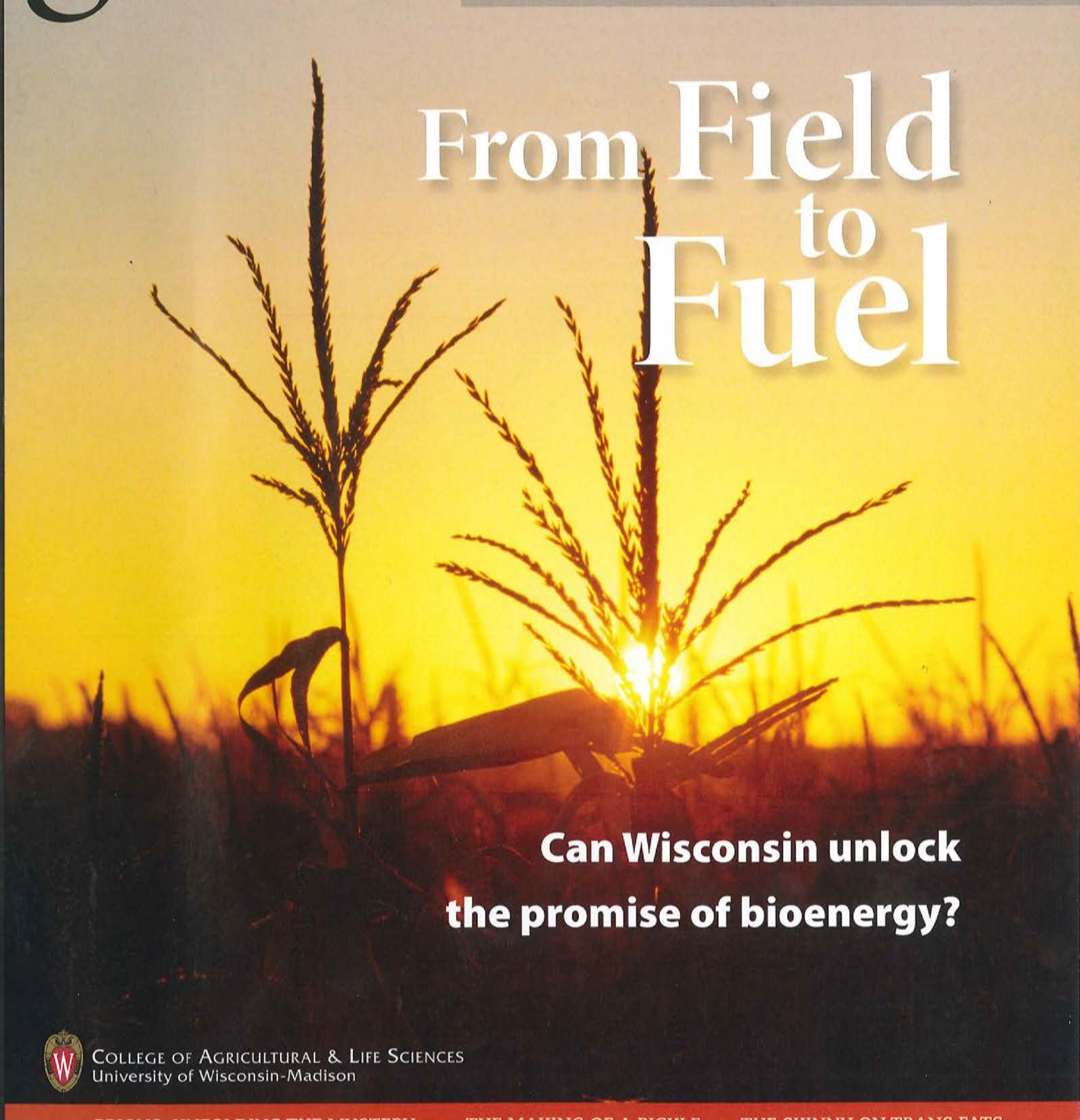
grow

Wisconsin's Magazine for the Life Sciences • Fall 2007

agriculture • food • health • environment



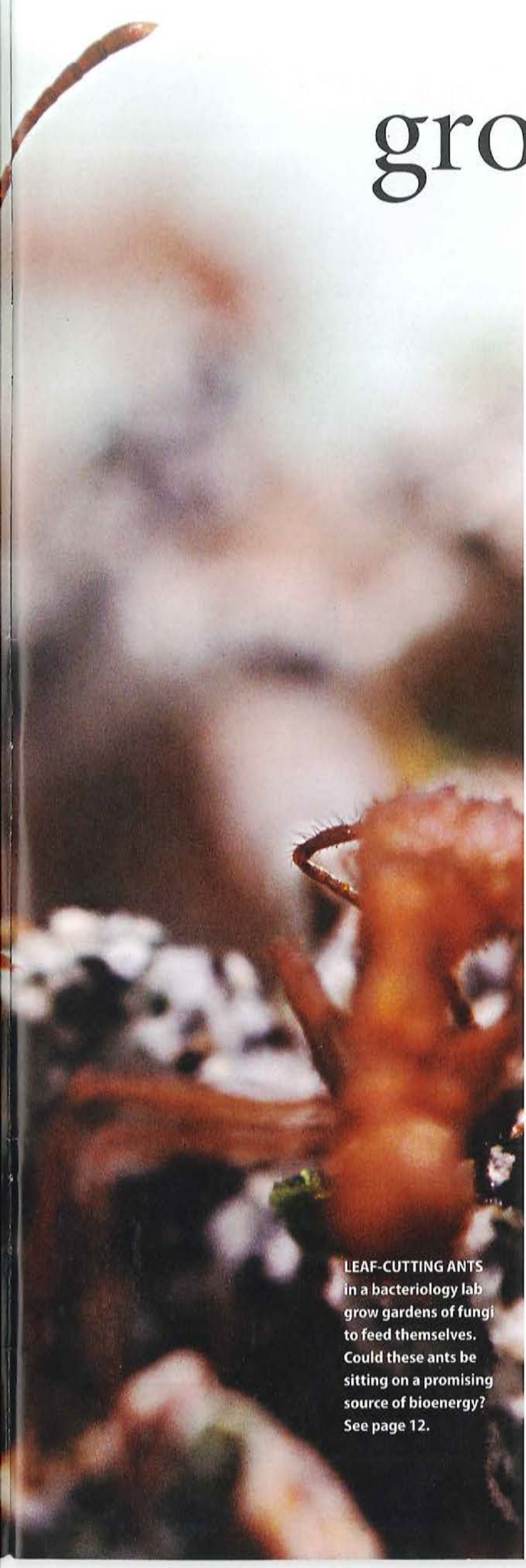
From Field to Fuel

Can Wisconsin unlock the promise of bioenergy?

COLLEGE OF AGRICULTURAL & LIFE SCIENCES
University of Wisconsin-Madison

PRIONS: UNFOLDING THE MYSTERY • THE MAKING OF A PICKLE • THE SKINNY ON TRANS FATS

Volume 1, Issue 1 • Fall 2007



LEAF-CUTTING ANTS in a bacteriology lab grow gardens of fungi to feed themselves. Could these ants be sitting on a promising source of bioenergy? See page 12.

grow

Wisconsin's Magazine for the Life Sciences

Departments

ON THE COVER
Corn tassels against the sun.
Photo byAGStockUSA/Curt Maas.

Dean Molly Jahn

Growing Together

YOU HAVE IN YOUR HANDS SOMETHING DIFFERENT. This inaugural issue of *Grow* is more than just a new magazine for our college. It represents a new way of communicating with you. We do not intend to talk *at* you about the activities of the college, but rather *with* you—engaging you in an ongoing dialogue about our work, our missions and our core values. We hope this magazine can be a vital way that we stay connected as a community.

As I look toward the future of this college, I see tremendous importance in fostering and enhancing this community. Across all of our academic disciplines, we are witnessing significant changes, which are creating new challenges and opportunities for our agricultural industries. We are in the midst of a scientific explosion that is rapidly expanding our knowledge of fundamental biology. At the same time, we are facing pressing concerns about how best to protect our farms, preserve our natural resources, promote good health and secure a more sustainable energy future.

These are broad issues that do not fit neatly into the confines of traditional academic departments. We must bring forward communities of expertise, working together to integrate knowledge and solve problems. Ultimately, our brightest future will require new heights of cooperation and teamwork, new modes of communication and renewed commitments to life-long learning.

Our brightest future will require new heights of cooperation and teamwork, new modes of communication and renewed commitments to life-long learning.

The very name of this magazine reflects this commitment. We have envisioned this publication as a way to grow—to grow as a college and to grow as a community. Our focus will be forward, and we invite you to join us in this journey.

From my office in Ag Hall, I can look out the same windows as have 11 deans before me. What I see are many of the same challenges and constraints that my predecessors faced. But I also see a community of unlimited talent poised on the brink of possibility. Our scientists have recently received the largest research award in the college's history, which will allow us to explore the enormous potential of bioenergy and create a focused, responsible discussion about a sustainable energy future. It is appropriate and exciting that this new venture is the subject of *Grow*'s first cover story.

Yet even as we pursue these scientific frontiers, we are guided by core values that have been with us since our earliest days: a commitment to excellence, visionary innovation, accountability, practicality and the knowledge that we're in this for the long haul. So as we lift our eyes to the future, I can assure you that the lights will burn late into the night around our campus. And in that regard, some things never change.

grow

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College of Agricultura[l]
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University of Wisconsin-Madiso[n]


Sunlight floods the atrium of the new Microbial Sciences Building, now the largest academic building on campus.

Microbial Mixer

CALS' new microbiology research building is an experiment in collaboration.

Like commingling chemicals inside a test tube, the arrangement of laboratories inside UW-Madison's new Microbial Sciences Building is designed to produce a reaction.

The 330,000-square-foot building, a glass-and-brick structure built on the site of the former E.B. Fred Hall, opens this fall as a sparkling new home for microbial research on campus. And even as they unpack, its two main tenants, the CALS Department of Bacteriology and the School of Medicine and Public Health's Department of Medical Microbiology and Immunology, are already engaged in an experiment. Instead of carving up the new space, the departments are interspersing labs and faculty into neighborhoods based on shared research interests.

"We tried to create a building where these (cross-unit) encounters will happen, sparking discussions and new ideas," explains Glenn Chambliss, the outgoing chair of bacteriology.

The $121 million building is part of the state's BioStar program, rolled out in the late 1990s to ensure Wisconsin maintained its pre-eminence in biology and biotechnology. More than half of construction costs were paid for by gifts and grants, including support from the Wisconsin Alumni Research Foundation.

The facility brings together research labs that were scattered in multiple places around campus, creating new opportunities for collaboration in an area of science that has increasingly broad applications. Research on microbes is central to understanding infectious diseases such as influenza and malaria, developing new antibiotics, ensuring the safety of food and exploring alternative energy sources.

And in their new home, faculty and students will find facilities build for speed—and comfort. The building includes a Union-catered café and a dramatic, sunlit atrium that affords grand views of Hiram Smith Hall. Probe a bit further, and you'll find facilities ingeniously tailored to the needs of laboratory science and instruction. There are even facilities for nursing mothers, which also double as sleeping quarters—complete with reclining chair and shower—for all-nighters in the lab.

—Nicole Miller MS'06

Number Crunching

330,000
Square feet of space, making the Microbial Sciences Building the largest academic building on campus

400,000
Bricks used in construction

2,200,000
Feet of electrical wire

68,000
Square feet of window glass

110
Students enrolled in the Microbiology Doctoral Training Program, one of the largest such programs in the nation

21
Academic departments at UW-Madison that have faculty who specialize in microbiology

$35 million
Value of 2007-08 research grants earned by the 40 faculty who have labs in the new building

The Plot Thickens

Rain gardens are popular, but researchers are only starting to explain what makes them effective.

Soil science professor Nick Balster is testing several different rain garden plantings to see how they handle rainwater.

Since their public introduction more than ten years ago, rain gardens—small garden plots that are designed to collect and filter storm water—have created quite a storm among environmentally minded homeowners. But as their popularity has grown, so have opinions about what makes the perfect rain garden. Many gardeners fill their plots with deep-rooted prairie plants, which they believe help water permeate the soil and replenish groundwater supplies. But some contend that turfgrasses do the job just as well.

"There are a lot of stories out there, and stories are good—they provide a starting point for science," says soil science professor Nick Balster. "But what we need are some repeated, controlled experiments that rise above bias."

After fielding several calls from people looking for rain-garden advice, Balster decided to start those experiments. With graduate students Marie Johnston MS'06 and Sara Rouse, he is growing rain garden plots blanketed by soil, shrubs and prairie plants and tracking where the water they collect winds up.

So which vegetation should you plant? Balster's answer so far: It depends.

Balster and his students have found that, contrary to popular belief, young, actively growing prairie gardens seem to let little rainwater past their roots. "When people look at their prairie gardens after a rain and see no water, they tend to think all that water went through the ground and into groundwater pools," he says. "Our trials with residential-sized gardens suggest this may not be true. What appears to be happening in our experiments is that the prairie plants can suck a substantial amount of water up and put it back into the atmosphere." That capacity could make prairie plants an ideal setup for trapping contaminated runoff from a parking lot, Balster says. Toxins like lead and zinc may end up staying behind in plant tissues and soil, making them easy to remove.

Turf, on the other hand, seems to act like a temporary sponge. Its shallow, dense root mass sops up rain and releases it slowly into the soil. Balster suggests this might make it a better choice for recharging groundwater, although this idea needs testing.

But sometimes the objective is simply to capture as much water as possible, regardless of whether it ends up the earth or sky. In this case, a study by horticulture professor John Stier and graduate student Jake Schneider suggests that what matters most is sizing a rain garden properly and surrounding it with a berm. "What we've found so far is that berms are the main factor controlling runoff," says Schneider. "I think the bottom line is that if you put in a rain garden, it's going to be incredibly effective at this, no matter what type of vegetation you have."

Questions remain about how rain gardens perform as plants mature and what role root systems play in collecting early-spring or late-winter runoff, when plants haven't broken the surface.

"Just like anything else in science, this has become a much more fun and interesting story than just 'prairie versus turf,'" says Balster. Stay tuned.

—Madeline Fisher

Ready to Wear ... and Eat

YOU'VE HEARD OF CARAT WEIGHT, BUT CARROT WEIGHT? At the Dane County Farmer's Market, students in UW-Madison's Dietetics and Nutrition Club are teaching children about good nutrition by making farm-fresh jewelry. As they string edible bracelets, necklaces and headbands, the volunteers talk to kids about the role fresh produce plays in a healthy diet, helping them see that good eating can be good fun. Since the effort began in 2003, many elementary school teachers, day care providers and families have adopted the idea, says Kelli Truszynski BS'07. So what makes the perfect veggie bling? Truszynski says, "We've used small potatoes, carrots, radishes, kohlrabi, cheese and even beef sticks."

A Touch of Grass

Study finds that cheese from pasture-fed cows tastes like a winner.

Consumers can taste a difference in cheese made from the milk of cows that graze on pasture, a recently completed study by two CALS professors has found. And they like what they taste.

That's good news for Wisconsin, where many cheesemakers are betting their futures on distinctive artisan cheeses, and where roughly one quarter of the dairy farms use a managed grazing system.

Scott Rankin, an associate professor of food science, and David Combs, a professor of dairy science, made and analyzed Cheddar cheese from milk produced under three feeding systems—cows fed exclusively on pasture, cows fed on pasture plus grain, and cows fed on a mixed ration of grains, minerals, vitamins and protein supplements, and alfalfa silage. Each cheese was aged two to four months and then sent to North Carolina to be tasted by a panel of expert evaluators, as well as a consumer taste panel.

The consumer panel tended to give the pasture-plus-grain cheese highest marks for flavor, texture and overall liking. When asked to pick a favorite, 60 percent chose the pasture-plus-grain cheese.

The expert tasters noted a significant "grassy note" in both pasture-based cheeses, especially in the pasture-only cheese. The mixed-ration cheese had a more buttery flavor than the pasture-only cheese, according to the study.

Because grazing is a seasonal venture, milk from pasture-fed cows is likely to vary according to differences in weather and growing conditions. For that reason, Rankin says pasture-milk cheese may not be an option for many producers. "If you have 30 trucks coming in and you need to make a consistent product for a national pizza chain, the milk has to be the same today as it will be a year from now," he says.

But for specialized cheesemakers, who often produce cheese in smaller scales for epicurean markets, the new findings show that using milk from pastured cows may pay off with consumers.

"Other states may out-produce Wisconsin in terms of mass production of cheese, because it's less expensive to produce milk elsewhere," Rankin says. "We can't win the battle of mass production. We can win the battle on quality."

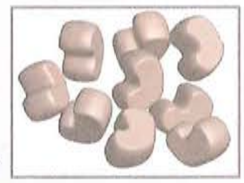
—Bob Mitchell BS'76

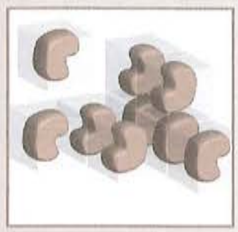
how to see a protein

Proteins are the workhorses inside every cell—yours, mine, a flower's, all living beings—that perform the duties that keep our cells functioning properly. But proteins are too small to see, even with the most powerful microscopes. Instead, scientists jump through various hoops to figure out their structures. Here's one method they commonly use:

Choose an important protein. Because coming up with a 3-D image of a protein's structure is costly and labor-intensive, it is important to choose your protein wisely. Often, scientists want to know the shape of proteins associated with particular diseases so that they might develop new treatments or pharmaceutical agents to target the cause of the disease.

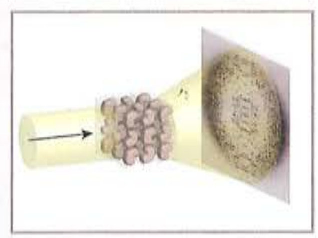
Generate a whole bunch of molecules of that protein. Scientists can trick bacterial cells to produce a particular protein by inserting DNA that instructs the cell to crank out copies of the desired protein. Another method uses cellular machines to make proteins in a test tube.



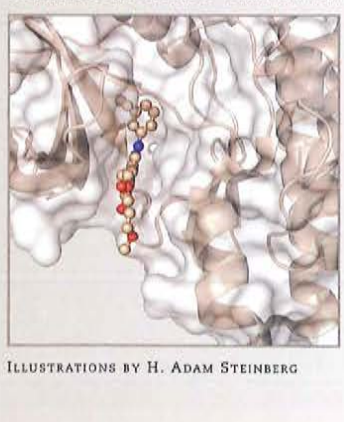


Coax those proteins to form crystals. Working with a solution full of protein, scientists adjust temperature, pH, salts and other components in a painstaking process to encourage crystals to form and grow. As proteins crystallize, their molecules line up in an ordered way, like individual chairs that stack together to make a tower.

Blast one of the best crystals with X-rays. When a narrow beam of X-rays penetrates the ordered protein molecules in a crystal, the rays bend as they pass by atoms in protein molecules. Software programs then read the pattern created by the X-rays and deduce a 3-D model of the protein molecule.



Refine the protein's 3-D structure. A human hand is always needed to fine-tune the protein's shape. Because this whole process is so complicated, less than 3 percent of attempts result in successful 3-D structures. At this point, each of these models costs around $80,000 to create. Work at the UW-Madison's Center for Eukaryotic Structural Genomics, part of the biochemistry department, is aiming to improve that success rate and lower the price of the process.



Illustrations by H. Adam Steinberg

Building Green, for Less Green

Design team plans energy-efficient housing that saves money, too.

Rick Miller (left), a member of the Lac Courte Oreilles tribe of Wisconsin, loads a hopper with straw during a training session on green building technologies.

In construction, affordable and green are often contradictory terms. What makes for an environmentally conscious building—such as the use of natural building materials or systems to generate alternative forms of energy—often also makes for an expensive one, leaving sustainable design a choice only a few can afford.

A team of UW-Madison faculty, students and community organizations, however, is out to construct a new reality: green housing that doesn't require as much up-front expense. Sue Thering, a CALS assistant professor of landscape architecture and a community development specialist for UW-Extension, is coordinating a partnership with several of Wisconsin's Native American communities to create affordable, energy efficient housing on tribal lands throughout the state. Supported by a three-year grant from the Baldwin Wisconsin Idea Foundation, the project included a for-credit outreach program this summer, which trained 20 participants in green community design techniques and culminated in the construction of two model homes in the St. Croix Ojibwa community near Hertel, Wis. Plans are to construct affordable housing in other tribal communities during the next three years.

"There are green technologies that already go into very high-end housing," says Thering. "We have assembled a team of national experts who have dedicated themselves to this project, and through good design, research and testing, they have made these technologies work on a more modest scale."

Thering notes that builders in the Southwest are using a mixture of straw and clay to construct "green" walls in expensive homes. Participants in the summer program, including UW-Madison students and tribal housing officials, spent a week in Santa Fe, N.M., learning how to work with the straw-clay compound, which can be adapted for Midwestern temperatures to create highly energy efficient structures.

By mastering such techniques, Thering says participants can open the door to jobs and business opportunities. "Builders tell us that there is pent-up demand for these technologies, but a shortage of people who are trained to work with them," she says. "We're responding to the market."

—Brescia Cassellius

When Your Classroom is a Cow

A developing calf appears in an ultrasound image, one of the tools CALS students master in a new course on dairy reproduction.

ONE OF THE FIRST LESSONS STUDENTS LEARN IN Milo Wiltbank's new dairy reproduction course is that they'd better wear their barn clothes to class. For every hour in the classroom, they spend two-and-a-half at the business end of a dairy cow.

Wiltbank's class is part of the dairy science department's efforts to refocus its curriculum more closely on the needs of the industry. The upshot is that students are spending more time learning sophisticated technical and analytical skills that will pay off in agricultural careers. Wiltbank's class, for instance, was developed to address one of the toughest challenges facing dairy farmers: the difficulty of breeding top-producing cows.

"We are finding more and more dairy herds with reproductive problems that are seriously affecting their bottom-line profitability," says the professor.

During the semester, Wiltbank's students master artificial insemination and use of ultrasound for monitoring reproductive status. They also learn how to synchronize cows' breeding cycles to give herds the best chances of reproductive success.

"They really have to learn these skills," says Wiltbank. In one class exam, for example, students have to inseminate three cows in 10 minutes. "It's not just a matter of doing it once."

A New Wrinkle

CALS research launches a rival to BoTox.

To microbiologist Eric Johnson, it's a second chance at the one that got away.

In the mid-1980s, UW-Madison missed a chance to license the technology behind BoTox, the wildly popular treatment used to erase wrinkles and ease muscle spasms. Based on techniques developed by the late Ed Schantz BS'31 PhD'39, Johnson's mentor and longtime collaborator at CALS' Food Research Institute, BoTox now generates an estimated $1 billion in annual sales.

Now, California-based Mentor Corporation may help ease the pain of missing the BoTox boom. The company has licensed new technology developed by Johnson and other FRI scientists to produce PurTox, an anti-wrinkle product that would compete head-to-head with BoTox. Mentor is building a new production facility in Madison's University Research Park to make PurTox, which is currently in clinical trials, and other botulinum-related pharmaceuticals, which involve injecting tiny doses of the poison into the skin to freeze nerve endings.

"They already have a sales force calling on the right customers," says John Hardiman, a licensing manager with the Wisconsin Alumni Research Foundation, which negotiated the deal. "They're well positioned to (take the botulinum product) to the same market."

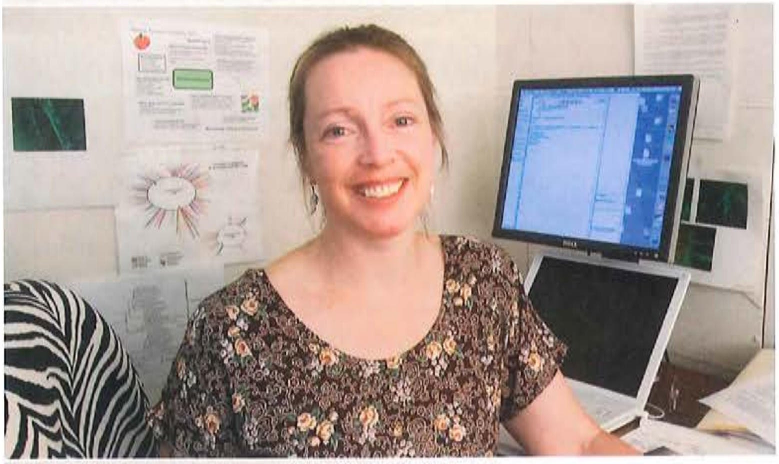
Schantz helped pioneer therapeutic work with botulinum toxin, the deadliest natural poison known. In the 1980s, he and San Francisco ophthalmologist Allan Scott showed how small doses of the toxin could be used to relax muscles in the treatment of certain eye disorders. Schantz approached WARF about patenting his technology for purifying the toxin, but the agency passed, leaving Scott to license the technology to Allergan, Inc.

Since then, Johnson has continued Schantz's work, developing new strains and exploring new applications for the toxin. He and three colleagues have founded Metabiologics, a company that supplies botulinum toxin to researchers and vaccine manufacturers around the world. A vaccine made from their product was used recently to stem a major botulism outbreak in Thailand, Johnson says.

While none of this work takes away the regret of passing on BoTox, Johnson says the decision was understandable at the time. "You have to realize the times back then," he says. "The idea of the most poisonous substance ever known being used as a pharmaceutical? It seemed like a real stretch."

—Bob Mitchell BS'76

caitilyn allen



- **job** Professor of Plant Pathology
- **lab** Located on the eighth floor of the Russell Labs building
- **team** Six researchers, including five students
- **current research** Investigating how certain bacteria cause wilt disease in crop plants

What's the goal of your research? I study bacteria that cause plant diseases, with the ultimate goal of improving the lives of subsistence farmers in the developing tropics.

Is work in the lab 9-to-5 or 24/7? Not quite 24/7, but almost. My students and postdocs often work at night and usually on weekends. Since most of my work now involves the computer rather than plants and pipettes, I work at home nights and weekends to be near my kids.

What's the view from the window? Pretty wonderful. We look out on Lake Mendota and Picnic Point. It can make you feel a little wistful on sunny summer days when the lake is dotted with sailboats.

What's playing on the lab radio? I made a no-radio rule about 10 years ago after an ugly dispute broke out between country and hard rock factions in the lab. But the radio does play at night and on weekends, everything from salsa to bluegrass to '80s dance music.

If you had to evacuate your lab, what would you grab first? My laptop—but only because my culture collection is too big to carry.

Clean desk or messy desk? Messy, in spite of all my resolutions.

Eat out or brown bag? Brown bag—the workday's too short as it is. But it does lead to crumbs in the keyboard.

Any personal items in the lab? My yoga mat—stretching keeps my back from getting too knotted up.

What's your desktop picture? My daughters. Also one of my bacterium inside a tomato stem. I'm afraid the picture of my bacterium is bigger.

Where do you get your best work done? For working with people on my team, I need to be in the lab. For grading, a coffee shop is great. And for serious writing, you can't beat the back corner of Steenbock library near the annual reports of the Southeast Asian Tuna Fishing Commission.

What's the coolest thing you've learned by doing research? That bacteria can sense when they are near a host plant and swim over to start an infection.

Digging Dirt

Soil scientist **Teri Balser** says we can learn a lot from what lives under the surface. Even the weather.

TERI BALSER, assistant professor of soil science, studies microbes in the soil, focusing on their role in releasing carbon dioxide into the atmosphere. Balser believes this release, rarely accounted for in climate models, may be a crucial piece of the climate-change puzzle. She recently received a Faculty Early Career Development Award from the National Science Foundation—one of the most prestigious honors beginning researchers can receive—to advance her research and teaching.

GROW: *What does soil have to do with climate change?*

BALSER: The soil has more carbon stored in it than the atmosphere and vegetation combined, and bacteria and fungi living in the soil are responsible for decomposing that carbon. Basically, they eat it, if it's something they like. They chew it up, decompose it and turn it into carbon dioxide.

As the climate warms, it's predicted that soil carbon is going to be decomposed faster by microorganisms. So there's a real possibility that you might get this vicious cycle set up, where increased warming causes more carbon dioxide to be released from the soil, which causes more warming.

Ninety percent of soil carbon is in a fairly stable form. But it's such a large amount of carbon that even a tiny change in that pool size can really influence atmospheric carbon dioxide levels.

GROW: *Yet we don't often hear about soil in the discussion of global warming. Why not?*

BALSER: So far, the people who have been studying climate change have typically been climate modelers. They look at the large scale and try to make models that will predict the impact of increasing atmospheric carbon dioxide. They tend to leave out details about the soil microorganisms, which are like the valve that controls the release or storage of carbon in soil.

What I'm really studying is the extent to which the microbial community controls that release and how we include it in models. I'm asking: Are we getting ourselves into trouble by ignoring the microbial community when we're talking about climate warming?

GROW: *Are we? What have you found so far?*

BALSER: I found that when we look at the physiology of the organisms, we sometimes get the opposite result than what the modelers predict.

Warming the soil a little is great for microbes; it makes them more active. If you're just thinking like a chemist, then an increase in temperature equals an increase in reaction rate, and that means more carbon dioxide. For a really stable molecule, like complex carbon, you have to have a lot of energy input before it will break down, and so the higher the temperature, the faster and easier those big complex molecules will break.

That works great in a test tube. But this is where the biology comes in. Microorganisms are not just simple reactors. Microorganisms are biological entities, and although it's not really accurate to say they make choices, they do have survival strategies. What we have seen happen is that when we increase the temperature, the microbes did not increase the breakdown of complex carbon. We saw the opposite. When the temperature went up, the utilization of simple carbon increased, and the utilization of complex carbon decreased. So, they're effectively making a choice to use simple carbon and not complex carbon.

GROW: *What does this mean for climate change models?*

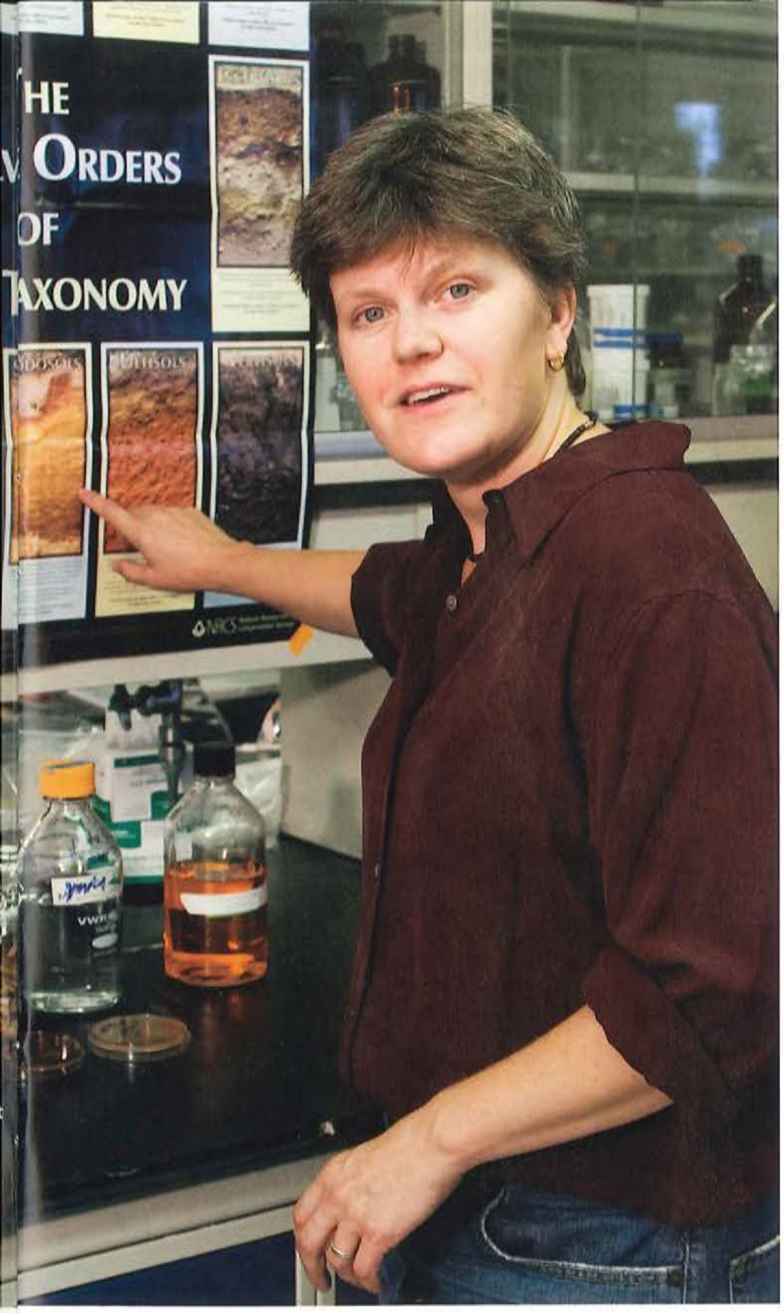
BALSER: It means that microbes may not make a continuous contribution to atmospheric carbon dioxide as the climate warms. It could be that after all the simple carbon is used up, they won't release any more carbon dioxide no matter how much the temperature heats up.

It's just a big unknown. It's something that could turn out to be important in the grand scheme of things.

GROW: *If it's possible that microbes may release less carbon dioxide, does that mean the current models may overstate the effects of warming temperatures?*

BALSER: Absolutely. That is definitely a possibility. However, temperature is only one of many factors that influences microbial communities in soil. One of the most important things we are doing in my lab is trying to understand how much temperature is actually controlling carbon dioxide release versus the influence of other factors. Microorganisms generally respond to stress by producing more carbon dioxide, and things like extreme soil pH or disturbance from land use changes such as tillage can also result in carbon dioxide feedbacks to the atmosphere.

Teri Balser's interest in soils stems from the diversity that lies underneath the surface.



"People make fun of me all the time for saying that you never forget your first spodosol. But it's true."

GROW: How are you simulating these changes in your research? Do you physically warm the soil to see how the microbes react?

BALSER: We are taking soil from northern Wisconsin and moving some of it to middle Wisconsin and some to southern Wisconsin. Basically, we use the change in latitude to simulate climate change.

In another experiment, we'll be taking soil cores and flipping them upside down. Soils that are deeper don't experience temperature fluctuation the way that soil on the surface does. So if you want to create artificial climate change, you can take soil that's deeper in the ground and put it at the surface, where suddenly it's experiencing temperature fluctuations and stress.

GROW: Is this the kind of work you imagined when you set out to be a soil scientist?

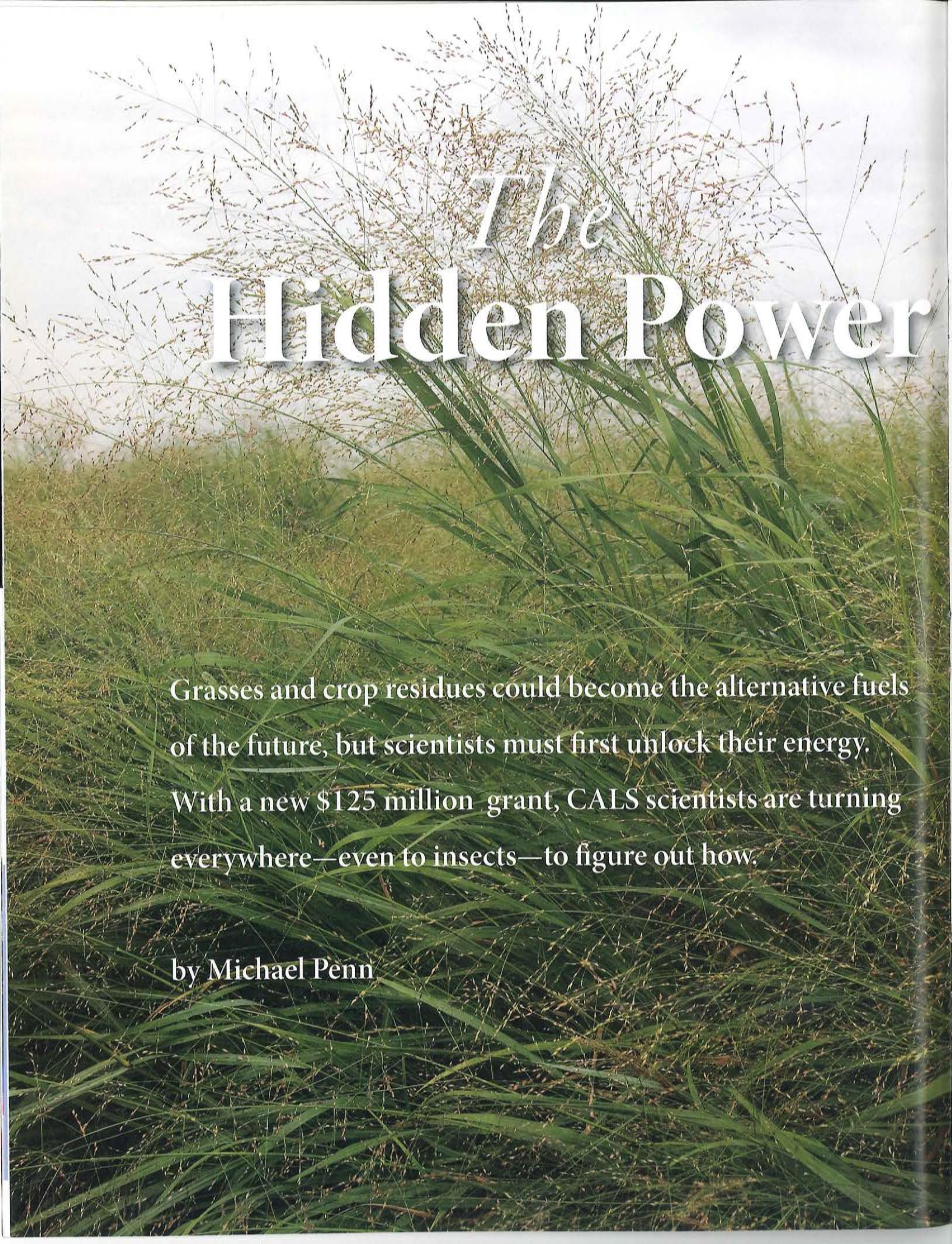
BALSER: I wasn't born knowing I wanted to study dirt. I kind of stumbled into it, and it turned out to be the perfect thing. In my first soils class I learned that soil is formed from rocks, which brings in a geology aspect, and it's also formed by vegetation at the surface, which brings in a biology aspect. So soil is this perfect blending of my major interests, geology and biology.

In my junior year of college, I took a field trip to a pine stand on the Dartmouth campus. Back in colonial times, it had been cleared and plowed for agriculture, and if you dig a soil pit there today, you will see a layer of charcoal exactly 30 centimeters below the surface, which is exactly the level where a plow would flip the soil over. I guess they planted potatoes or corn, and they would burn the stubble and then plow it under. So even a hundred years later, there was this layer of charcoal right exactly where they flipped the soil over with a plow. And that to me was just really fascinating. I never expected to see that in the soil.

GROW: What's the most interesting thing you've unearthed in your work?

BALSER: There is a type of soil, called spodosol, that you find in conifer forests, and it's very dramatic and pretty. It's dark black at the top, because that's where high levels of carbon are decomposing. And then it has a bright white layer that is called the e-horizon, for eluviation. Underneath that is this bright orange-red layer that has streaks of brown in it, which is super pretty. And then it gets to be yellow and then cream colored as you go down. It looks like a sunset below the surface of the earth and it's absolutely beautiful.

People make fun of me all the time for saying that you never forget your first spodosol. But it's true. Any time I had dug holes in the ground before that, the soil was just brown. I had no idea that soil could be that pretty, and that helped convert me.



The Hidden Power

Grasses and crop residues could become the alternative fuels of the future, but scientists must first unlock their energy. With a new $125 million grant, CALS scientists are turning everywhere—even to insects—to figure out how.

by Michael Penn

of Plants

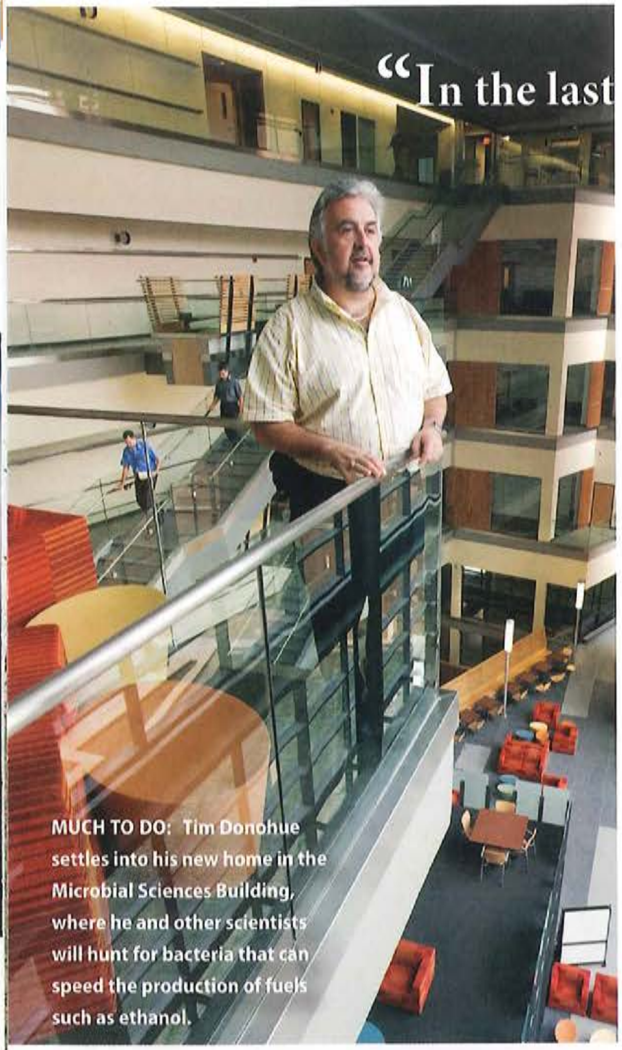
HAVING SPENT HIS CAREER STUDYING A TYPE OF LEAF-CUTTING ANT native to the rainforests of Costa Rica, Cameron Currie never imagined he'd have much to offer on the subject of America's insatiable thirst for gasoline. A native of the Canadian prairie with an abiding curiosity about evolutionary biology, Currie came to CALS in 2004 as an assistant professor of bacteriology with his ants in tow. These days he is caretaker to some 50 nests of the insects in his laboratory, where he studies their symbiotic relationships with fungi and bacteria. Fascinating and enlightening work, yes—but hardly connected to the problems of gas-guzzling SUVs and spiraling oil prices.

Except that maybe it is. Currie's ants, belonging to the genus *Atta*, do something remarkable, a capacity shared only by humans and a few other insects. They grow their own food, tending vast gardens of leaves that provide nutrients for the main source of the ants' diet, a strain of fungi related to common mushrooms. And while humans began farming around 10,000 years ago, these ants have been at it for some 50 million years. Is it possible—especially as we enter the dawn of a new era of agriculture, in which we hope to cultivate crops that we can easily convert into energy sources—that the ants in Currie's lab could teach us a trick or two?


A leaf-cutting ant in Cameron Currie's lab tends to a garden of fungi, one of the oldest models of farming known.

FACING PAGE: At CALS' Arlington Research Station, fields of switchgrass hold potential as a source of sustainable energy.

"In the last 100 years or so, we have gone through a very significant fraction of fuels that it has taken this planet millions of years to accumulate ...



MUCH TO DO: Tim Donohue settles into his new home in the Microbial Sciences Building, where he and other scientists will hunt for bacteria that can speed the production of fuels such as ethanol.

That possibility intrigues Tim Donohue, scientific director of UW-Madison's newly minted Great Lakes Bioenergy Research Center. Launched by the largest federal research grant ever received by CALS, a five-year, $125 million award from the U.S. Department of Energy, the center has lassoed a diverse group of researchers to come up with new ways of drawing energy from nonfood sources, such as plant stalks, wood chips, crop residues and agricultural waste. The idea of turning the planet's organic leftovers, collectively called biomass, into energy has great appeal as an alternative to fossil fuels, but the methods for making fuel from plant biomass aren't yet anything close to a commercial reality, a bottleneck Donohue and the center hope to overcome.

And that's where ants come in. As opposed to corn kernels, which are made up of simple sugars like glucose, plant stalks and leaves are comprised mainly of cellulose, a tough polymer that gives plants structure. One of the most common organic materials on the planet, cellulose is a polysaccharide, a long chain of linked sugar molecules that must be broken apart before the sugars can be processed. The reason we can't eat tree branches, for instance, is because our bodies lack the digestive enzymes to attack the chemical bonds in cellulose and get at its sugars. The same problem exists in the ethanol process; we don't have efficient means for degrading cellulose into soluble materials that can be fermented into alcohol-based fuels.

But Currie's ants may. Their nests harbor an array of microbes, most of which are unknown to science, and Currie believes many of those microbes play essential roles as leaves are broken down and cycled through the ants' gardens. Given that this collaboration has been perfected over millions of years of evolution, it's not unreasonable to expect that we might find something useful—a microbe particularly adept at degrading cellulose, for example—in those nests if we looked.

The thing is, no one has thought to look, not until Donohue struck up a conversation with Currie about his new bioenergy center.

"It's not an obvious connection," says Currie. "But there is enormous potential to learn how these ants are using microbes to break down plant material, and those discoveries could be highly relevant to bioenergy."

ANTS may never solve the world's energy problems, but it says something that they're getting a chance. Certainly, it speaks to the growing urgency surrounding the search for alternatives to fossil fuels, which provide more than 85 percent of the human-generated energy on the planet. With supplies of crude oil dwindling and worldwide energy demands projected to rise by more than 50 percent in the next two decades, it's hard to make the math add up to anything less than a crisis.

"As a planet, we're facing big problems," says Donohue. "In the last 100 years or so, we have gone through a very significant fraction of fuels that it has taken this planet millions of years to accumulate, and when those are gone, we're going to have to have entirely new technologies. This is an experiment we only get to do once."

Bioenergy potentially settles some of those big problems. Drawing energy from crops, grasses and trees—renewable resources that can be grown season after season—helps answer the supply issue, while also easing the political pressure of dependence on foreign oil. The environment could benefit, as well. Because oil and coal form as organic material decays underground, dredging them up and burning them releases several billion tons of carbon dioxide into the atmosphere each year, a factor chiefly blamed for global warming. Fuels such as biodiesel and ethanol can help stem the flow of greenhouse gases because the plants used to make them absorb carbon dioxide from the atmosphere as they grow, offsetting the amount released when they are burned.

Still, one problem with current biofuels is that nearly all of them are made from food, such as ethanol from corn kernels or biodiesel from soybeans. Economists fear a major expansion of the existing ethanol industry would threaten food supplies and raise prices. Deriving fuel from materials such as corn stover, plant residues and animal waste, on the other hand, would pose no threat to food markets, while also creating new economic opportunities for agricultural states such as Wisconsin. Brett Hulsey, an environmental analyst who wrote Governor Jim Doyle's policy paper on bioenergy, estimates that Wis-

. . This is an experiment we only get to do once."

consin creates some 15 million tons of excess biomass each year, which if converted to ethanol would supplant half of the state's annual petroleum use. "It's like sitting on an oil reserve," says Hulsey. "You've got fuel literally laying on the ground that could be used."

But this is hardly a new dream. People have envisioned replacing petroleum-based chemicals in fuels and plastics with the carbohydrates in plants for most of the last century. Henry Ford designed his first Model T in 1908 to run on ethanol, believing it would be the fuel of the future. The great horticulturist George Washington Carver foresaw whole industries built on agricultural residues. "I believe the Great Creator has put ores and oil on this earth to give us a breathing spell," Carver once wrote. "As we exhaust them, we must be prepared to fall back on our farms, which are God's true storehouse and can never be exhausted. For we can learn to synthesize materials for every human need from the things that grow."

While science long ago mastered the fermentation of simple sugars to make beer, wine and grain-based ethanol, however, it has yet to dent the steelier challenge of making fuel from the cellulose-laden leftovers. The best existing methods rely on harsh chemical treatments and complicated microbial reactions, all of which are too inefficient, too expensive or too caustic to make ethanol from biomass a commercial reality.

Solving this dilemma has been likened to a Manhattan Project-scale quest, involving thousands of scientists and the backing of powerful interests. Responding in part to rising public rustration with high gasoline prices, governments and private industry have staked multiple millions of dollars on research into biomass-to-biofuel technologies. Petroleum giant BP has committed $500 million over the next decade to this effort, funding a research consortium led by the University of California-Berkeley. Exxon, Chevron and Conoco Phillips have made smaller-scale arrangements with other university labs.

"I see bioenergy as a research field in 10 or 15 years being as large as biomedicine," Donohue says. "This industry is going to be as big as Silicon Valley, as big as Route 128 in Massachusetts."

As principal investigator of the Great Lakes Bioenergy Research Center, Donohue will attempt to secure a piece of that future for the Midwest. Announced in June, the center is one of three such facilities funded by the Department of Energy to speed progress on biomass energy sources. (The others are based at the DOE's Oak Ridge and Lawrence Berkeley laboratories.) Its administrative home will be Madison, but it will draw on expertise from Michigan State University, as well as a handful of other university labs and institutions. Fifty-seven scientists are listed as primary investigators, an unprecedented alliance of plant geneticists, chemists, microbiologists, computational scientists, engineers and agronomists.

Gregarious and broad-shouldered, with an unmistakable note of New York City in his speech, Donohue has spent 20 years studying bacteria that turn sunlight into renewable fuels and other organic compounds. Under his leadership, the center will have a strong bent toward microbiology. Among his main goals is to probe the genetic pathways that microbes use to break down cellulose and other plant materials, which would allow scientists to optimize the processes that are currently used in industrial fermentation systems and to engineer new, more effective ones.

But the center will attack the scientific knots of bioenergy conversion from multiple angles, from breeding new plants better suited for the energy pipeline to rethinking existing processes for making ethanol to pioneering entirely new energy solutions, such as the direct production of hydrogen or electricity from sunlight. For example, the center will fund research by James Dumesic, a professor in the UW-Madison College of Engineering and one of the nation's leading experts on the chemical conversion of sugar into liquid hydrogen, which as a transportation fuel may have 40 percent more energy content than ethanol. Dumesic is co-founder of Virent Energy Systems, a Madison-based company that already is making hydrogen fuel from the simple sugars in fruits and starches, and his lab is working on the conversion of other sugars found in plant biomass.

Another intriguing idea comes from the lab of Sandra Austin-Phillips, a senior scientist in the UW-Madison Biotechnology Center. For the past 10 years, Austin-Phillips has been changing the genetic makeup of plants such as alfalfa and tobacco to cause them to make certain chemicals as they grow, essentially turning them into manufacturing centers for compounds that can be used in pharmaceuticals or animal feeds. Her lab is now trying to get plants to churn out microbial cellulases, the proteins that trigger the chemical breakdown of cellulose, the critical first step to any biomass-to-biofuel process.

"For biomass conversion technology to have a major impact, we're going to need millions of tons of these enzymes, and there's no way that we can produce these quantities in fermentation systems with our current capacity," says Austin-Phillips. "Our idea is to produce them in the plants."

Since cellulases break down plant cell walls, Austin-Phillips says she was met with open skepticism when she

sought funding for her work. "People told me the plants would fall over," she says. But the cellulases she's working with are active only at relatively high temperatures, meaning they have virtually no effect on the plants that make them. Once the plants are harvested, the cellulases can be separated for use in biorefineries, which could help reduce the cost of currently expensive enzymatic treatments.

True, some of these projects have a considerable hike to reach field applications. But that's the nature of fundamental research, says Donohue. "This is not *CSI Miami*, where you can bring me a plant and tomorrow and I'm going to tell you how to use it," he says. "This is going to take a long time." Many of the center's projects will be speculative and may never prove fruitful at all. But they are shots worth taking.

Such is the case with Cameron Currie's work with leaf-cutting ants. Currie's team has begun studying the compost-like heap of organic material left after the ants finish their meals, which they believe teems with a microbial stew that helps chew up the remaining cellulose and cycle it back to soil. Given that a tiny fraction of microbial life has been characterized in the lab, they must first do genetic analyses to figure out what all is living in those sites. These studies have already identified a microbe that is active at high temperatures, a sign of energy efficiency that could be valuable in industrial applications.

"There's this massive process of converting plant material through the whole system," says Currie. "But our understanding of what goes on in terms of the breakdown of plant materials is really fairly limited. There are microbes playing roles in there that we don't know about, and those have potential interest for bioenergy."

But ant nests are hardly the only natural system that attacks the tough defenses of plant cellulose. Termites and ruminant animals such as cows do essentially the same thing, and very few of those systems have been explored with bioenergy in mind. This kind of inquisitiveness may be exactly what the bioenergy field needs to move forward, says Robert Landick, a professor of biochemistry who is coordinating the center's research on bioconversion.

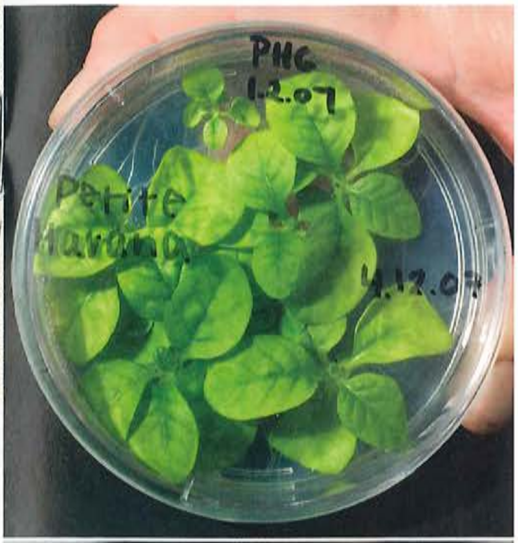
"The spirit of this center will be to fund numerous small projects that are high-risk, but also high-reward," he says. "If you really want to crack a problem, the rational way to do it is to get 10 different ideas from 10 different people. You know at the outset that eight of those 10 are going to be a bust, but the key is that you don't know which eight. What you can be reasonably sure of is that if you enable highly motivated, bright scientists to go after these problems from a bunch of different angles, that's your best shot at really producing a breakthrough. All of our biotechnologies have come from that kind of basic research, with breakthroughs that come from all kinds of unanticipated, weird places, but in the end get assembled into a very powerful technology."

SCIENCE is ultimately one variable in the matrix that will determine if bioenergy lives up to its promise. As important are the policy decisions that will affect how the industry grows and matures. And right now, at least, bioenergy is moving with such speed that policy can barely keep up.

Consider the U.S. corn ethanol industry, which in 2000 produced about 1.8 billion gallons of ethanol from corn kernels. Since gas prices spiked and venture capital began pouring into the construction of biorefining plants, production has rocketed, tripling by 2006 and likely to eclipse 10 billion gallons in the next year or two. Wisconsin, which produced not a single drop of ethanol in 2000, now has seven operating ethanol plants, with eight more on the way. This year, more than 20 percent of the corn grown in the state is expected to be converted into ethanol. Nationally, it may soon be the case that one in every three ears of corn goes to fuel.

"The industry is moving faster than our ability to develop the infrastructure to support it," says Randy Fortenbery, a professor of agricultural economics who directs CALS' Renk Agribusiness Institute. "It's moving faster than our understanding of the economic and sociological issues, and it's moving faster than the public policy is keeping pace." The key question, says Fortenbery, is whether the social good created by renewable energy sources justifies the social investment necessary to make those

IN THE FIELD AND IN THE LAB, researchers are taking varied approaches to make bioenergy a real alternative to fossil fuels. At Arlington Research Station (left), students take samples of reed canary grass, one of the perennial grasses that scientists are evaluating as a feedstock for ethanol production. At the same time, microbiologists such as Bernice Lin (far below) are working to understand the biology of the microbes that turn such plants into ethanol. Lin and colleagues at the U.S. Forest Products Laboratory have sequenced the genome of a yeast that naturally breaks down xylose, a common sugar in woody plants. Another intriguing angle is to genetically engineer plants that are easier to convert into ethanol than are current crops. These transgenic tobacco leaves (below left) produce cellulose-degrading enzymes as they grow, potentially reducing the need for expensive enzymes necessary to break down plant cell walls.



sources competitive in the marketplace.

At least in the case of ethanol from corn kernels, many are not convinced that the answer is positive. With ethanol fueling increased demand for grain, corn prices soared to $4 per bushel this past winter and remain some 30 percent higher than 2005 levels. While farmers have welcomed the boost to long-depressed commodity prices, the spike has also illustrated the potential of ethanol to shake up food prices. In Mexico, for example, the price of corn tortillas, a prime source of protein in the Mexican diet, quintupled last year, causing the government to cap prices.

High corn prices have also led farmers to plant 12 million more acres of corn this year than last, marking the largest crop shift since World War II. This historic movement toward corn has sparked concerns that farmers are abandoning crop rotations or tilling lands that are poorly suited for intensive row crops. Environmentalists are warning that high corn prices might lead farmers to withdraw lands from the federal Conservation Reserve Program, which pays farmers not to plant on highly erodable lands. According to John Panuska PhD'06, a UW extension specialist who has studied Wisconsin's CRP lands, returning those lands to corn will increase nitrogen runoff and exacerbate water-quality problems in the state's lakes and rivers.

Citing such troubling side-effects as the clearing of rainforests in Asia to harvest palm oil for biodiesel, the United Nations has adopted a similarly cautionary tone on the promise of bioenergy. In May, the U.N. made one its first public reports on the subject, which concluded none too cheerily: "Unless new policies are enacted to protect threatened lands, secure socially acceptable land use, and steer bioenergy development in a sustainable direction overall, the environmental and social damage could in some cases outweigh the benefits."

Scientists say these problems underscore the need for new technologies that enable fuel production from a wider array of feedstocks. They point to the potential of crops such as switchgrass, a perennial prairie grass native to the Midwest that can be burned to generate electrical power or fermented into fuels. Low in input and high in energy yield, switchgrass holds great promise as a feedstock in a sustainable bioenergy pipeline, especially since it can be grown on marginal lands such as those in the conservation reserve.

But many questions remain before we will know if it's a viable option. "I can go out and make bails of switchgrass, and I can take those to the biorefinery right now," says Kevin Shinners BS'81 MS'82 PhD'85, a professor of biological systems engineering. "But it's going to cost me more to bring it to their gate than they're going to be able to pay me. If we can't figure out more effective ways to grow and harvest and store these materials, there will be no biorefinery."

Typically in such cases, the research community needs money and time to sort out the big picture. With the influx of recent funding, no one these days is complaining about money. But what about time? The Department of Energy's plans call for the United States to be making 250 million gallons of cellulosic ethanol by 2013, perhaps not an overwhelming quantity compared to the 139 billion gallons of gasoline Americans consume each year, but a steep climb from where we are today, which is more or less zero. Can science move fast enough—and carefully enough—to meet those expectations?

"It is a short amount of time, and we have a long way to go," says Donohue. "But, you know, we've done this before. In the sixties, we had a president who said, 'Let's go to the moon.' He issued a bold challenge, and with the support and technology that was there, we achieved that goal. This is our chance to say, 'Let's go to the moon.'" And lest we forget, such hopeful journeys involve not only giant leaps, but small steps.

Long Journey into Or

More than a decade ago, CALS plant breeders set out to build a better pickle. The result is sweet, crunchy—and the color of a cantaloupe. Here's why **orange** may be the shade of pickles to come.

BY NICOLE MILLER MS'06

ange

At a wooden table under the yellow lights of the Walnut Street Greenhouse, Hugo Cuevas presses small, petal-shaped seeds into soil-filled trays with his index finger, gently covering each with dirt and sprinkling them with vermiculite, a mineral that helps keep the soil moist. The scene is typical of the meticulous work of plant breeding, the mundane hours spent toiling over tiny trays and fragile sprouts. But the white kernels Cuevas plants are anything but typical. Like the beans in the children's fable Jack and the Beanstalk, these seeds were once cast aside, only to be found again. And they may yet have some magic in them.

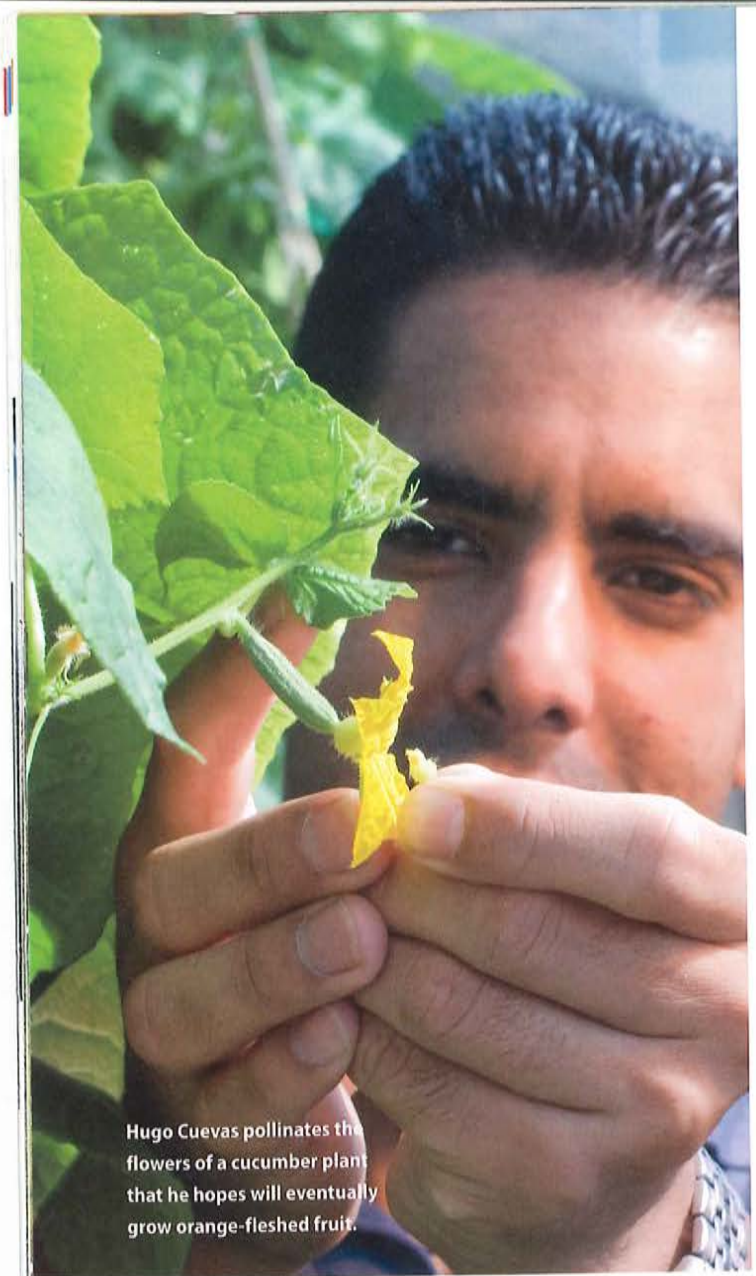
Some fifteen years ago, the seeds grew cucumbers, oblong fruits that by all appearances looked like any garden-variety pickling cucumber. But inside, the cucumbers were bright orange, a cantaloupe-hued flesh rich in beta carotene that researchers had worked for years to cultivate. They had hoped to introduce the cucumbers as a healthy alternative to standard grocery pickles. But the world wasn't ready for an orange pickle, and so hundreds of the seeds were dropped into manila envelopes and filed away in a back room at the Walnut Street Greenhouse. During the past two years, Cuevas, a graduate student in the plant breeding and plant genetics program, has been working to refresh the seeds, many of which lost the ability to germinate while sitting on the shelf. At the same time, his advisors—horticulture professors Philipp Simon PhD'77 and Jack Staub—are trying to revitalize their old idea of a healthier pickle, one capable of warding off cancer and heart disease and even aiding the fight against obesity. With the wave of nutraceuticals—foods and beverages that are stoked with health-promoting additives and ingredients—that has flooded grocery shelves in recent years, the researchers think their pickle's time may have finally come.

The tale of these seeds starts in 1986, when Simon came across an academic paper describing an unusual cucumber growing in China. The size and shape of a football, the plant yielded a bitter and ungainly fruit, but one trait piqued Simon's interest: It was orange inside.

Having spent much of his career studying carrots, Simon knows that the color orange is a calling card for the antioxidant beta carotene. Carrots, melons and squash are especially rich in the substance, a natural pigment known for its ability to combat cancer and heart disease. In the body, beta carotene can also turn into vitamin A, an essential nutrient critical for optimal vision and immune response. In his lab, Simon has worked for more than 20 years to boost the content of such healthful pigments. He has bred a full rainbow of carrots, including orange, red, purple and yellow varieties that have elevated levels of particular compounds. Red carrots, for example, are high in lycopene, a red-hued antioxidant.

When Simon began doing this work in the 1980s, few people had heard of nutraceuticals, which in 2006 was a $20 billion industry whose sales are growing around 13 percent annually. But researchers had signs that a boom was coming. In 1992, for instance, after researchers at Johns Hopkins University announced that broccoli was an excellent source of sulforaphane, a cancer-fighting compound, sales of the green vegetable doubled and remain high to this day.

Seeing what a cancer-fighting reputation could do for something as unloved as broccoli, other food industries began exploring ways to turn their foods into agents of good health. After hearing Simon's idea to breed a healthier cucumber, two national associations, the Pickle Seed Research Foundation and



Hugo Cuevas pollinates the flowers of a cucumber plant that he hopes will eventually grow orange-fleshed fruit.

the Pickle Packers International, jumped aboard to fund the project.

When seeds arrived from China, they were planted at the university's Walnut Street Greenhouse. The plants grew and grew, but wouldn't flower. "I just kept pruning them back, and they just kept sending out shoots," says Linda Crubaugh BS'81, the greenhouse manager who tended the plants. Eventually, Crubaugh learned that the Chinese plant was daylight-sensitive, meaning it needed to be exposed to a very specific day length in order to produce flowers, similar to how poinsettias only turn red during the short days around Christmas.

After nearly two years of tweaking conditions in the greenhouse, a few male flowers emerged and produced enough pollen to fertilize the female flowers of some standard varieties growing nearby. The resulting hybrid cucumbers grew and produced seeds, which were then replanted by John Navazio MS'92 PhD'94, a former organic farmer who was pursuing his doctorate in Simon's lab. Starting in 1993, Navazio grew three cycles of cucumber crops each year, making new crosses to refine the cucumbers' characteristics. The process was complicated by the fact that the researchers wanted essentially nothing of the Chinese cucumber except its color; American varieties were more suitable in every other measure, including disease resistance, fruit yield and the ease with which the plants flower. "We needed the beta carotene genes from the Chinese cucumber, but didn't want any of the other Chinese genes," says Simon.

Nowadays, researchers often use laboratory techniques to monitor the success of this type of breeding project, analyzing the DNA of young plants for signs—called genetic markers—that indicate the presence of genes of interest. Using genetic markers, breeders can know soon after a plant sprouts its first leaf whether or not it will display traits that would not otherwise be observable until much later in the season. But in the early 1990s, the group didn't know the molecular markers for beta carotene in cucumbers. In fact, they weren't even sure how many genes were involved. So the work had to be done the old school way, which meant waiting until harvest time to collect the cucumbers, and then assessing each fruit's size and shape before finally cutting it open to see whether or not it was orange inside.

"We used a good old, classical plant-breeding tool: What you see is what you get," says Navazio, now a professor of agroecology at Prescott College in Prescott, Arizona.

Navazio found a group of cucumbers from one particular cross that were light orange at an immature stage, when cucumbers are harvested to make pickles. For these promising cucumbers, he did some inter-crossing to enhance the orange color while encouraging the expression of other commercially important traits, such as size, shape, texture and seed side. Then, with the best plants, he used self-pollination to avoid further genetic mixing, and thus to lock in the desirable combination of traits. Analysis revealed that these orange cucumbers had about as much beta carotene, bite for bite, as a summer squash.

This was good news, but left one critical question unanswered: What kind of pickles would these cucumbers make? They needed to exhibit the quintessential crunch of a top-notch pickle, as well as to taste and feel right in the mouth. Perhaps even more pressing was whether the cucumber's enhanced beta carotene would withstand the pickling process.

Here the team received help from Claussen, a brand of Kraft Foods and a long-time member of Pickle Packers International. The company had previously established a relationship with the university through Jack Staub, a horticulture professor specializing in cucumbers and melons. Staub runs the campus' brine stock evaluation program, and he had advised Navazio's master's work on the effects of drought on cucumbers. In fact, a Claussen representative had trained Navazio to brine cucumbers using the company's proprietary process when Navazio was in Staub's lab.

For this new project, Claussen kicked in most of the materials for the pickling process, sending vats of brine, bags of spices and pickling jars to the lab. Navazio prepared a batch and then gathered about a dozen colleagues, *The color **orange** is a calling card for the **antioxidant beta carotene,** a natural pigment known for its ability to combat cancer and heart disease.*

mostly from Simon's and Staub's labs, to crack open the inaugural jar. Not only had the pickles retained their beta carotene, but they tasted pretty good. "We tested all the sensory evaluators," says Navazio, who concluded "these pickles were lovely to eat."

Some of the researchers took pickles home to test them on their children, with mostly promising feedback. "Generally, kids are more willing to try stuff like this," says Simon. "Adults have more trouble; they're more set in their ways."

That proved true of Claussen's marketing specialists, who after evaluating the lab's pickles were uneasy about their strange color. "Our marketing guys don't like anything that looks too different. They're afraid it'll scare consumers away," says Gary Mader, a procurement manager for Claussen who has followed the project over the years. Claussen also had concerns about the product's shelf life, which the company worried would not equal that of its other products.

The researchers were not deeply dismayed by the reaction. They were confident other industry and academic labs would pick up the project and help refine the pickles. "We decided this genetic material was valuable enough to make it available to the agricultural industry," says Navazio. The fruits of the team's labors—literally fruit seeds—were released to the agricultural community in 1997, and the project made the front cover of the journal *HortScience*.

Then, nothing. A few groups requested seeds, but none initiated the serious breeding program needed to complete the project. With Navazio graduating and no funding to continue the project, the seeds sat, languishing among the hundreds of seed envelopes stored away in the Walnut Street seed library.

Fast-forward eight years. After seeing the nutraceutical boom they imagined would eventually come, Simon and Staub in 2005 secured funding for a new graduate student to jump-start the project. Beyond the potential of orange pickles to be a source of beta carotene, Simon is intrigued by another prospect. He thinks pickles might help America's fight against obesity. Last year, he gave a talk at the Pickle Packers International's annual meeting noting that pickles have virtually no calories. "Traditionally, a no-calorie food wouldn't be considered a health food, but with today's obesity epidemic, that may well change," he told the group. "Pickles make a great snack; they help fill up the stomach without adding many calories."

After the meeting, Gary Mader of Claussen raised the idea with the company's marketing agents and concluded that it might be time to resurrect the old collaboration with Simon's lab. "This is something to revisit," Mader says. "It's a different era. People are more conscious about eating healthy foods."

But in plant breeding, it's not always possible to pick up where you left off. "When you say no to a breeding effort and you don't move ahead with it, the seeds die," explains Staub. "You have to start all over again." And that is what the UW team has done.

Reviving the seeds became a project for Hugo Cuevas, who arrived at UW-Madison from the University of Puerto Rico. Cuevas discovered that some of the decade-old seeds still produced plants, but they no longer generated the orange-fleshed immature cucumbers that the researchers desired. A few of the cucumbers did turn orange later in maturity, a good sign that the color trait wasn't lost entirely. But Cuevas has had to go back to cross-breeding, essentially recreating Navazio's work, to restore the desired characteristics.

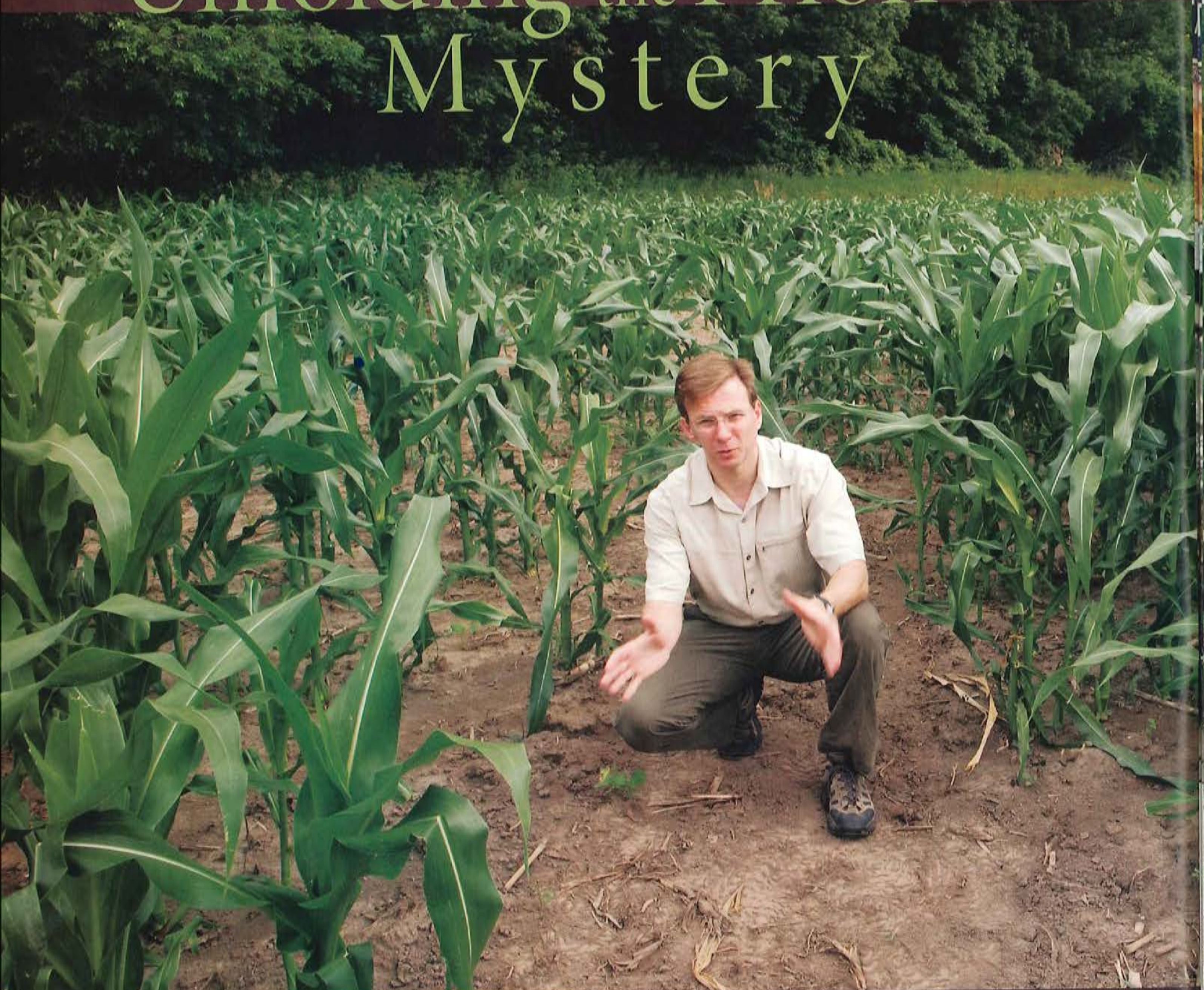
Cuevas is optimistic that he will locate the genes responsible for making beta carotene in the hybrid cucumbers before he graduates, which would greatly speed future breeding efforts. In that sense, the eight-year hiatus has actually helped the project, as lab techniques for locating such genetic markers are far more advanced these days.

This time, the project looks to avoid a dead end. Simon and Staub have already lined up a graduate student to take over where Cuevas leaves off. The beta carotene trait should be fixed sometime within the next two years, says Simon, and then it's just a matter of connecting with the right "renegade thinker" in the seed, food processing or restaurant industry. He imagines a restaurant chain spicing up a salad bar with orange cucumbers alongside purple lettuce and red carrots or a seed catalog selling packets to home gardeners. There is also still the possibility that Claussen or some other brand will pick up the idea and start making orange pickles for grocery-store shelves.

In the meantime, the old school breeding program continues. From four-foot-tall cucumber plants supported by poles and string, Cuevas plucks golden male flowers from one plant and then transfers their pollen to nearby female blooms. To ensure the genes from two flowers mix, he uses a twist-tie to bind them together, one enveloping the other. The process must be repeated again and again, making for a summer's worth of long, tedious days under the hot light of the greenhouse.

But from this laborious winnowing of genes may come those magic seeds, which yield fruit capable of fighting cancer, heart disease and perhaps even obesity. And this time, there are good signs that those seeds are being planted in fertile ground.

Unfolding the Prion Mystery



To help control the deadly rise of CWD among Wisconsin's deer herd, Joel Pedersen went hunting for the source of the infection. His studies of the strange protein behind the disease are uncovering surprising answers—and new questions.

By David Tenenbaum

PRIONS are creepy. Although not alive by any accepted definition, these unusual particles—believed to cause diseases such as mad cow and chronic wasting disease—still manage to propagate by deforming normal proteins, triggering a chain reaction with typically fatal results. They are lethal in vanishingly small doses, and as opposed to viruses or bacteria, which succumb to environmental conditions or antibiotics, prions are resistant to extreme temperatures, radiation exposures and many chemical treatments that kill any life. For all of these reasons, the fight against prion-related diseases largely relies on understanding and stopping the movement of the pathogens. It's a battle of containment.

Since the first cases of CWD surfaced among deer in southwestern Wisconsin in 2002, the state Department of Natural Resources has waged that war using hunters and sharpshooters to kill deer in a targeted exclusion zone. At the same time, UW-Madison launched a significant research effort to study and explain the strange protein that seems to be at the root of the outbreak. The good news is that recent research has filled in some blanks about the movement and behavior of prions. The bad news is that the results suggest that prion control will be extremely difficult.

Just this summer, in one of the most notable studies to date, Joel Pedersen, a CALS professor of soil science, and Judd Aiken, a virologist in the UW School of Veterinary Medicine who studies several types of prions, reported a drastic increase in prion transmission when prions attach to clay particles in soil. Pedersen says the finding could explain how the disease is transmitted among deer in southwest Wisconsin: Saliva, urine or feces dropped by deer can make soil infectious.

"Our studies on prion disease transmission underscore the need for wildlife managers to consider soil as a potentially important environmental reservoir of infectivity," Pedersen says.

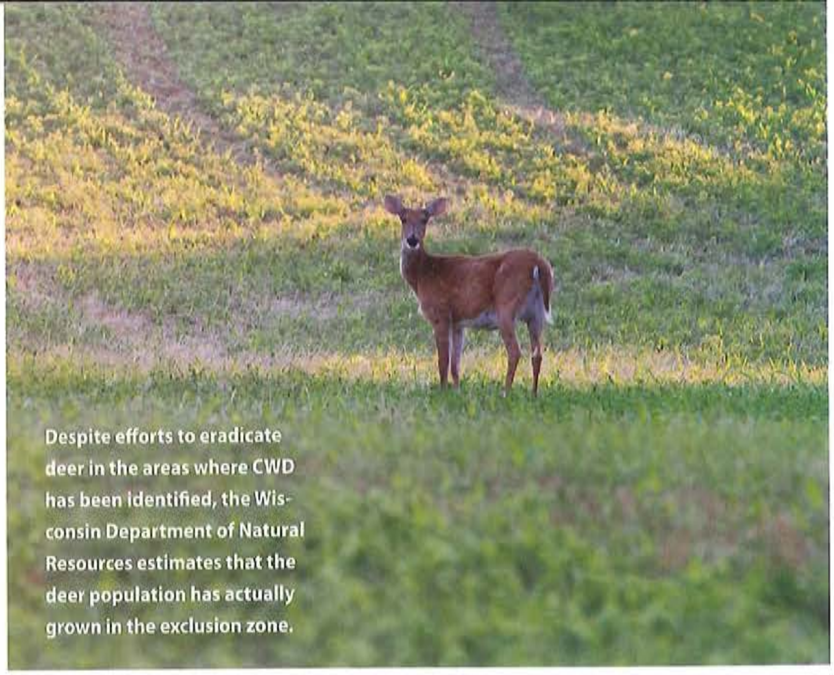
A Warning—and a Disaster

More than 200 years ago, Scottish shepherds found that some of their animals seemed to itch uncontrollably, and noting that the affected sheep compulsively scraped up against rocks and trees, they nicknamed the condition "scrapie." It would be the first of a host of related degenerative diseases observed in mink, deer, elk, cats, bovines and humans that followed a similar destructive pattern. In each case, some infectious agent got into an animal's nervous system and set to work chewing up its brain, causing an invariably fatal disease.

Not until the 1960s did scientists theorize that the infectious agent might be a prion, an otherwise normal protein that somehow folds itself into the wrong shape and somehow—there's that word again—distorts other prion proteins in a cell. Able to propagate despite having no DNA or RNA, prions seemed to defy the laws of biology, and some considered them too good—or too bad—to be true until California biologist Stanley Prusiner isolated them in the lab in 1982. That finding was "intellectually shaking," recalls Elizabeth Craig, a CALS professor of biochemistry who studies proteins. "Self-propagation was associated with DNA and RNA. It was shocking to find it without either one."

Prions grew considerably more mainstream in the 1990s, when an outbreak of mad cow disease in the United Kingdom forced that nation to cull millions of cattle to control the infection. Since the start of the epidemic, about 150 Britons have died of a human prion disease called variant Creutzfeld-Jakob disease, apparently as a result of eating infected beef.

UW-Madison scientists have played a critical role in the exploration of the prion diseases, and indeed, had the warnings of a Wisconsin virologist been heeded, the United Kingdom might have been spared the mad cow disaster, or at least controlled it much sooner. Beginning in 1990, Richard Marsh MS'66 PhD'68 cautioned that dairy cows might get infected from feed that contained byproducts from prion-infected cows. (In many countries, inedible byproducts and the carcasses of diseased cattle are treated with heat or chemicals before being blended into animal feed.) Marsh, who had grown up on a mink farm, reached this conclusion after studying a 1985 outbreak of prion disease at a mink farm in Stetsonville, Wis., which killed 60 percent of the animals.



Despite efforts to eradicate deer in the areas where CWD has been identified, the Wisconsin Department of Natural Resources estimates that the deer population has actually grown in the exclusion zone.

But the notion that prions could be transmitted in feed was treated as heresy until cases of mad cow multiplied in the United Kingdom. The government's slow response allowed the disease to spread among cattle and humans. Only when the United Kingdom banned cattle byproducts from cattle feed—as Marsh had advocated—was mad cow brought under control. In 1997, the same ban was enacted by the Food and Drug Administration in this country.

The United States never endured the human and economic costs of mad cow disease due to a combination of tighter regulation on cattle feed and a bit of luck. But several states from Wyoming to New York have seen spot outbreaks among wild deer and elk of CWD, which causes a range of neurological symptoms, including staggering, slobbering and eventually death.

Although no Wisconsinite is known to have been infected by eating venison, the DNR estimates that 5 percent of does and 10 percent of bucks in the deer exclusion zone in southwestern Wisconsin are infected with the disease. Wildlife managers have tried to contain CWD by increased hunting pressure, hoping that reducing the deer population in the infected zone will slow or halt transmission and at least prevent the disease from spreading further. Hunters must have kills from the exclusion zone tested for prion infections, and because the tests are not perfect, animal that passes must be carefully butchered to avoid any residual threat of infection. Yet despite the DNR's efforts, the deer population in the exclusion zone has grown since CWD was first identified there in 2002.

Follow the Soil

A more complete scientific understanding of how the disease is transmitted could suggest better methods for containment. While feeding practices were the root of the mad cow problem, CWD in deer and elk "is transmitted horizontally, from animal to animal, apparently through an environmental reservoir," says Pedersen. The most likely source happens to be Pedersen's area of expertise: soil.

An environmental chemist, Pedersen joined a team of UW researchers who in 2003 landed more than $5 million in grants from the U.S. Department of Defense to probe the disease. His role was to come up with a system to test how prions move around in various types of soils, which might help scientists pinpoint how deer were getting and passing on the disease. In 2006, Pedersen, Aiken and Christopher Johnson, a graduate student in the UW's cellular and molecular biology program, reported that prions could transmit the disease in the laboratory even when bonded to clay particles. In follow-up experiments, Pedersen mixed sand and prions in a test tube to see how well prions are absorbed at different pH values.

Although he notes that his test-tube soils are an "idealized system," Pedersen says the data suggest that prion absorption depends on soil pH, with alkaline soils promoting the particles' movement. The results could have implications for the disposal of infected deer meat. Currently, the carcasses are decomposed in chemical digesters, but authorities are considering dumping them in landfills to reduce costs. The study results will help outline what landfill conditions would promote prion movement, says Pedersen, especially if lime is used to hasten decomposition. "If you are concerned about prion migration through a landfill, you don't want them moving, so more absorption is good," and alkaline conditions should be avoided.

However, some movement could be beneficial in a natural environment, Pedersen adds. "Where prions enter the soil through excretion or the decomposition of a carcass, prions that migrate to deeper soil would be less accessible to organisms like deer, so it might be a good thing if they are mobile."

Soil may be doing more than just transporting prions, however. Pedersen and Aiken have recently reported that prion infectivity increased by a factor of 680 when the aberrant proteins were bound to a common type of clay, meaning a prion dose of just 0.2 micrograms (less than one one-hundred millionth of an ounce) could infect a significant number of lab animals.

"I think we have made an important step toward establishing that soil is a plausible reservoir for infection, and that the dose does need not to be high," Pedersen says.

Pedersen cautions that the infectivity study was done with hamsters and must be repeated with ruminants, which have a different type of digestive system. "If the results hold," he says, "we may want to minimize situations where transmission is likely to occur via soil, such as where deer tend to congregate and exchange fluids with soil." To avoid such situations, the Department of Natural Resources bans baiting and feeding deer in the exclusion zone.

But how could tiny clay particles make prions more dangerous? Perhaps by protecting them from destruction in the digestive system, Pedersen says. If that hypothesis proves correct, it could have human-health implications. Various clays, such as bentonite or kaolin, are added to some foods during processing. If clay does boost the infectivity of any prions we happen to eat, it could also help prions that infect deer, sheep or cattle jump to another species, such as us.

"This is speculation," says Pedersen, "but it's not outside the realm of the imagination that this enhancement of infectivity could perhaps enhance interspecies transmission."

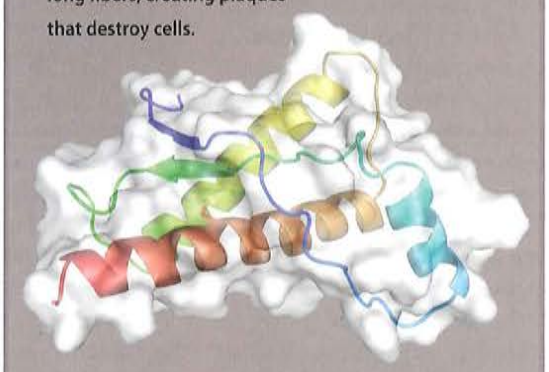
Knowing When to Fold

Beyond urgent efforts to control prions and the diseases they trigger, CALS researchers are also engaged in fundamental research aimed at understanding the nature of the particles themselves. Proteins capable of forming prions are in many ways like the thousands of other proteins found in every cell, where they play many structural and chemical roles. Defined by a particular combination of amino acids, which link like beads on a chain to form a long molecule, each protein folds itself into a unique shape that allows it to do its job inside a cell. Prions form when the folding goes wrong.

Protein folding resembles a microscopic version of origami on steroids, and so errors can arise. Normally such mistakes cause no problems; a lone protein that takes on the wrong shape can't do any harm by itself. But some proteins that get misfolded become capable of triggering a chain reaction, in which they recruit other healthy proteins with the same amino acid sequence and convert them into prion form. As their numbers get larger, these malformed proteins band together in long strings that can destroy a cell's functions.

Protein Origami

Like other proteins in the body, prions are essentially long chains of amino acids, which fold up into particular shapes that allow them to function in cells. But with prions, the folding process goes berserk. Rogue proteins somehow become folded into the wrong shape and begin to recruit other healthy proteins around them to adopt the same shape. Often, a deadly chain reaction ensues, in which misfolded prions link together to form long fibers, creating plaques that destroy cells.



Elizabeth Craig has found that both the formation and propagation of prions may be abetted by other proteins called chaperones. Ironically, scientists began studying these molecules for their ability to repair damaged proteins, a function that helps some microbes survive in extremely hot temperatures. Doubling the irony, one job of chaperones is to protect proteins from misfolding. Nonetheless Craig is finding that with chaperones, more of a good thing is not always a good thing.

Her experiments have shown that chaperones can help a prion convert a normal protein into a new prion. Furthermore, they have also shown that chaperones can accelerate the chaining activity that links prion proteins into long strings. "When a prion is growing into a long fibril," she says, "new subunits can only be added at the ends. If you cut the fibril in half, now you have four ends." This is exactly what she has seen in yeast experiments.

"They are doing what the chaperones are supposed to do, altering protein conformation, but this cutting turns out to be essential for allowing the prion to spread by making more ends, where additional prion protein molecules can attach," she says.

As research into these bizarre proteins proceeds, scientists see hints that protein malformations play a role in other conditions. In the brain-destroying disease Alzheimer's, for example, misfolded beta amyloid proteins form filaments and big, snarly tangles that seem to eat the brain.

Even the very existence of prions has changed the way biologists frame their experiments. The mere reality of a protein that can exist in two forms—one able to infect cells and convert its healthy proteins—introduces a range of complexities into experimental biology, Craig says.

"When we thought about disease transmission or inheritance of traits, we always used to think only about (DNA or RNA)," she says. "Now we have to think about protein as well." And if prions break the laws of replication, who is to say that some other bizarre pathogen isn't out there, waiting to overturn biology again? As Craig says, "It makes you a little humble."

THAILAND

In a Land of Rice, a Potato Crop Blossoms

Seven years ago in Thailand, Patchara Pongam MS'93 PhD'97 found herself with a potato problem.

A graduate of the CALS plant pathology department, Pongam was working at Kasetsart University to help establish Thailand's potato industry, a pet project of Thai King Bhumibol Adulydej. The king's negotiations had helped land a Frito-Lay potato processing plant in the northern city of Chiang Mai, and he hoped farmers in the region would supply the plant with locally grown potatoes. But the crop was struggling. The combination of Thailand's wet and hot growing seasons proved ideal for late blight, and Pongam was beginning to think it would be nearly impossible to produce potatoes year round.

Seeking a crash course in potato pest management, Pongam contacted Walt Stevenson PhD'73, a CALS professor of plant pathology. She traveled to UW-Madison in 2000, and her visit sparked a cross-continental effort to increase the productivity of Thailand's potato crop through sustainable growing and pest management practices. Since then, Stevenson has made numerous trips to educate students and researchers on the integrated pest management system used by the Wisconsin potato industry. He also works closely with Somsiri Sanchote, a fruit and vegetable pathologist at Kasetsart University who has succeeded Pongam in monitoring the country's potato crop. The two scientists now co-advise a graduate student, who will spend at least a semester in Wisconsin learning about seed certification techniques, as well as improved diagnosis and disease-resistance screening. Ultimately, the goal is to breed new disease-resistant potatoes for use in Thailand that would allow farmers to produce crops year-round and help supply the Frito-Lay plant.

In Thailand, Stevenson has taught classes, assisted with research projects, met with growers and industry representatives and even helped install a weather station. "It helps to put them on notice that the conditions have been favorable for late blight," he says. "As the crop comes up, we run the data through software we developed here at the University of Wisconsin and that would indicate when to initiate sprays and the timing of the subsequent sprays."

On one of his trips, Stevenson observed workers spraying 60 acres of potatoes by hand with limited protection. "When they walked across the field, their clothes become soaked with pesticide," he says. "That's not sustainable, and it's pretty risky." After discussing the problem with the grower and Sanchote, a simple change was implemented: The workers now walk backward while applying the sprays.

"It all goes back to, 'How do we have a sustainable potato crop in Thailand that protects their environment and protects their workers, and yet produces a quality crop that Frito-Lay can use for chipping?'" says Stevenson. "This project capitalizes on our experiences here in Wisconsin and North America (using) solid, science-based integrated pest-management programs."

PARAGUAY

Figuring the Net Worth of Trust

You can't put a value on good friends, or so the saying goes. But Laura Schechter, an assistant professor of agricultural and applied economics, thinks you can. She is out to understand the economic value of social networks—the friends, coworkers, families and organizations that we rely on for money, food or other kinds of support.

"Networks are important, but no one has really put a dollar value on it," says Schechter. "Are networks worth 10 dollars or thousands of dollars? What's the relative size?"

Schechter says such values are especially important in developing countries, where connections—and the lack of them—may have a significant impact on economic activity. She saw that firsthand as a

Workers spray pesticide on a potato field in northern Thailand, where a collaboration with CALS professor Walt Stevenson is leading to a more sustainable crop.

Peace Corps volunteer in Paraguay, where she says a historical lack of trust bred by dictatorial regimes often prevented cooperation among farmers.

"They could do something that would make them all better off," Schechter says, "but they couldn't do it because they don't trust each other. It has economic outcomes, and it isn't in our models of behavior."

After joining the UW-Madison faculty, Schechter returned to Paraguay to spend six months surveying farming communities around the country. She collected data on how much they borrowed from and leant to other farmers and explored deeper issues of trust and mistrust. She found, for example, that four in 10 farmers gave gifts to people they suspected might steal from them as a way of attempting to win trust and loyalty.

This intriguing union of economics and sociology has gained Schechter national attention. Last year, Yale Economic Review named her as one of "5 Hot Minds in Economics" for her innovative methods studying cash flow in communities. But Schechter's real desire is that the work begins to influence economic policy.

"Figuring out who is important and which pieces of networks contain more economic value should be important for designing policy," she says. "A person in the network who has very few connections, but only to important people, may be better to focus on rather than a person with many connections to unimportant people."

In Paraguay, farmers "could do something that would make them all better off," says agricultural economist Laura Schechter, "but they couldn't do it because they don't trust each other."

UGANDA

A Community Approach to Diabetes Care

After studying the prevalence of diabetes in Uganda for five years, James Ntambi has come up with what he thinks may be the only realistic answer to a growing health problem: self-help.

Simple as it may sound, Ntambi, a CALS professor of biochemistry and nutritional sciences, believes that promoting the benefits of healthy lifestyles such as eating a balanced diet may be the best approach to combating the rising incidence of diabetes in African nations.

"You're not going to ask people to start buying insulin and other expensive diabetes medications, or ask them to go to far away hospitals because they don't have the funds," Ntambi says. "You have to take care of yourself—that's the message. Especially in the case of diabetes, where there is no cure, prevention is the key."

To carry that message forward, Ntambi is launching a series of nutrition training sessions for health care professionals and policy leaders in Uganda. He says that educating leaders not only can help spread healthy practices into communities, but it can also help him explore the problem more deeply through survey research and targeted education.

"By the time we go there to the communities to evaluate, the people know about us, and they have heard about our intentions," Ntambi says. "The impact we can make by training the local people is going to be big over time."

In his previous research, Ntambi has uncovered an interesting trend in the incidence of Type II diabetes. Ugandan women who are diagnosed with the disease tend to be overweight or obese, while Ugandan men who are diagnosed tend to be thin. This gender split marks a significant difference from what health care workers and researchers have documented about diabetes in Western countries, where most people diagnosed with Type II diabetes tend to be overweight or obese. Ntambi's co-investigator, Linda Baumann, of the UW-Madison School of Nursing, saw the same trend during an independent study in Thailand. While he isn't sure what is causing this pattern, Ntambi says it may be a result of "environmental factors playing on genes" in developing countries.

To discover what those environmental factors may be, Ntambi, Baumann and their collaborators in Uganda are carrying out a project to survey people about their behaviors. The surveys are a way "to get into the community and get to know the people," he says. "We want to learn how these people take care of themselves and how they monitor their blood sugar." If the evaluations reveal connections, Ntambi's team will follow up with tailored materials to educate people about preventing the disease.

—MARGARET BROEREN MS'07

Food Fighter

Campaigning to end world hunger, **Florence Chenoweth** plants seeds of hope.

After 12 years with the United Nations Food and Agriculture Office, Florence Chenoweth is returning to Wisconsin to launch UW-Madison's new Human Rights Initiative.

In Florence Chenoweth's native Liberia, a nation stumbling out of the darkness of a 25-year civil war, schools long shuttered by violence and political turmoil have reopened. Children again stream into classrooms, but when they arrive, they often find few books or supplies. They take notes on scraps of paper, using pencils that have been broken into pieces so that everyone might have something to write with.

In such images, Chenoweth MS'70 PhD'86 sees both the hope and the heartbreaking reality of Africa, a continent widely plagued by disease, malnutrition and poverty, yet full of promising signs of recovery. And she equally sees opportunity, a chance to make a sustained difference in the future of her homeland.

"When I met (Liberian president Ellen Johnson-Sirleaf), I asked what I could go out and start working on, and she said education," says Chenoweth. "So we sent out a massive appeal to raise money for textbooks." Working through the U.S.-based charity Books for Africa, Chenoweth marshaled a campaign that so far has sent more than 75,000 books to Liberia's schools.

Making a difference is something of a career habit for Chenoweth. In 12 years with the United Nations Food and Agriculture Office, including the last six as the FAO's representative to the U.N. General Assembly, she has led an international push to improve food systems and aid the estimated 850 million people around the world who are hungry. After retiring from the U.N. in May, she headed back to Madison, where she is now launching UW-Madison's new Human Rights Initiative. The cross-campus program will carry out research and education to promote fundamental rights, such as freedom of speech and religion, and draw attention to parts of the world where those rights are denied.

To this new effort Chenoweth brings a humbling sense of the scale of these threats. She says she goes to sleep each night reminding herself that 16,000 children will not wake up in the morning because they don't have sufficient food. But she also brings a resilient belief that such realities can be turned around.

"By nature, I am an optimist. Even in the darkest of times, I see hope at the end," she says. "The end that I see in my mind—and the end that I hope for and the end that I work for—is a positive one, that things will change for the better."

Throughout her life, Chenoweth has found her optimism tested by circumstance. After earning a master's degree in agricultural economics, she returned to Liberia and at age 32 became Africa's first female minister of agriculture. Forced to resign in 1979, following a controversial proposal to raise tariffs on imported rice, Chenoweth was fortuitously outside of government when an violent coup erupted less than a year later. Soldiers stormed the capital city of Monrovia, assassinating the president and marching 13 government officials to a beach, where they were tied to stakes and shot.

"If Florence had been minister at that time, she would have been on that beach," says John Rowe, a former associate director of CALS international programs who spent three years in Liberia during the 1970s as a representative for the U.S. Agency for International Development.

Warned that her life was in danger, Chenoweth retreated to her home, hiding in a closet and risking movement only after dark. After three months of this sequestered life, she and three siblings fled Liberia, walking for two days to reach safety in Sierra Leone. She has not returned since. Only in the past two years, as stability returned and Liberia elected Johnson-Sirleaf as Africa's first female president, has she been "proud to sing my national anthem again."

When her homeland fell into civil war, Chenoweth blazed a path into international activism. She returned to UW-Madison to complete her doctorate and eventually caught on with a UW-Madison project in Zambia that worked to improve the country's agricultural policies. Joining the FAO in 1995, she worked to establish sustainable farming practices in Gambia, South Africa and several other African nations.

"If there's one thing that is really the mark of her career, it's that she has always been a person who can make good things happen," says Rowe. He recalls working with Chenoweth to assess Liberia's agricultural production in the 1970s, a project often bogged down by a lack of money or supplies. "She always had an idea, whether it was for where to get a new set of tires for the car or how to get a budgetary request approved."

In recent years, Chenoweth has pushed for long-range solutions to the conditions underlying world hunger. While international aid organizations do an admirable job of supplying and distributing food, she says those efforts need to be complemented by improvements in water management and agricultural practices. "We can never solve the problem with a stop-gap measure," she says.

"By nature, I am an optimist. Even in the darkest of times, I see hope at the end."

This is why Chenoweth is so heartened by the growth of programs such as the FAO's junior farmer training schools, which teach agricultural and life skills to children whose parents have died of AIDS. FAO has set up 34 of these schools in Mozambique, Kenya, Namibia and Zambia, and Chenoweth says the results are inspiring. "The children (who graduate from these schools) are just bursting with enthusiasm," she says. "They know that they can take care of themselves, and they no longer see themselves as left out of society."

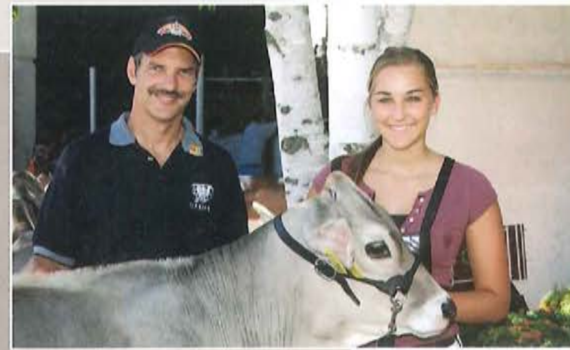
Chenoweth has seen entire villages wiped out by AIDS, leaving orphaned children who have lost more than just their parents. They have lost the people who can teach them the skills they need to survive.

"Part of the African society is to take care of your community. But the scale of (the AIDS) pandemic has just weakened that ability for society to cope," Chenoweth says. "That is why you have all of these orphans. It is just overwhelming."

It might be enough to cause one to give up hope—except that Chenoweth has shown repeatedly that while her heart is easy to win, her resolve is hard to break.

—Michael Penn

catching up with **pete kappelman**



Pete Kappelman and daughter Erin on their family farm.

BS'85 *Dairy Science*
home *Manitowoc, Wis.*
occupation *Partner, Meadow Brook Dairy Farm, and Chairman, Land O'Lakes, Inc. Cooperative Board*
what I'm doing when I'm not working *Spending time with my family, running, flying as a licensed private pilot, coaching youth basketball, serving as a 4H Dairy Leader.*
best thing I learned at CALS *My years at Madison in CALS exposed me to some of the greatest professors in the country. More than teaching just subject matter, they taught me how to learn, and the value of learning for my lifetime.*

GROW: **You've been very active in a range of dairy organizations since the start of your career. What motivated you to get involved?**
KAPPELMAN: At 25, I was asked to join the new UW-Madison Center for Dairy Profitability board. We really wanted to convince producers they were business people and give them a place to receive help with business decisions. A few years later, I also helped start the Professional Dairy Producers of Wisconsin. At the time, these were new ideas and new organizations, with no status quo. For the first few years, it was really a labor of love for the industry.

GROW: **With Land O'Lakes, Inc., you oversee a cooperative with $7 billion of annual revenue. How did you earn members' trust?**
KAPPELMAN: People trusted me because of what I had done in other leadership roles. Your farm or business should also be a reflection of the kind of board member you will be. I keep a well-run, attractive and respected operation, so neighbors will look at it and think, 'He'll represent my equity the same way.'

GROW: **You're also on the National Dairy Board and the U.S. Dairy Export Council. What are you hearing about the outlook for producers?**
KAPPELMAN: Increased international demand has made dairy a valuable worldwide commodity. Right now, we're in the driver's seat for agricultural export. I want to make sure, for producers around the country, as well as my own kids' sake, that we take advantage of every opportunity we're given to help the industry grow.

GROW: **Are your kids involved with the business?**
KAPPELMAN: Yes, my wife Shellie and I have three teenagers: Erin, a high school freshman; Mitch, a high school junior; and Beth, a freshman at UW-Madison in CALS. All three are very involved in the farm, and they have been from an early age. Not only do they work on the farm, but they also own cattle.

GROW: **Do you expect them to follow your path?**
KAPPELMAN: Right now, I'm just enjoying watching them grow up. Whether they come back and farm is up to them. I try to show them the opportunities agriculture gave me—the same thing is there for them if they so choose.

Five things everyone should know about . . .

Trans Fats

By Sherry Tanumihardjo

1 | Artificial trans fats have been around for almost a century. While recent campaigns to ban trans fats from foods and restaurants might give the impression that trans fats are new, they were first produced in the early 1900s, when a soap and candle maker joined forces with a chemist to find a substitute for animal fats in their products. Trans fats, produced by hydrogenating plant oils, turned out not to be suitable for soaps and candles, but they soon were marketed as a healthier alternative to cooking with animal fats. Cheaper than butter and longer in shelf life, trans fats have long been a popular ingredient in packaged cookies and crackers, and they are found in the oils often used to deep-fry foods such as French fries.

2 | Some trans fats are produced naturally in meat and animal products—and actually may be healthy. In fact, researchers at the UW-Madison Department of Nutritional Sciences are testing a milk product for children that has enhanced levels of conjugated linoleic acid (CLA), a natural trans fat found in animal products, to see if it can mitigate fat weight gain.

3 | As restaurants and packaged-food suppliers rid their recipes of trans fat sources, they are often replacing them with artery-clogging saturated fats. Watch out for palm, coconut or tropical oils, which contain more saturated fat than other vegetable oils, such as corn, soy and cottonseed oils.

4 | Not all fats are bad. The Dietary Guidelines for Americans recommend a diet that derives 20 to 35 percent of total calories from fats. The key is to find sources of polyunsaturated or monounsaturated fats, rather than saturated fats. Corn, soybean and safflower oils, for example, are great sources of Omega-6 fatty acids, which are necessary for the formation of hormone-like fats that promote blood clotting and smooth muscle contraction. Omega-3 fatty acids in soybean oil, canola oil, walnuts and flaxseed reduce pain and inflammation.

5 | The bottom line is that total fat and calories are still important considerations for a healthy diet. While it's a good idea to keep intake of trans fats to a minimum, it's just as important to look at the whole picture. If cutting trans fats means increasing the portion of saturated fats in your diet, you may not be doing yourself any favors. Always check the nutritional facts of the foods you eat and compare products.

Sherry Tanumihardjo, a CALS associate professor of nutritional sciences, developed educational materials about fats for the Wisconsin Nutritional Education Program, which aims to help Wisconsin citizens make healthier dietary choices.

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Questions from actual exams given to CALS students

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Bacteriology: A newborn infant is passively immune to bacterial infection due to:

a. transplacental transfer of maternal antibodies in utero
b. exposure to foreign antigens during birth
c. activation of the immune system which occurs at birth
d. immediate colonization by a normal flora
e. recovery from diseases acquired after birth

From Bacteriology 303: Procaryotic Microbiology, taught by Kenneth Todar

Soil science: Name the highly decomposed organic matter that gives topsoil its dark color.

From Farm and Industry Short Course: Introduction to Soils, taught by Dick Wolkowski

Biochemistry: When your body uses food you have eaten as a source of energy to power muscle contraction, the order in which energy changes forms is:

a. C-C and C-H bonds → NADH and $FADH_2$ → ATP → proton gradients
b. carbon dioxide → NADH and $FADH_2$ → ATP → proton gradients
c. NADH and $FADH_2$ → C-C and C-H bonds → proton gradients → ATP
d. C-C and C-H bonds → NADH and $FADH_2$ → proton gradients → ATP

From Biochemistry 501: Introduction to Biochemistry, taught by Richard Amasino

Economics: Assuming that the driving of cars generates negative externalities and should be curtailed in the name of economic efficiencies, which of the following policies are consistent with that goal?

a. Increase per gallon tax on gasoline, a complement to cars
b. Subsidize buses or trains to lower the price of substitutes for cars
c. Impose an ad valorem tax on vehicles that get below average miles per gallon
d. A and C but not B
e. A, B, and C

From Agricultural and Applied Economics 215: Introduction to Agricultural and Applied Economics, taught by Marv Johnson

Food science: A brand of chocolate-peanut butter Rice Krispies treats contains 24 ingredients: toasted rice cereal, fructose, peanut butter, sugar, marshmallow, dextrose, partially hydrogenated palm kernel oil with sorbitan tristearate, cocoa processed with alkali, sunflower oil and/or soybean oil with TBHQ, whey, molasses, glycerin, salt, soy lecithin, natural and artificial flavor, DATEM, acetylated monoglycerides, BHT, niacinamide, almond flour, whole wheat flour, riboflavin, thiamin hydrochloride, and pyridoxine hydrochloride.

Match the ingredient with its functionality:

Ingredient	*Functionality*
1. Glycerin	a. Emulsifier
2. DATEM	b. Humectant
3. Pyridoxine hydrochloride	c. Antioxidant
4. TBHQ	d. Lubricant
5. Partially hydrogenated palm kernel oil	e. Nutrient

From Food Science 542: Food Engineering Operations, taught by Mark Etzel

SUPER TUBERS

TINY POTATO PLANTS sprout inside the germ-free environment of test tubes, part of the process of growing disease-free seed potatoes for use on Wisconsin farms.

WANT TO SEE OTHER COOL STUFF GOING ON AT CALS? VISIT:

www.cals.wisc.edu/grow/.

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