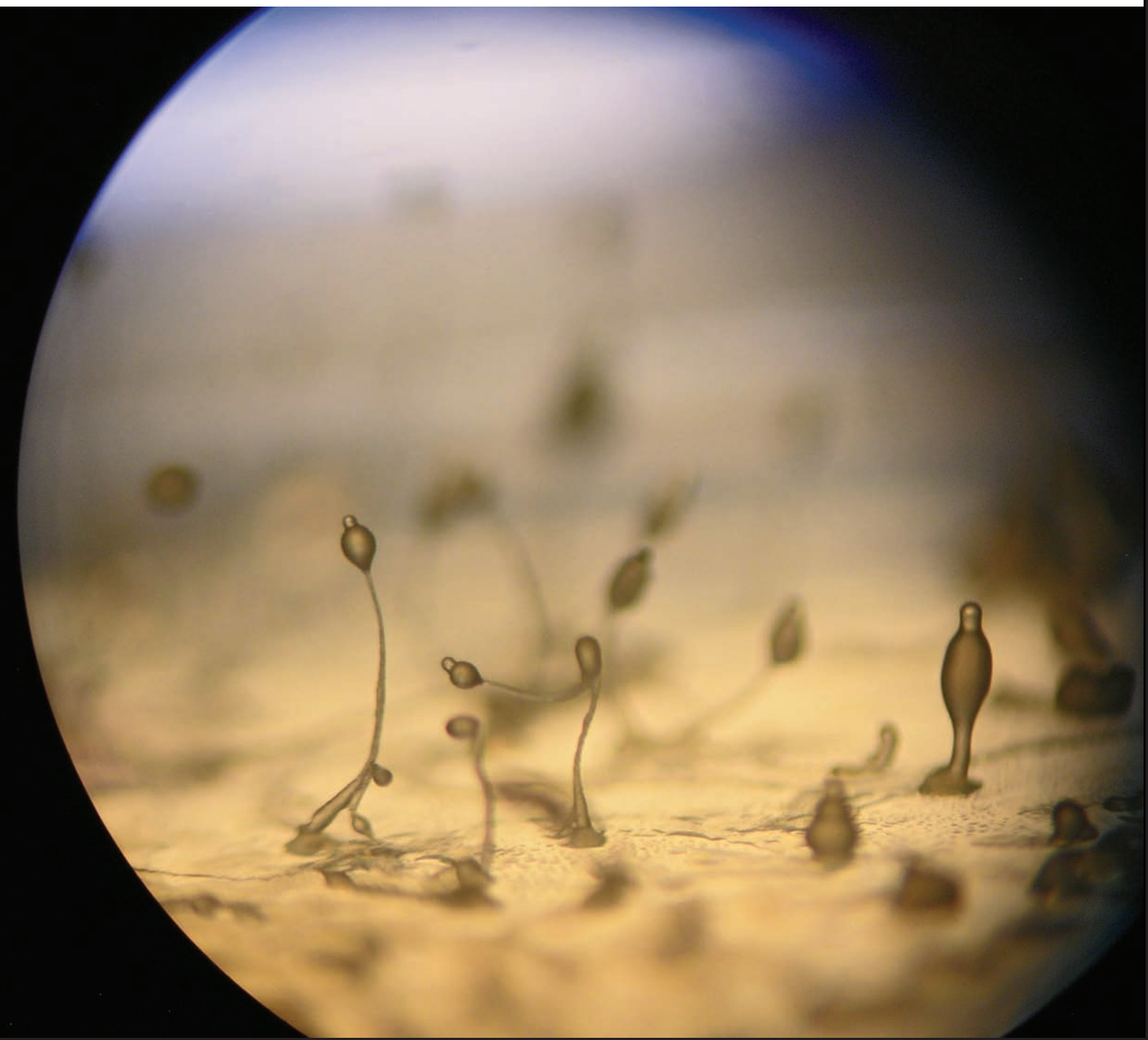

MiddleEarth is the title of this photo by Sheryl Rakowski, a researcher in the Department of Bacteriology at CALS. "Slime mold has a foot in two worlds, macroscopic and microscopic," says Rakowski, explaining the title. When conditions are favorable, single-celled amoebae roam around under our feet, hunting and eating bacteria. But "when food gets scarce, they become social, forming 'flash mobs' that morph into multicellular organisms like those shown here," notes Rakowski, whose photo was a winner in the campus-wide Cool Science Image Contest. See all contest winners at www.news.wisc.edu/slideshows/coolscience2013/