grow

Wisconsin's Magazine for the Life Sciences • Fall 2011

food & agriculture • environment • energy • health

BIOENERGY
Getting It Right

What we're learning, where we're going

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN–MADISON

SEARCHING FOR SUSTAINABLE • THE RESEARCH PIPELINE: A GUIDED TOUR • NEW USES OF BIOMASS


ASK THE EXPERTS
CUCUMBER
Wisconsin ranks 4th nationally for producing pickling cucumbers. Varieties developed by UW plant breeders remain the standard for northern growers. Research continues toward developing high producing varieties that are disease and pest resistant.
GENETIC IMPROVEMENTS
TOMATOES
Tomatoes have become the 2nd most popular vegetable, behind potatoes, in the United States. UW researchers test many different varieties to determine which are best suited for Wisconsin's climate, growing season, and pressures from disease and insects.

Volume 5, Issue 1 • Fall 2011

A CALS market stand at the Wisconsin State Fair provided a colorful education about local foods and growing.

Photo by Bryce Richter/University Communications

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Wisconsin's Magazine for the Life Sciences

BIOENERGY: *Getting It Right* A Special Feature
What have we learned about biofuels—and where are we going? In this edition we catch up with work being done at the Great Lakes Bioenergy Research Center some four years after its founding.

Departments

On the cover: A prairie plot at the Arlington Agricultural Research Station, where scientists are examining a range of plants as potential feedstock sources for biofuel. *Photo by Beth Skogen.*

Interim Dean William F. Tracy

Discovery Under Way

Photo by Wolfgang Hoffmann BS'75 MS'79

What will be the next oil?

That's a frequent question raised about the future of energy—and not a surprising one considering the dominant role that that single fuel source has played in filling our energy needs.

While we still are searching for the answers to our energy future, one thing seems clear—there probably won't be one next big thing, one dominant fuel source that will take the place of oil.

Which brings me to the topic of this issue: bioenergy. In 2007 CALS was awarded an initial $125 million from DOE—the largest federal grant ever received by CALS—to come up with new ways of drawing energy from plants. And so we embarked on a scientific endeavor that ranks as one of humankind's biggest when we consider what we might gain: more ways to free ourselves from dependency on fossil fuels.

> The discoveries emerging from these efforts are likely to benefit farmers, businesses and the overall economy in the entire state and region.

While some may have hoped that by this point we'd be tanking up with cellulosic ethanol, anyone familiar with the challenges recognized that after three and a half years, we'd just be warming up.

In fact, we've done that and more. As the stories in this issue show—and as an illustration on page 20 offers at a glance—Tim Donohue and his colleagues at the Great Lakes Bioenergy Research Center (GLBRC) have built a research pipeline that already has produced some promising discoveries and is poised to deliver more.

Hundreds of scientists are blazing trails in everything from sustainability—learning how biofuels will affect the environment in the long run—to fundamental research about cell wall growth and interactions with microbes. The GLBRC has strengthened connections with institutions across campus—for example, with the College of Engineering, where researchers are engine-testing biofuels—and across Lake Michigan, working in close cooperation with our partners at Michigan State University. Beyond college campuses, the discoveries emerging from these efforts are likely to benefit farmers, businesses and the overall economy in the entire state and region.

We do not yet know the exact role biofuel will play in the mix of renewable sources that will comprise our energy future. Time and more discovery will tell. We do know that the GLBRC is off to a promising start.

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Smart Birding

A new birdsong app identifies feathered friends by their tweets

Photo by Sevie Kenyon BS'80 MS'06

CALS' Mark Berres using the latest tool for birders. You can see a demonstration at youtube.com/user/UWMadisonCALS.

Squinting into windblown trees and bushes is for the birds—especially if it's birds you're looking for.

"You have to listen. There's no way around it," says Mark Berres, an ornithologist and CALS animal science professor. "The most difficult aspect of bird-watching is call identification, but calls are the most important tool for identifying birds."

Even experienced birders have trouble matching more than a handful of songs with species, but Berres may have answered the prayers of birdwatchers, researchers and even the most casual naturalist.

Not surprisingly, salvation comes in the form of a smartphone app: WeBIRD, the Wisconsin Electronic Bird Identification Resource Database.

WeBIRD users can record a nearby bird's call, submit that song wirelessly to a server and retrieve a positive ID of the species.

"I am amazed at how good it is," says Berres, who also has used WeBIRD to identify grasshopper species by their clicks and frogs by their croaks. "Not only can WeBIRD tell you which species you're hearing—in some cases it's good enough to identify individual birds from their song."

That's no mean feat. Birdcalls can differ throughout the day, among groups just miles apart, and by individual birds.

"When a bird sings, the song itself may have varying amplitudes and frequencies," Berres says. "It can also speed up a little bit and slow down a little bit. They may throw in a note here or take out a note there."

WeBIRD dices songs into time-ordered chunks, using data-organization techniques often applied by geneticists to jumbled bits of DNA to "align temporally misaligned data, working around a lot of the variation," says Berres.

Berres expects WeBIRD—which could be available to the public in time for the 2012 spring migration—will enable field research through remote recording and analysis. More important, he hopes WeBIRD will help birds.

"If people can appreciate intrinsic beauty—and birds have got that part down—a closer awareness of the natural world will follow," says Berres. "Fostering a connection with wildlife is one of the ways we're going to save it, and WeBIRD puts that connection to birds in the palm of your hand."

—Chris Barncard

Detectives in Training

A new internship puts undergrads on the trail of foodborne pathogens

Bad microbes beware: With guidance from Oscar Mayer scientists, Katie Kennedy tested the safety of a new meat cooling system.

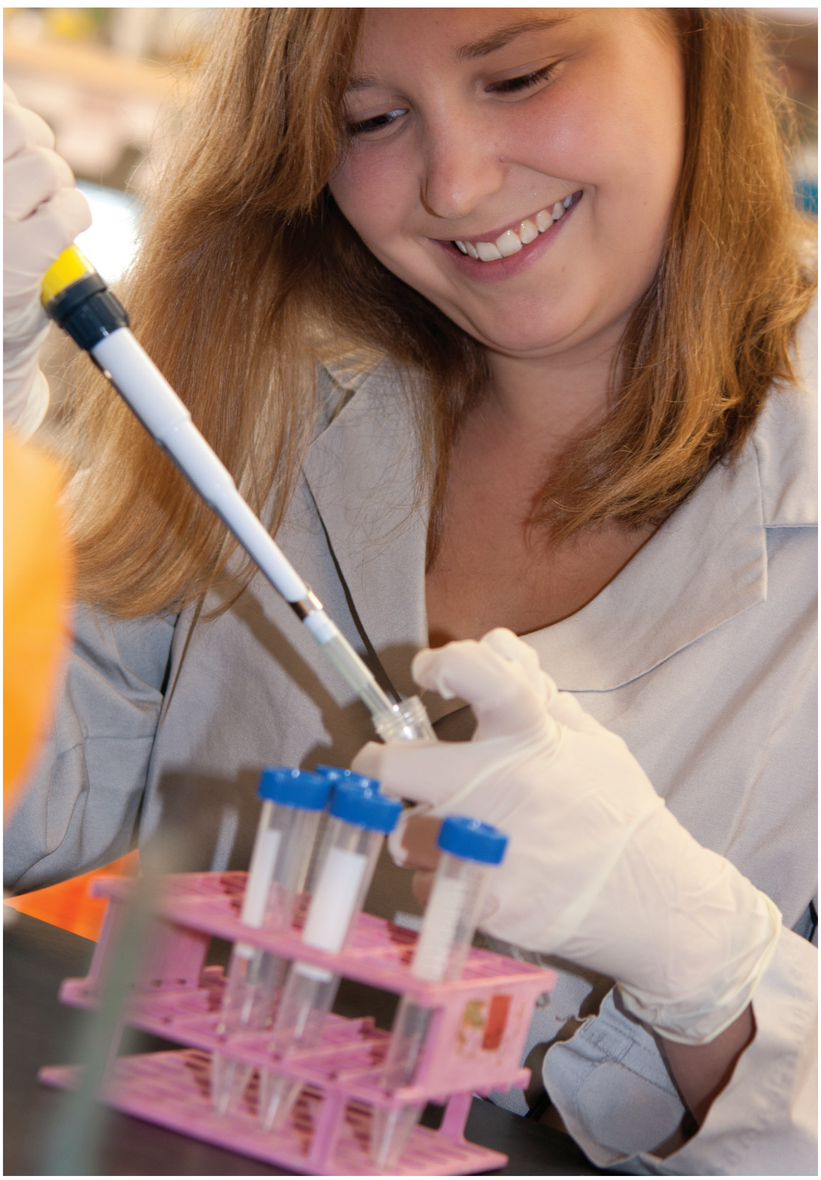


Photo by Sevie Kenyon BS'80 MS'06

In just nine weeks this past summer, senior Katie Kennedy tackled an important food safety research project, one that may change the way some large food companies process their deli-style turkey meat. Not bad for a summer job.

"It was my impression that this was just going to be a pilot project, but we're actually going to publish the results," says Kennedy, an animal sciences major.

Kennedy was one of seven undergraduates who interned at the internationally respected Food Research Institute (FRI), which is housed in CALS and focuses on microbial food safety. The internship program, which debuted this summer, had students investigating everything from *Salmonella* and *E. coli* to *Clostridium* and *Aspergillus*.

"Training is an important part of the FRI mission," says Chuck Czuprynski, the institute's director. "So we decided to create an opportunity where young people can learn about—and deal with—real food safety problems."

In Kennedy's case, she worked with FRI mentors and scientists at Oscar Mayer Foods in Madison to tackle a challenge faced by many large meat processing facilities: keeping the growth of the foodborne pathogen *Clostridium perfringens* in check as large volumes of uncured, processed meats are cooled after cooking. Cooling is energy-intensive, and Kennedy's project showed that plants can cool their deli-style turkey more slowly—but still safely—if they add some potassium lactate, a commonly used antimicrobial, to the meat.

"Oscar Mayer waited eagerly for Katie's results," says FRI assistant director Kathy Glass, who co-mentored Kennedy. "They provide Oscar Mayer, as well as other FRI sponsors in the meat industry, with the safety data they need to show inspectors that the cooling system they'd like to implement is indeed safe."

Another goal of the internship program is to raise awareness about academic and professional career opportunities in the food safety field. To that end, the interns met weekly to hear from scientists in the field and also toured a handful of food processing plants.

"I was surprised that every place we visited had microbiologists and food scientists. I don't think people realize those types of jobs are available at food processing plants," says Brad Gietman, a medical microbiology and immunology major who spent the summer studying how long, filamentous *Salmonella* cells—which are found on certain foods—sometimes break apart into scores of daughter cells, increasing the risk of foodborne illness.

Both Gietman and Kennedy are continuing their lab work this fall, and Kennedy is now leaning toward doing a yearlong internship at a food company before going to veterinary school.

—Nicole Miller MS'06

Stealth Science

An innovative program for young learners folds hands-on science into reading

Photo by Wolfgang Hoffmann BS'75 MS'79

Kids at Hawthorne Elementary School in Madison field-testing Reading Green, which educators say will help keep science on a crowded agenda.

With all the demands for better STEM education (science-technology-engineering-mathematics), you'd think that getting more science into elementary schools would be a top priority.

But you'd be wrong, says Hedi Baxter Lauffer, a science educator and director of Wisconsin Fast Plants, a CALS-based program that for 25 years has helped grade-schoolers and teachers around the nation grow plants—the really satisfying kind that sprout and bloom within two weeks, allowing young learners to see growth day by day.

Federal policies emphasizing other subjects are squeezing science out of the classroom, Lauffer says, with science getting short shrift in terms of allotted hours. "Reading and mathematics are the primary areas that elementary teachers are being held accountable for because of current testing structures," she says.

Lauffer and her team offer a practical solution: Reading Green, a new program that combines reading and writing with science learning based on fast plants. It's a classic case of killing two birds with one stone—and teachers say it works.

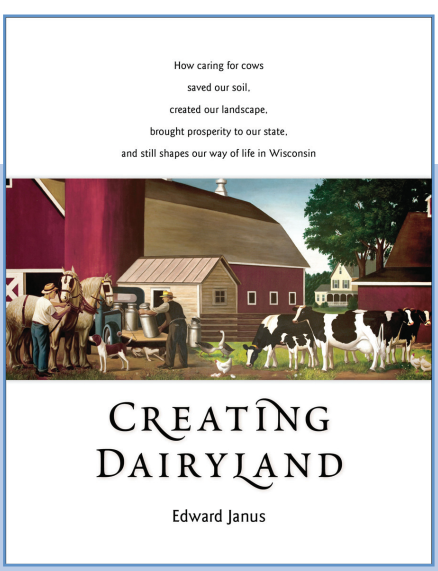
"They're getting science content while reading fun stories with characters they can relate to," says Michele Sheets, who earlier this year field-tested the program with fourth- and fifth-graders at Turtle Creek Elementary School in Delavan. "The stories in Reading Green helped them connect the science activities to their inquiry activities with the fast plants."

The playfully illustrated stories in Reading Green, written by Lauffer and communicator Douglas Niles, revolve around a twin brother and sister (Allie and David Sanchez-Ryan) and their lives in school and with their scientist parents, whose work takes the family to such far-flung places as Egypt and Siberia.

Along the way Allie and David (and, of course, the student reader) learn about plant growth requirements, the global importance of plants, and how humans have depended on plants throughout history. Students grow fast plants along with reading the stories, with companion science notebooks allowing them to track their observations.

Reading Green is available for purchase through Carolina Biological Supply, the same company that sells materials for Wisconsin Fast Plants, and is debuting in classrooms around the country this fall.

—Joan Fischer



How Wisconsin Became Cow Country

That's the question Edward Janus pursues in *Creating Dairyland*, a new book from the Wisconsin Historical Society Press. Not surprisingly, it's a CALS Who's Who, covering everyone from Stephen M. Babcock ("The patron saint of dairying") to contemporary alumni in chapter-length profiles (including Karl Klessig BS'78 MS'79, Laura Daniels BS'97 and several Crave brothers). "Anyone who grew up on a dairy farm or has any connection to the dairy industry will enjoy reading this book," states Bob Cropp, a CALS emeritus professor of ag and applied economics, in a cover blurb.

classAct

Michael Crossley

Learn by Doing

Photo by Wolfgang Hoffmann BS'75 MS'79

Crossley started working in labs as a freshman—but that's not all he does. In his free time he plays flute, banjo and whistle for West Wind, an Irish band that performs in various public venues around the state.

Michael Crossley BS'11 remembers the experience that sealed the deal for his career choice. A local organic farmer's spinach crops were under attack from a centipede that feeds on plant roots. Crossley—although "only" a sophomore—was tapped to help via an independent research project under the mentorship of CALS entomology professor Eileen Cullen.

"I spent a semester visiting the farm's hoop houses and doing lab experiments," says Crossley. "I came up with a simple and novel approach—heating the infested beds with solar radiation. The essentially zero-cost strategy was implemented with great success and, two years later, the farmer told me there's still no infestation."

For that work Crossley just won a national prize from the Entomological Society of America—but it wasn't his only big score. Another research project he helped with resulted in an article for *Soil Biology and Biochemistry*. Crossley's co-authors: CALS entomology professor Richard Lindroth and researcher Tim Meehan.

In addition to those projects, Crossley as a freshman began working as a student hourly in Lindroth's lab. There he not only completed "countless chemical assays" but also participated in lab meetings, attended seminars and learned a lot about the realities of a science career, he notes.

Indeed, Crossley serves as a case study in the benefits of hands-on science. And he's not alone. Half of CALS graduating seniors report having worked on a research project with a faculty member outside of a course requirement—a rate higher than at any other college at UW–Madison.

Crossley recommends the experience. In addition to helping him identify his desired career, applying science to the real world helped motivate him in his academic work.

"Because of my early experiences in research, I've known from the beginning the value of fundamental courses like chemistry, biology and statistics, and have excelled where I otherwise may have floundered aimlessly," says Crossley.

This semester Crossley starts work on a master's degree in entomology under professor David Hogg, where he'll focus on genetically modified soybean resistance to soybean aphid.

HONORED with awards from CALS: dairyman **John Pagel**, potato producer **Stephen Diercks** and agricultural economist **Edward Jesse**. Pagel received the Honorary Recognition Award, Diercks, the Distinguished Alumni Award and Jesse, the Distinguished Service Award.

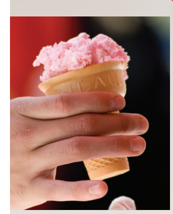
TRAINED for service in Afghanistan: a National Guard Agribusiness Development Team headed by CALS alum **Colonel Darrel Feucht BS'85**. This past summer the team completed a 40-hour course dubbed "Agricultural Extreme 101" organized by the Babcock Institute for International Dairy Research and the Arlington Agricultural Research Station.

NAMED a fellow by the American Society of Animal Science: **David L. Thomas**, a CALS professor of sheep management and genetics. The recognition was based on Thomas' research, outreach and teaching and his service to ASAS during his 34-year academic career.

WON first place: **Pixie Dust,** a fruit drink mix concocted by CALS graduate food science students in a national food development contest sponsored by Disney. The students were honored at the Institute of Food Technologists annual meeting in New Orleans. At left, the Pixie Dust team: **Kellie Grant, Maya Warren, Mustafa Ozturk, Jackie Koch** and **Tessa Porter**. Another CALS team earned third place in a separate IFT competition with a yogurt and cereal snack called Blissful Bites.

Number Crunching

60 YEARS OF BABCOCK HALL



Call it 60 years of delicious. But the award-winning ice creams and cheeses produced at Babcock Hall don't just please our palates, they represent globally significant advances in food science. Prior to Babcock Hall, the department of food science, once called dairy husbandry, was housed in Hiram Smith Hall. It was there that the first Dairy School trained farmers in the use of Stephen M. Babcock's groundbreaking milk fat test. The 1951 opening of Babcock Hall, which included a dairy plant and store and, later, the Center for Dairy Research, helped usher food science into the modern era.

how **bees make honey**

WE SLATHER IT ON BREAD, use it in cooking or stir it into tea without thinking twice, but producing honey is a strenuous team effort for bees. It takes about two million flowers and more than 55,000 miles in flight to make a single pound of honey—and Americans consume some 410 million pounds of it per year, according to the USDA's Economic Research Service.

The sweet substance results from a process that is none too pretty. Honey is derived from a plant product, nectar, which serves to attract pollinators. Bees drink the nectar from flowers and then regurgitate and dehydrate it back in the hive.

Johanne Brunet, a professor of entomology, explains how:

Illustration by Renée Graef

- **A honeybee colony is composed of one queen,** hundreds of drones (males) in the spring and summer months, and thousands of sexually undeveloped female workers who do all the heavy lifting. Their duties include cleaning and caring for the brood, tending to the queen, guarding the hive, gathering pollen, producing beeswax and building honeycomb, and making and storing honey to feed the colony over the winter months. The expression "busy bee" is very well justified!

- **Using her tubular mouthparts,** which work like a straw, the worker bee sucks nectar from the flower into a second stomach—a "honey stomach"—within her abdomen.

- **Enzymes in the honey stomach** break down the complex plant sugar sucrose (a disaccharide) into the digestible simple sugars glucose and fructose (monosaccharides).

- **When the bee's honey stomach is full,** the bee returns to the hive to offload its contents to one or several worker bees. The receiving bees distribute it to the young as food or place it into the honeycomb for long-term storage.

- **Before placement into the honeycomb,** bees will move the nectar around in their mouthparts, thereby exposing the nectar to air and evaporating some of the water content.

- **Once placed into the honeycomb,** worker bees further dehydrate the stored nectar by fanning their wings, gradually turning the nectar into honey.

- **Finally, worker bees seal the honey-filled comb cells** with wax that is secreted from the worker's abdomen. That cover is intended to preserve honey as the bees' food supply.

A variety of flowers and climates lead to an array of different flavors and colors of honey. In the United States there are more than 300 types of honey, ranging from such standbys as clover, alfalfa and orange blossom to such regional specialties as fireweed, tupelo, and macadamia nut.

VIETNAM

In Vietnam, mopeds help teach economics

Moped fumes are promoting greater consciousness about pollution in Vietnamese cities, says CALS' Corbett Grainger. (Right, rear) Grainger posing with his ag business management students at the Hanoi University of Agriculture.

When Corbett Grainger wanted to teach Vietnamese students the basics of environmental economics, he had no problem getting them motivated. He just talked about the motor scooters jamming the roads of Hanoi.

The bikes make for great local color, he says—it's not unusual to see one carrying an entire family or livestock or large pieces of furniture. But it's also not unusual to see people wearing masks to filter out the fumes from tens of thousands of scooters.

So students were very curious about potential market-based solutions to road congestion, such as taxes and tolls, says Grainger, a CALS assistant professor of agricultural and applied economics.

"The environment in Vietnam is kind of in a state of disrepair, particularly in terms of air and water quality," he says. "Their economy is booming but it comes at a cost, and the younger people realize that."

Grainger is one of a number of CALS and other UW–Madison faculty members who recently made the 8,000-mile trip to help the Hanoi University of Agriculture (HUA) set up an undergraduate program in agricultural business management. Not all are ag economists. Al Gunther of life sciences communication went to teach business communication. Randy Dunham of the UW School of Business taught a course in management. Other offerings have included accounting, international trade, co-ops and contracts.

The plan is for the Wisconsin professors to teach the first class of students enrolled in the program. Hanoi faculty sit in on the lectures so that they can teach subsequent classes on their own.

While course content is much the same as in Madison, some adaptations are needed. For one thing, the class is condensed into three or four weeks. And even though the courses are taught in English—constituting the first English-language classes held at HUA—not everything "translates" perfectly because Vietnamese students bring a different set of skills and knowledge to the classroom.

They're ahead of their U.S. counterparts in math but behind in computers, says CALS ag economist Paul Mitchell. Most of them didn't know how to use a spreadsheet, he says. And when Mitchell talked about his research on markets for certified organic potatoes, first he had to explain organic certification.

But the CALS team found the Vietnamese students to be unsurpassed in one respect—they were intensely eager to learn. "After class, they all lined up with questions," says Grainger. "When I held office hours in the afternoon, the whole class would show up."

—Bob Mitchell BS'76

Photo courtesy of Corbett Grainger

Photo courtesy Jiwan Palta

Peruvian farmers are seeing bigger potato crops after adding gypsum to their fields.

PERU

A simple sprinkle improves yields in potato's homeland

After proving he could increase the yields of some of Peru's most popular potato varieties, Jiwan Palta still had a tough panel of critics to face: the Peruvian women who had been growing, cooking and eating the potatoes their entire lives.

"Initially there was some concern. They have all kinds of potatoes—all sorts of colors and flavors and textures—and didn't want anything altered about them," says Palta, a CALS professor of horticulture. "We set up a taste test and they couldn't tell the difference. So then they were convinced."

Palta first visited Peru, the ancestral home of the potato, six years ago after becoming head of the UW–Madison Potato Breeding Program. He was accompanied by colleagues John Bamberg and Alfonso Del Rio. His original goal was to set up a research collaboration with scientists at Peru's International Potato Center (CIP) to improve frost tolerance in Wisconsin's commercial varieties. Researchers at CIP study and breed the region's stunning array of potato cultivars, which serves as a valuable genetic resource for potato breeders around the world.

But during a tour of the nation's potato fields, which are located in the highlands of the Andes and cultivated by poor subsistence farmers, Palta quickly identified a second project for his team.

"When I saw the mountains, I said, 'My goodness, those soils must be highly leached because of the high acidity and the way the rain washes down the slope of the fields,'" says Palta. "And it turned out the soils were very low in calcium, and that got us thinking: Would these native potatoes—which don't yield a lot—respond to a simple calcium amendment?"

Earlier in his career, Palta cracked the mystery of how calcium gets inside potato tubers, where the nutrient is known to strengthen the integrity of the tuber's tissues, reducing internal defects and making potatoes last longer in storage. His findings led to a major change in the way calcium is applied to Wisconsin's potato fields.

In Peru, Palta decided to try adding gypsum powder—a cheap and locally available source of calcium—to the traditional Peruvian planting system. On his test plots, local farmers followed their regular procedure for the most part: placing a seed potato at the bottom of a hole and covering it with alpaca manure. But before piling dirt on top to form a "hill," they also added some white gypsum powder. At harvest time, Palta flew back to Peru to assess the results.

"On average we saw about a 25 percent increase in yield," says Palta. "We were startled because some varieties almost doubled in yield."

Palta is now partnering with CIP, Peruvian universities, non-governmental organizations and USAID on a variety of projects to expand his lab's work and spread its benefits to additional communities. Down the road, he hopes to help create and see distributed a "Top 10" list of popular native potatoes that benefit the most from extra calcium.

"It's such a joy to see that we can make a difference in the lives of poor Peruvians who depend so much on potato as a food," says Palta. "And for those who live near cities, perhaps some of them will even be able to sell their surplus."

—Nicole Miller MS'06

The Infection Eaters

Marcin Filutowicz stumbled upon a potentially powerful biotherapy—using amoebas that feast on antibiotic-resistant bacteria to cure such ills as staph infections and diabetic ulcers

BACTERIOLOGIST Marcin Filutowicz specializes in developing antimicrobial technologies that one day may help replace antibiotics—and save lives—as the power of our antibiotics arsenal wanes. But he doesn't stop there. Filutowicz has founded or co-founded three biotech companies to help ensure that his technologies actually make it into the world's hospitals. The idea for his newest venture, Amebagone, founded this year, sprung from his work investigating a collection of soil-borne amoebas assembled decades ago by UW bacteriologist Kenneth Raper, who is best known for helping ramp up penicillin production in time to save thousands of soldiers wounded during World War II.

g Let's start with the basics. What's an amoeba?
Amoebas are unicellular organisms. They are not animals or plants or bacteria. They are protists, which is a whole separate group. And what they do, their sole purpose in life—as much as we can say—is to feed on bacteria. So this is their primary source of sustenance, and once they eat all of the bacteria in their environment they yell at each other—using chemical signals—and gather together.

On the Petri dish, you can see them swarming when they decide to aggregate. Initially, they form something that looks like a slug. It's a community of a million or so amoebas that are packed together into a sack. The slug moves around looking for more food. If it can't find anything to eat, the slug transforms into stalks and spores that get distributed by the wind. When the spores land on moist soil, they germinate and start eating the bacteria in the soil, and the process repeats itself.

g How did you start working with these organisms?
For one of my companies, PlasmiGon, we needed access to libraries of small molecules to be successful. After screening a few libraries that were available to me, I started thinking about other potential sources of small molecules, and I realized that Ken Raper, who established the whole field of amoeba studies, had left a huge collection of amoebas in our department. This collection involves over 1,000 different amoebas gathered from five continents and several island nations. So it's extremely diverse in terms of the geographical locations. It represents a huge resource of diversity of small molecules.

So my take was, why don't we start reviving these amoebas and come up with techniques to look for useful small molecules produced by them? So we started opening those samples, some of them 70 years old. And then the issue was, well, how do you propagate them? Because, to be honest, I knew nothing about amoebas.

I went to a colleague and asked, "How do you grow these beasts? Do you grow them like bacteria?" And he said, "You feed them with bacteria." The moment he said that—"You feed them with bacteria"—I went back to my office and I quickly computed all of the information I had learned over the past few days. I realized that this could be a new biotherapy because the particular amoeba we wanted to grow, *Dictyostelium discoideum,* is benign. There was no single report of it having adverse effects on humans, animals or plants. It's an organism that you simply put alongside bacteria, and they do nothing else but eat it. I disclosed this to WARF in 2009, but they turned my disclosure down.

g That's surprising.
Not really. At the time, we didn't have any proof-of-principle, no data, nothing. It was just an idea. But I decided that I could not let it die. I decided to form Amebagone and let that company patent the technology.

g How do you picture amoebas being used in medicine?
Right now we're focused on methicillin-resistant *Staphylococcus aureus* (MRSA). This MRSA is a major agent of nosocomial infections in hospitals. It kills a lot of people. And it happens that two billion people on this planet carry staph in their nostrils. It is part of our natural biota. They inhabit a very narrow area in our nostrils that has just the right temperature and salinity, so they are not all over. They are compartmentalized in a band or section of the nostrils.

And we all touch our noses. We can't help it. As we touch, there's moisture in there, and so we contaminate our fingertips. And after surgery, it's natural to want to see the wound, and in many cases people accidentally self-contaminate the surgery site just by lifting up the dressing to look at it.

But if we can deliver amoebas to the nostrils presurgery, we can essentially decontaminate the nostrils of undesirable microbes. We did proof-of-principle experiments with MRSA, and amoebas eat MRSA like crazy. So even though antibiotics cannot kill MRSA, amoebas can.

g Is it safe to use amoebas this way?
In the literature, there is no reported evidence to support virulence of *Dictyostelium discoideum,* but obviously once we have a product ready for clinical trials, the FDA will scrutinize that. And keep in mind that amoebas are all around us in the environment—in the soil, in the air we breathe, on our food and in and on our bodies.

PHOTO BY WOLFGANG HOFFMANN BS'75 MS'79

“Amoebas are all around us in the environment—in the soil, in the air we breathe, on our food and in and on our bodies.”

Preferable to maggots: Biotherapy innovator Marcin Filutowicz hopes that amoebas will be used to treat various bacterial infections.

Watch videos of amoebas producing spores at youtube.com/user/UWMadisonCALS.

Are there other applications for this technology? Yes, it's just a matter of finding the right amoeba—or combination of amoebas—to combat a particular infection. Already, we have beautiful data showing that amoebas can eat *Erwinia amylovora*, the fire blight pathogen that infects orchards. We also have amoebas that can eat the bacteria that cause pneumonia.

Now we are starting to look at biofilms, which are thick aggregates of bacteria that are virtually impervious to antibiotics. Amoebas can eat biofilms, so they must produce something that dismantles biofilms and releases individual cells for them to access. One potential application for this is diabetic ulcers. The rise of diabetes in the United States is alarming, and one of the consequences of advanced diabetes is skin ulcers, which lead to amputations. The ulcers are incurable with antibiotics because they are seeded with biofilms. Currently, some doctors prescribe maggot therapy—where they apply maggots directly to the ulcer—as a treatment of last resort for this. That's because the maggots “debride” the site, meaning they eat away the dead tissue, removing the bacterial biofilms as they go, which allows topical antibiotics to work.

When I came up with the idea for treating diabetic ulcers with amoebas, I talked to an infectious disease expert, and he said it would be a marvelous alternative to maggot debridement therapy. He would rather prescribe amoebas, which are too small to see, to his patients than have them witness maggots eating their flesh. So this could be huge application.

We're also going to hunt for new kinds of antibiotics produced by *Dictyostelium discoideum* and other amoebas, as genome analyses indicate they have the capacity to make a lot of compounds that may function as antibiotics.

HOW DO WE GET BIOMASS FROM THE LAND WHILE PRESERVING—OR EVEN BENEFITING—ITS LIVING COMMUNITIES? WHICHEVER COURSE WE TAKE, RESEARCHERS AT THE CALS-LED GREAT LAKES BIOENERGY RESEARCH CENTER ARE DETERMINED TO PUT ALL PROS AND CONS ON THE TABLE.

Sustainable by design

Photos by Beth Skogen

Tallgrass prairie as part of the mix: Randy Jackson, a CALS professor of agronomy, showing a plot at the Arlington Agricultural Research Station.

By Madeline Fisher

THE CHILDREN'S SONG URGES HER TO FLY AWAY HOME, but the ladybug—or ladybeetle, as she's properly called—is anything but a homebody. After feasting all summer on soybean aphids and other crop pests, the beetles take off from farm fields in search of snug overwintering spots, often winding up in people's houses. Around Madison, this usually means a journey of five miles or more, says CALS entomology professor Claudio Gratton. But the insects can also fly much farther. In the Southwest, for example, they congregate on mountaintops. "You'll come upon a bush just dripping with ladybeetles, and you know they probably had to travel 30 miles to get there," says Tim Meehan, a research scientist working with Gratton who earned his doctorate in New Mexico.

Those wandering ways got Gratton and Meehan wondering a few years back if the beetles' lives were touched not just by the soybean fields where they fed, but by the wider world as well. They soon discovered that, indeed, "What the landscape looks like actually makes a big difference," says Gratton. In experiments across the Midwest, ladybeetles devoured more aphids in fields nestled within a patchwork of woods and grassy pastures than in those surrounded by soybeans and corn as far as a bug's eye could see.

Although the two still aren't sure why this is, it led them to ponder another possibility that has big implications for the sustainability of our farmlands. If the chance variation that exists in some farming areas already gives ladybeetles a boost, what if farmlands were purposely designed for diversity? Would the insects dispatch even more aphids? Might they even become tiny tools of sustainability, allowing farmers to spray fewer chemicals?

It takes a lot of imagination to picture such a landscape today, with two-thirds of the Midwest's cropland blanketed in corn and soybeans. But there is a force that could re-stitch the Corn Belt into a crazy quilt—the push toward ethanol and other types of bioenergy. True, the ethanol blended into gasoline today still comes exclusively from corn kernels. And few "dedicated" bioenergy crops, such as grasses, have been sown so far for making cellulosic ethanol from stalks and stems, or burning in power plants instead of coal.

But bioenergy crops will almost certainly grow widely one day. The goal of the U.S. Department of Energy (DOE) is to replace 30 percent of gasoline and other U.S. transportation fuels with biofuels by 2030. And that, CALS scientists say, offers a chance to reshape our farmlands in an unprecedented way, so they yield not only food and fuel, but also things like ladybeetles and the benefits they provide.

In scientific parlance those benefits are called "ecosystem services"—natural processes we rely on but don't usually pay for, Meehan says. Pest control by ladybeetles is one service; pollination by native bees, water cleansing, soil formation and even aesthetic beauty are others. Today's simplified agricultural landscapes excel at producing corn, cotton and other vital commodities in massive amounts, but these may come at the price of water quality, erosion, loss of bird and insect habitat and increased pesticide use, as another study by Meehan and Gratton recently found. The question now is whether switchgrass, willow and other biofuel crops could cut those costs by sowing some plant diversity back into the system.

"The focus now is land use, not just food or fuel or a new crop. How do we use land sustainably?" says Chris Kucharik, a CALS professor of agronomy and environmental studies. "It just so happens that fuel has ignited the debate over sustainable land use right now."

At the same time, strong forces are working to maintain the status quo. Skyrocketing commodity prices and rising demand for ethanol have led many farmers to put as much land in corn as possible. This year, 92.3 million acres were planted, according to the U.S. Department of Agriculture, four million above last year's total and the second highest amount since World War II.

Meanwhile, the lack of markets for dedicated biofuel feedstocks, such as switchgrass, has created demand for cornstalks, slash from timber harvests, and other agricultural and forest "waste" as fuel sources for power plants, even though decades of research show these materials are critical to ecosystems—and that their removal could be damaging.

Even the promise Gratton and Meehan see in bioenergy crops could easily be wiped away. Much will depend on which crops are planted and where, as well as how much water, pesticides and fertilizers they need. Growing them might also release more of the greenhouse gas, carbon dioxide (CO_2), than the plants pull in, negating what's considered their premier advantage over fossil fuels.

The biofuel mosaic: Out at the Arlington Agricultural Research Station, scientists are growing and scrutinizing neat plots of switchgrass, miscanthus, poplar, prairie and mixed grasses alongside traditional row crops. Some plots (photo right) remain undisturbed as a control group.

The uncertainty has generated a flurry of new research in CALS.

"Biofuels are a force that we think is going to change things for the next 100 years," says Kucharik. "So we want to make sure we get this right."

Few people likely believed 10 years ago that biofuels could be gotten wrong, so naturally "green" did they seem. Then ethanol made from corn grain came along. Widely hailed at first as plentiful, non-polluting, and a cure-all for peak oil and climate change, it descended almost immediately into a storm of criticism for being, opponents contended, none of these things.

With every two of five rows of U.S.-grown corn destined for ethanol plants today, the cloud still hasn't lifted, and now cellulosic biofuels are being similarly accused. The difference now is that federal agencies are paying more attention to the potential problems—and paying for research to help prevent them. The DOE, for example, funds the Great Lakes Bioenergy Research Center (GLBRC) based in CALS, whose team of engineers, microbiologists and other technology-focused types also includes scientists like Gratton, Meehan and Kucharik who study sustainability and ecosystem protection.

If this suggests that the health of farmlands is a newfound concern, however, biological systems engineering professor Doug Reinemann assures it is not. Disasters like the Dust Bowl, in which eroded topsoil blew up in vast, black blizzards for nearly a decade, taught the country long ago that soil and water needed protecting even as they were being used to produce food. The environmental regulations and programs that have since been enacted aren't perfect, but they have taken us a long way from the days when livestock grazed in streambeds and sensitive lands were plowed up at will. Reinemann sees the emphasis now on ecosystem conservation as a natural outgrowth of these earlier efforts.

"It's really a continuation of traditional soil conservation," says Reinemann, who leads the GLBRC effort to model the impacts of biofuels crops on landscapes. "But I think we're also looking at it in a broader sense, particularly with the issue of landscape diversity and the importance of insects, birds and soil microbes—that they're essential in providing ecosystem services."

One CALS scientist who was examining these questions long before biofuels became popular is agronomy professor Randy Jackson. A grasslands ecologist, Jackson has spent much of his career studying the environmental and agronomic value of seeding native prairie grasses, such as switchgrass and big bluestem, into pasturelands planted in more traditional forages. When the "biofuels juggernaut" came along, he says, the sustainability questions the GLBRC wanted to ask were right up his alley. He now co-leads its sustainability research group with Michigan State University professor Phil Robertson.

The group's mantra is the "three Ps." First, biofuels crops must be productive, Jackson says, because farmers need to make a living. Also favored are perennial plants, whose deep, lasting root systems cut erosion, build soil organic matter and scavenge nutrients, in contrast to corn and soybeans that leave ground bare in winter and must be replanted every spring.

Then there is polyculture, which simply means planting a mixture of species as one crop versus the monocultures we mostly cultivate today. Assortments of plants, the thinking goes, use nutrients more efficiently because individual species take them up at different times and they perform more functions, such as fixing nitrogen or resisting drought, than do single species.

GLBRC scientists are still debating a fourth "P": placement on the landscape. "We aren't so starry-eyed as to think that there won't be monocultures planted in the future," Jackson says. "So what we're pushing for is that we maintain diversity between patches, so we have patches of switchgrass and corn and woody crops."

Due to all this hypothesizing, a section of Arlington, the CALS agricultural research station 20 miles north of Madison, now resembles Jackson's vision in miniature. Alongside traditional row crops like corn has sprouted a mosaic of switchgrass, shrubs like willow, an Asian grass called miscanthus and mixtures of prairie species. They are all auditioning for roles as tomorrow's bioenergy crops, and the researchers are scrutinizing them from every angle.

Jackson's students, for example, are examining nutrient use. "The neat thing about prairie grasses is they resorb nutrients at the end of the season," Jackson

Poplars are being grown and studied at Arlington as a promising biomass crop. In other biofuel studies they are being used to test new technologies aimed at breaking down lignin in plant cell walls (see graphic on page 20).

Take it or leave it: Stumps, logs, branches and twigs make for a healthy forest. Some forest ecologists warn of the ill effects of excessive harvesting of forest debris as biomass.

says. After hitting their peak of growth in August, he explains, the plants shut down over two to three months, pulling nutrients and carbohydrates back into their roots for use again in the spring. Measurements by his group show that up to 70 percent of plant nitrogen gets recycled this way, suggesting that prairie species might need less fertilizer as bioenergy crops than does corn. By pulling nutrients from deep soil layers, their roots might also reduce nitrate leaching into groundwater and runoff into lakes and streams.

Bioenergy crops could also be a boon to birds and insects. Wisconsin alone hosts some 500 native bee species, most of which don't form hives like the social European honeybees do. Instead, they're solitary creatures, Gratton explains, that crawl inside cavities in trees, holes in the ground or dried stalks of flowers and grasses to lay their eggs. "They have nesting requirements that are very diverse," he says, "and if all you have is corn and you're looking for stem-nesters, you're not going to find a lot of them." But a lack of bees isn't what is most troubling, he adds. It's loss of the service they provide: pollination.

For his part, Kucharik studies one of the most critical services of all in this era of climate change: Locking away carbon in plant tissues and soils to cut CO_2 levels in the atmosphere. Many people assume this will happen automatically so long as some kind of bioenergy crop is sucking up the gas, but the situation is actually more complex, Kucharik says. Take corn, for example. "Corn is actually great at converting energy from the sun, water and CO_2 into plant biomass," he says. "But it's really the net soil storage in the long term that's important." Most corn biomass gets removed from the ground every year, he notes. And the rest is often tilled under, releasing additional CO_2 as microbes are stimulated to break down organic matter in the soil.

Here again is where prairie species could shine: After all, their massive root systems built the Midwest's fertile, carbon-rich soils in the first place. Even if they are widely planted as bioenergy crops, however, accumulating carbon will take a very long time—if it happens at all. "That's really what we're going toward in my research," Kucharik says. "Will we store carbon? And if so, how much?"

Despite the caveats, many are still betting that biofuels will ultimately drive farmlands toward greater diversity and ecosystem health. The impact on forests, though, could be very different. In fact, CALS forest ecologist David Mladenoff fears bioenergy is taking them in the opposite direction.

For decades, Mladenoff has studied what keeps managed forests healthy and productive over time. And often, it's variety, he says: sunlit gaps in the canopy, trees of different ages, and—critically—an abundance of stumps, logs, branches and twigs on the forest floor. Just as in farmlands, debris like this reduces erosion, stores carbon, recycles nutrients and creates habitat for animals and understory plants. But in the quest for new fuel sources, it has been dubbed "waste" and ripe for the taking—much to Mladenoff's alarm.

"From my standpoint, we've spent much of the last 20 years learning that we need to be leaving more wood behind in the forest after harvesting, and now all of a sudden the movement is: We want to take the rest," he says. "It's in total conflict with what we know ecologically."

Photo courtesy David Mladenoff

Not that the intentions here are bad. In an effort to replace coal with cleaner, renewable energy sources, many states have built power plants that can burn plant-derived materials instead, such as scrap lumber, debris from timber harvests and cornstalks. Environmental groups have praised the move, but the power plants' ravenous appetite for fuel is creating other problems. A few years ago, for example, Wisconsin set a guideline stating that loggers need leave only one ton per acre of woody debris behind after cutting trees—some three to eight times less than after a normal harvest, or what amounts to "a bunch of pen-sized twigs scattered around in an acre," Mladenoff says.

"What does it mean, then, if we can basically remove as much debris as possible?" he asks. In a series of studies in different parts of northern Wisconsin, he and a group of collaborators are now trying to find out. Similar to Kucharik's work at Arlington, they're examining the effects of intense debris harvesting on forest carbon: How much is released and how much is stored? They're also measuring the amount of nitrogen forests lose when different amounts of biomass are taken—data that Mladenoff will then use to model impacts on forest productivity long-term.

And that's the easy part, he adds. Just as worrying, but much harder to assess, is how simplified forest landscapes scoured clean of woody debris will affect the birds, insects, amphibians and mammals that rely on it for habitat. "People are just starting to think about that," he says.

So does this mean the practice is wrong? Mladenoff definitely has his views on the subject, but he also thinks "right" or "wrong" is somewhat beside the point. "Biofuels may not end up making sense ecologically or economically, but society may still decide to pursue them. Maybe it's better than going to war with Iran over oil, for example," he says. "But the way I put it is, we need to know what the trade-offs are. Then society can make a policy decision."

Jackson agrees, noting that mixtures of plants chock-full of ecological benefits may be something of a mixed bag as well. "It's pretty clear from our two years of data that the extra services we may get from a diverse system are likely going to be offset by lower productivity overall," he says. Few, if any, bioenergy crops will probably ever rival King Corn's sheer biomass-growing power, for one, especially on rich soils like those at Arlington. But even monocultures of switchgrass often are more productive, easier to manage—and thus more attractive to farmers—than mixtures of species.

So what's needed now is a full accounting, Jackson says. "Okay, the diverse system is less productive. But what does it do to greenhouse gas emissions, carbon accumulation, nitrogen retention?" he says. "Are we seeing extra benefits there, or is maybe the switchgrass monoculture just as good on all those accounts as diverse prairie?"

He believes the sustainability group's biggest contribution will be to quantify all those trade-offs and present them to farmers, policy makers, land managers and citizens in a way they can easily grasp. And then it will be up to us to decide: Is fuel the utmost goal? Or are ecosystem services also worth pursuing—and paying for? Because like the ladybeetle, what the agricultural landscape looks like, how it functions, matters to us. But unlike her, we have a say in shaping it.

From field to fuel

Where are we in terms of moving toward the "green gas" of the future?
The Great Lakes Bioenergy Research Center, led by CALS with Michigan State University as a major partner, has over the past four years been conducting basic research to convert non-edible plants such as grasses and trees to ethanol and other advanced biofuels. Here we present an overview of research progress.

Building Better Bioenergy Crops

Goal: *To design energy crops that produce higher yields, contain more energy and are built of easy-to-access sugars*

Research Progress

● A technology called Zip Lignin™, which makes it easy to break apart—or unzip—the lignin in plant cell walls to release the cellulose within, could significantly reduce the energy requirements needed to process biomass and therefore cut costs. Researchers have located and isolated a gene that could make this concept possible and are now testing it in poplar trees.

● Researchers developed a method to produce novel plant oils called acetyl-triacylglycerols (acTAGs) in oil-seed crops. These low-viscosity oils have the potential to be used as a biodiesel-like biofuel.

● Using cutting-edge DNA sequencing technologies and high-throughput analysis software, researchers have screened thousands of plants to identify the genes that affect such key biomass traits as increased yield and digestibility.

Creating Sustainable Landscapes

Goal: *To develop fuel technologies that are economically, environmentally and socially sustainable*

Research Progress

● Planting perennial biofuel crops such as switchgrass could increase the number of beneficial insects on the landscape and reduce the need for insecticides, which Midwestern farmers now spray on an extra 3.5 million acres each year to combat an uptick in crop pests. The increase in pests is the result of the ongoing conversion of natural habitat to farmland planted in annual crops, a trend called "landscape simplification."

Reimagining Plant Processing

Goal: *To engineer low-cost processing schemes to unlock plant sugars that are feedstock-flexible*

Research Progress

● Improvements to a unique biomass pretreatment process called AFEX resulted in a $4.3 million grant from the Department of Energy to scale up the technology. Using ammonia, heat and pressure, AFEX blasts open the cell walls, allowing enzymes easier access to the sugars inside.

● Using AFEX, researchers have created an alternate form of cellulose that is five times more susceptible to breakdown by enzymes. This discovery paves the way for additional improvements to cellulosic biofuel processing.

● By analyzing the microbes and enzymes produced in the gardens of leaf-cutter ants, scientists have identified novel enzymes that break down leaf matter, many of which outperform commercial enzyme mixtures.

● Scientists developed a robotics platform called GENPLAT that tests the ability of new enzymes and enzyme cocktails to break down biomass of all sorts into fermentable sugars. The system, which can process up to 96 samples at a time, is far more efficient than the normal testing method.

Converting Plant Sugars into Fuels

Goal: *To create efficient and scalable ways —whether biological or chemical—to turn plant sugars into biofuels*

Research Progress

● Using an ionic solvent, researchers can convert raw plant biomass first into fuel precursors and next into a potential drop-in fuel called DMF (for 2,5-dimethylfuran). In another chemical engineering approach, lining up a series of catalytic reactions allows researchers to create hydrocarbons, which are the basis for petroleum fuels.

● Researchers have increased yeast's appetite for xylose, which is the second most abundant sugar in plant biomass (the most abundant: glucose). By encouraging these microbial powerhouses to consume a larger share of the available plant sugars, researchers could significantly increase the amount and speed with which biomass can be used to produce biofuels.

● The carbon costs of converting Conservation Reserve Program (CRP) lands to corn and soybeans is high—even when using no-till cultivation practices. Growing grasses rather than corn or soybeans on the existing 30 million acres of CRP land could maintain climate, wildlife and other conservation benefits indefinitely while providing a valuable bioenergy feedstock.

● A study confirmed that in order for farmers to start growing dedicated bioenergy crops, their net earnings from biomass crops would need to meet or exceed those from conventional crops and include a risk premium to account for the transition.

Photo by Matt Wisniewski

IN LESS THAN FIVE YEARS OF OPERATION, THE CALS-LED GREAT LAKES BIOENERGY RESEARCH CENTER HAS PRODUCED A NUMBER OF BREAKTHROUGHS THAT MAY LEAD TO A LESS OIL-DEPENDENT FUTURE

Where are we now?

Genetics researcher Dana Wohlbach displaying a common industrial yeast, which she is infusing with a yeast gene found in bark beetles to more efficiently help convert an abundant plant sugar to biofuel.

By Margaret Broeren

TIM DONOHUE HAS SPENT THE LAST FOUR YEARS BUILDING A PIPELINE—but not the kind that springs to mind when we think of fuel.

The professor of bacteriology heads the CALS-led Great Lakes Bioenergy Research Center (GLBRC), founded with $142 million from the U.S. Department of Energy and a groundbreaking charge—to create the next generation of biofuels by harnessing renewable energy from the nonfood plants that are so plentiful all around us: grasses, trees and crop residues.

"We need to create liquid transportation fuels that are more cost-effective, more sustainable and won't compromise the Earth or our quality of life," says Donohue. "We're in the middle of developing ways to generate these new fuels that are essential for powering our daily lives."

With Michigan State University (MSU) as UW–Madison's major partner, Donohue has assembled a team that now includes more than 400 researchers and staff and an additional nine member institutions. The effort spans two countries, 11 states and more than 60 individual lab and field facilities.

That's a lot of brainpower. But the magnitude of the effort is commensurate with the task at hand, Donohue notes.

"We need to be considering everything from roots in the ground to what's coming out of the nozzle," Donohue says. "Without such a holistic approach, we won't be able to demonstrate that this technology is feasible or see the weak spots where we can make improvements."

What GLBRC has built is a research pipeline, a process that considers all factors that go into developing and implementing cellulosic biofuels—from creating sustainable agricultural landscapes and building better bioenergy crops to innovations in plant biomass processing and converting plant sugars into fuels (see illustration on page 20).

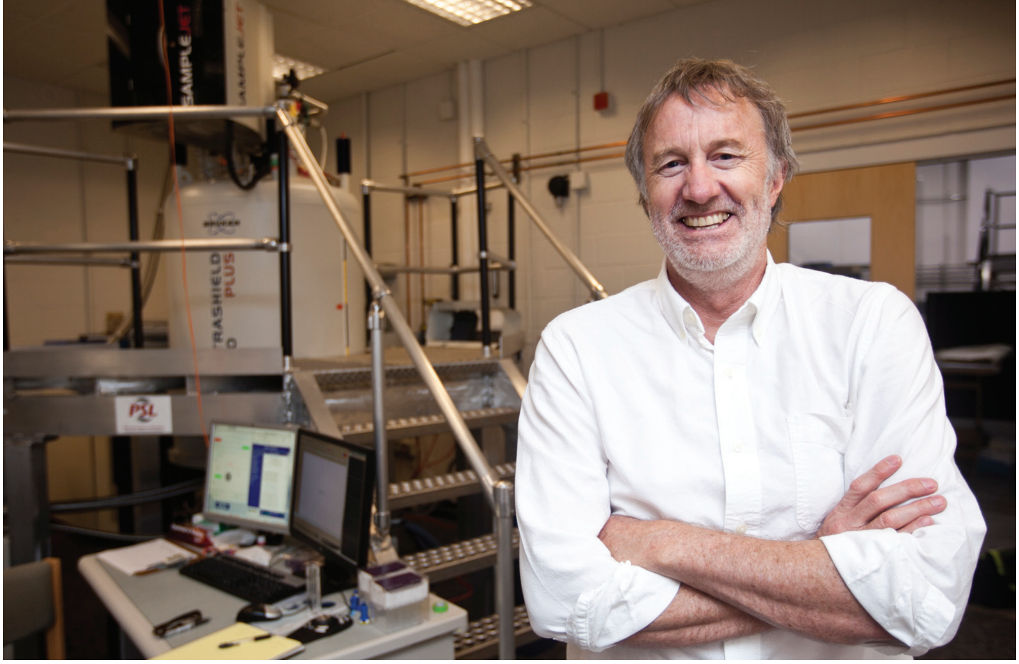


Photo by Matt Wisniewski

Biochemistry professor John Ralph and his team are working to create Zip-Lignin, a new technology to break apart one of the plant cell wall's toughest compounds.

While the promise of creating sustainable plant-based fuels isn't new, the level of public investment needed to tackle this challenge has only recently emerged. According to the International Energy Agency, the United States leads world spending on biofuels public research, development and demonstration projects, investing $189 million in 2010 alone.

"By relying on fossils fuels, we're living on energy that arrived on Earth many millions of years ago," says Steve Slater, GLBRC's scientific programs manager. "In order to reach a sustainable energy economy, we need to learn to live on the energy that arrives from the sun today. There's a lot of that solar energy held within plant biomass, if we can figure out how to sustainably convert it to liquid fuels."

Four years into its five-year grant, GLBRC has made some significant breakthroughs along the research pipeline. Here are some major points of interest.

First Stop: PLANTS

At agricultural research stations in Wisconsin and Michigan, GLBRC researchers tend to tall stands of such biofuel crops as switchgrass and miscanthus, measuring above-ground traits like crop yield and digging down in the dirt to monitor soil microbes and water movement. Sophisticated instruments measure greenhouse gases such as carbon dioxide and nitrous oxide. Researchers count birds and insects to measure biodiversity and use satellite data to capture a watershed-level view of land use patterns.

It's a lot of information, but each measurement plays a role in determining how these crop contenders would fare as large-scale bioenergy crops.

The leaves and stalks of these potential bioenergy plants are comprised of large quantities of cellulose, the most abundant organic compound on the planet. Cellulose is a polysaccharide, a long chain of tightly linked sugar subunits that must be broken down into simple sugars before they can be processed into biofuel. That alone is difficult—but to make the process even harder, much of a plant's cellulose is locked within cell walls that form a tough, protective barrier. Breaking past the walls, using enzymes or chemicals to do so, is one of the biggest challenges in creating economically viable cellulosic biofuels.

Plant cell wall structures have evolved over time to fight off pests and disease. The more scientists understand about how the walls are created, the easier it will be to break them apart. DNA sequencing capacity provided by the Department of Energy (DOE) Joint Genome Institute allows plant breeders access to genetic and genomic data that provide clues about how those cell wall layers are built.

While determining the best genetic traits for bioenergy crops is a long-range goal, GLBRC plant researchers already have made important headway when it comes to tackling lignin, one of the toughest compounds that make up plant cell walls. Researchers hope to take it apart to get at the cellulose locked inside and convert small pieces of lignin into valuable co-products. CALS biochemistry professor John Ralph and his team have identified a gene that would allow easily breakable bonds to be incorporated into plant cell walls. They're calling this new technology Zip-Lignin™ for its ability to break apart—or unzip—the lignin within. By getting lignin out of the way, biomass processing could be completed at lower temperatures. And lower temperatures mean lower overall costs.

And on another track, GLBRC researchers at MSU have located an enzyme that creates a plant oil with unique biodiesel-like properties. Now they're working to encourage plants to produce more of that oil, which could be used directly as a "drop-in" or ready-to-use diesel replacement.

Second Stop: PROCESSING

Just as people need to chew food to better access and digest the nutrients inside, mechanical and chemical pretreatment of plants disrupts the cell walls and allows access to the sugars within. Using ammonia, heat and pressure, a pretreatment method known as AFEX (ammonia fiber expansion) blasts open cell walls, allowing enzymes easier access to the sugar polymers inside. Enzymes then break polymers apart into simple sugars for conversion to biofuel.

AFEX technology, developed and patented by GLBRC researcher Bruce Dale, an MSU professor of chemical engineering and materials science, has moved one step closer to commercialization. Dale and his team have partnered with MBI, a subsidiary of the Michigan State University Foundation, and in

Below, a technician prepares biomass for a new pretreatment method known as AFEX, which blasts open plant cell walls.

June received a $4.3 million DOE grant to scale up the technology as part of a one-ton-per-day cellulosic ethanol plant.

"We've come up with a less costly way of doing AFEX that we think is ready to commercialize," Dale says. Improvements to the AFEX pretreatment process have also reduced the need for costly enzymes by a factor of three. And if the team can push the technology further, accomplishing another three- or fourfold reduction, enzyme cost would no longer be a limiting factor in biofuel production.

As Dale's team tinkered with different approaches to implementing this technology, they found that a modified approach to AFEX actually changed cellulose into a slightly different form that is five times easier for enzymes to break apart.

"We can understand in a much deeper way now how the AFEX process works, how it operates to produce digestible biomass," Dale says. "Because we know that, we can do a much more rational job of picking the enzyme cocktails."

Third Stop: ENZYMES

In the GLBRC's early days, CALS bacteriology professor Cameron Currie's work with leaf-cutter ants shed light on how these remarkable insects actually grow food—in one of the world's oldest instances of farming—by tending leaves that provide nutrients for a strain of fungi that is the ant's dietary staple. Along the way, Currie discovered something else: the ant's nests are home to a number of previously unknown microbes whose enzymes may help break down the leaves. Currie recognized this property as a potential asset in the attempt to break down cellulose for biofuel.

That research has given Currie insight into the way cellulose-degrading microbes like bacteria or fungi work. One thing he's seen so far is that microbes rarely go it alone. "Microbes in nature do not occur in isolation," says Currie. "They do not break down plant biomass in a pure culture. In many systems, like the ant system, you have increased success and ability to compete with other organisms through beneficial symbiotic associations."

He predicts that within many of these symbiotic systems, combinations of microbial organisms are each producing different enzymes, and that these enzymes each play a part in the efficient breakdown of plant biomass.

With a selection of contenders sitting in cold storage, Currie has begun collaborating with Brian Fox, a CALS biochemist, to understand how different types of enzymes function. Currie and Fox have formed a tightly knit duo, in effect merging their labs and working off of each other's expertise.

"This collaboration has made a major impact on the work we're doing," Currie says. "It's allowed us to really pick apart these systems and the microbes within them."

Connecting with new colleagues is just one way that research centers like the GLBRC are tackling big science. And access to next-generation DNA sequencing tools speeds up the discovery process. Since starting at the GLBRC, Currie has worked with the Joint

Photo courtesy of MBI

Photo by Matt Wisniewski

Biochemistry professor Brian Fox (here with researcher Lai Bergeman) is working closely with bacteriology professor Cameron Currie to understand which enzyme combinations will best release sugars from plant biomass.

Genome Institute to generate dozens of bacterial genomes for comparative analysis.

"Sequencing is an area that is changing science in so many different ways," says Currie. "It really helps us understand not only the evolution of a community of microbes that break down plant biomass, but also the evolution of the process of enzyme production."

Currie and Fox are working to deliver newly characterized enzymes to their colleague Jonathan Walton, an MSU plant biologist who uses a robot to create enzyme cocktails that release sugars from plant biomass. This robotics platform, GENPLAT, runs through an impressive 96 tests at once, allowing Walton and his team to quickly evaluate new combinations of enzymes on different types of bioenergy crops.

Fourth Stop: CONVERSION

Once biomass has been pretreated and the sugars released, GLBRC scientists work with bugs like yeast and *E. coli* to optimize the way they churn through sugars and ferment them to produce fuels.

Even though *S. cerevisiae*, an industrial yeast that has been used by brewers for centuries, is great at chewing through glucose, it hasn't had much of an appetite for the five-carbon sugars like xylose—the second most abundant plant sugar—that make up a good part of the plant cell wall. That is, until now.

"Strains of yeast that are currently used for biofuel production can only convert xylose to ethanol very slowly and inefficiently," says CALS genetics researcher Dana Wohlbach. "But the more sugars a yeast can consume, the better, since more sugar consumption means more ethanol."

Researchers have identified a species of yeast found in bark beetles that is able to efficiently use xylose. After engineering that species' xylose-friendly genes into an industrial yeast, researchers found that the industrial yeast, too, could use xylose along with other sugars—a development that could significantly increase the amount and speed with which biomass sugars can be converted to biofuels.

Although encouraging bacteria and yeast to act as miniature biofuel factories shows incredible promise, GLBRC is putting a few other bets on the table.

"Ethanol will probably continue to have a place in the automotive industry in the U.S. and around the world for decades," says Tim Donohue, "but it is never going to be an acceptable biofuel for diesels or aviation or the shipping industry."

Donohue is eager to expand the Center's suite of fuels so that if an airline or shipping company comes knocking, they'll find options to help them meet ambitious industry goals for reducing petroleum use. (The airline industry, for example, has committed to achieving carbon-neutral growth by 2020, as stated by the International Air Transport Association.) These industries are demanding ready-to-use fuels that can be "dropped in" to existing infrastructure such as engines, gas tanks and pipelines.

GLBRC's Ron Raines and James Dumesic are working hard to meet this tall order. Using an ionic solvent, CALS biochemist Raines can convert raw plant biomass first into fuel precursors and next into a potential drop-in fuel called DMF (for 2,5-dimethylfuran). In another chemical approach, Dumesic, a UW professor of chemical and biological engineering, has used a series of catalytic reactions to create hydrocarbons, which are the basis for petroleum fuels.

Fifth Stop: SUSTAINABILITY

Biofuels generated by GLBRC get a reality check courtesy of UW mechanical engineer David Rothamer and the UW–Madison Engine Lab, where ethanol and other fuel precursors can be burned in engines to measure data on emissions and fuel performance.

"We understand how important it is to evaluate the feasibility of our technologies before we can call them a success, before we can decide that we've accomplished even the smallest goal," says Donohue. "If I were flying in a commercial jet burning our biofuels, I would want us to be confident about fuel performance at 30,000 feet."

How can GLBRC researchers be sure that successful fuel production at the lab bench can be scaled up to meet the needs of a state, a region or a country?

One way is to look at the fuel from every angle—counting the inputs related to growing, transporting and converting plant material into fuel. By using robust

Photo by Beth Skogen

Instruments positioned near biofuel crops at the Arlington Agricultural Research Station measure plant utilization of solar radiation, weather conditions, and temperature and moisture at different depths in the soil.

modeling software, GLBRC researchers are examining the feasibility of potential fuels or technologies not just for scalability, but also for sustainability.

Much more than a buzzword, "sustainable" means that trade-offs—social, environmental and economic factors—have been measured, modeled and validated against actual "boots on the ground data" measured at agricultural research stations and on Midwestern farms, says Randy Jackson, a grassland ecologist and CALS professor of agronomy who co-leads GLBRC's sustainability research group.

GLBRC research on bioenergy cropping systems, for example, has shown that such crops lead to everything from a reduced need for insecticide (due to an increase in beneficial insects) to increased bird and grassland diversity. "It's really exciting that these systems offer the opportunity to actually improve both landscape management and ecosystem services, or benefits, that we get from the land," says Jackson.

But the bottom line has to make sense to farmers, reports Scott Swinton, an MSU professor of agricultural, food and resource economics who has conducted studies exploring what it would take for farmers to transition their fields away from corn and soybeans. Farmers need to know that there's a solid market for dedicated energy crops such as switchgrass or miscanthus, and that moving away from what they know would help them pay the bills, Swinton says.

Looking Forward

Close to a year from now, GLBRC researchers will be wrapping up their first five-year funding cycle and awaiting word from DOE about a second round. They plan to close out the year with a set of promising technologies for further pursuit and recommendations based on which crops have shaken out as biofuel feedstock winners.

So far it's clear that deep-rooted perennials are great at sequestering carbon, a big benefit for reducing greenhouse gases and therefore combating climate change. And regardless of the particular source of biomass—corn stover, switchgrass, miscanthus or poplar—bioenergy crops will need to be productive if farmers are expected to make an investment in this budding industry. If clean water, erosion control and biodiversity are important to consumers, agricultural landscapes will need to be designed with these values in mind.

A big part of doing biofuels right may simply mean being aware of the trade-offs.

Randy Jackson frequently gets the question "What biofuel crop is best?" And he usually answers, "It depends on where you are in the landscape." If you want the landscape to improve water quality in your area, for example, you might need perennial biomass crops on the bottomlands.

After four years of collecting data and building models, Jackson is eager to roll the sustainability work up into scenarios, simulations and flexible decision-support tools so that farmers and other rural community members will have the ability to evaluate how their local landscape could be utilized for a combination of food, fiber and fuel.

At some time in the near future, the Center's findings and results likely will become—and should become—a point of societal discourse involving a wide range of stakeholders, including the general public. "We're committed to providing reliable, useful, relevant and thorough information to inform that discourse," says Jackson.

Entering the home stretch of this first phase, all projects are focused on making existing processes faster, cheaper and more sustainable.

"We've created this pipeline and developed technology at the core of our mission, and we've achieved it in a little more than three years," says Tim Donohue. "But we're far from finished." g

Photos by Wolfgang Hoffmann BS'75 MS'79

BIOMASS IS NOT JUST DESTINED FOR LIQUID FUEL. IT'S CHANGING THE WAY A DIVERSE RANGE OF GOODS AND SERVICES ARE BEING PRODUCED AND PROVIDED IN WISCONSIN.

Beyond the gas tank

Bioenergy specialist Tim Baye visiting Meister Cheese Company in Muscoda, which fuels its plant in part by burning waste woodchips from a nearby sawmill. (Inset) A look inside the boiler.

by Bob Mitchell BS'76

ON TIM BAYE'S LIST OF WISCONSIN BIOMASS-BASED PRODUCTS, LIPSTICK looms larger than ethanol.

"One of the most attractive markets this year is a paraffin derivative for lipstick use made from bio-based materials," says Baye, a UW–Extension professor of business development who specializes in bioenergy consulting and executive education.

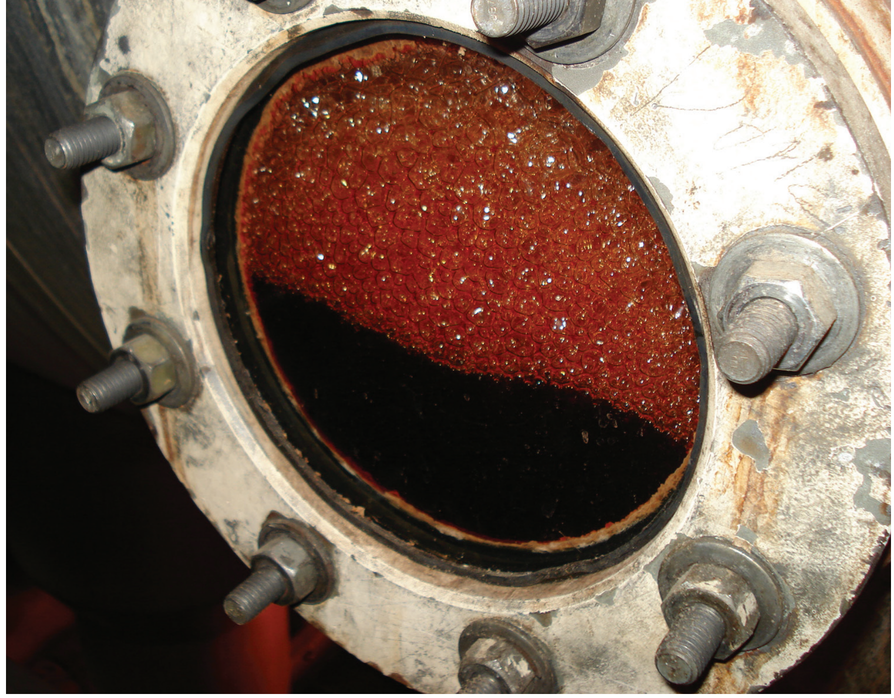
"The bio-based chemical market is appealing because you get a better return on a more modest amount of feedstock compared to fuels," he says. "The markets are not as volatile as they are for liquid fuels, and we don't need major infrastructure, such as pipelines, to move the stuff. We can do it by truck and train."

Baye has been crunching numbers on bioenergy projects for 27 years, both in his current job and in several private sector positions, including a two-year stint leading an initiative to start up an ethanol plant. Since the mid-1990s he's also been experimenting with growing biofuel crops—switchgrass, sorghum, aspen and mixed grass stands—on a 240-acre farm in Woodman.

Asked what he thinks Wisconsin will be doing with biomass in the future, he quickly ticks off a dozen projects that already are operating or are on the drawing boards. The tally includes electrical plants fueled by everything from old railroad ties to landfill waste to willow, paper mills that have branched into wood pellets and biodiesel, and municipalities making biogas and fertilizer from wastewater.

Notably lower on his list: corn-based and cellulosic ethanol.

New opportunities: Flambeau River Papers is refining pulp liquor (right) for use in the array of products shown below.



"We'll continue to produce liquid fuels from biomass, including corn, as long as the margins are justifiable," Baye says. "But we don't have the long growing season they have down South and in the tropics. That's where you have higher biomass growth rates and yields, and that's where we're likely to see most of the biomass-based liquid fuels produced."

What he does expect to see are lots of multipurpose facilities, where firms supplement their core business with energy and other biomass-based products in order to diversify, cut costs, spur revenues and make use of industrial residues. He cites the paper industry as a prime example.

"A number of our paper plants are planning on bolting on technology platforms to allow them to produce products other than paper," he says. "A pulp tree may still go to the paper plant, but be converted to something much different than paper."

He points to a Wisconsin paper mill, Flambeau River Papers, and its planned sister facility, Flambeau River BioFuels, as a national leader. Flambeau River Papers is refining its residual, pulp liquor—a rich red-brown broth left over from the paper-making process—into such value-added products as xylitol, used in making sugar-free gum, and into a binder used for dust control on dirt roads. The paper mill is powered by a biomass-fueled boiler. Flambeau River Biofuels plans on producing biodiesel and industrial lubricants and waxes in a facility scheduled to begin construction in 2012.

This strategy isn't limited to paper plants. Corn-based ethanol plants are also considering adding processes to improve performance and diversify. Some of the first cellulosic ethanol plants have taken this approach and are eyeing the chemical market too.

Baye also expects to see more biogas digesters—producing methane and generating power and heat—coupled with municipal waste treatment plants to deal with wastewater and industrial residuals laden with organic content from food processors and other manufacturers.

"Municipalities are under pressure to upgrade these plants, which means higher charges," Baye says. "To minimize these upgrades, they will look to divert the organic material and get a little gift back in the form of biogas. And there are a number of opportunities for them to produce additional, high value products—especially fertilizers." New regulations addressing phosphorus management will likely accelerate this trend.

Baye says that many such projects will require partnerships between municipalities, local industries and farmers, who will grow switchgrass, sorghum and other bioenergy crops as additional feedstock for the digesters.

And even if Wisconsin doesn't lead the pack in ethanol production, Baye thinks the Badger State will benefit from any growth in the ethanol industry. The expertise acquired making paper, beer, silage and cheese transfers nicely to the bioenergy business, and it's a marketable product in and of itself, he points out.

"In the future we probably will be buying cellulosic fuel from other regions, but we'll be selling them chemicals and enzymes and vats and pumps, technology, legal services and know-how," Baye says.

Photos courtesy Flambeau River Papers

Cash crop biomass

WISCONSIN FARMERS ARE WELL POSITIONED TO TAKE ADVANTAGE OF A NEW MARKET—BUT GETTING THERE WILL TAKE SOME FRESH VISION AND A LITTLE RETOOLING

Photo by Wolfgang Hoffmann BS'75 MS'79

by Bob Mitchell BS'76

WISCONSIN FARMERS have been growing biomass for generations, says Kevin Shinners. They just have a different name for it.

"Biomass is really just poor-quality forage," says the CALS agricultural engineer. "We allow it to get very mature and it's really high in fiber, so it doesn't make very good animal feed, but it makes great biomass."

And Wisconsin farmers have a leg up in the business of producing biomass, says Shinners, a specialist in forage systems who branched out into bioenergy crops about 10 years ago.

Biological systems engineering professor Kevin Shinners with the biomass known as corn stover.

A modified combine creates windrows of stover at the time of grain harvest.

"We have all of the tools to harvest and handle and process it. And an added advantage is that when we take biomass off the field, we have new places to put our dairy manure," he says. "When you take corn stover off the field, you're removing nutrients that you need for next year's crop. A Wisconsin farmer can apply manure, while an Illinois farmer may have to go out and buy fertilizer."

Wisconsin also is rich in off-farm resources. The state's custom harvesters are expert at chopping stalks and grass, and biomass could fit nicely into their schedule. After they finish chopping corn silage in September, crews could move on to corn stover or switchgrass in October and November, spreading fixed costs over more acres and keeping employees working longer.

In fact, under some business models, farmers might job out most of their biomass crop production. If the crop is a perennial, such as switchgrass, the farmer may spend more time in front of the computer and on the phone than out in the field. "Once the crop is established, he'll manage fertilization and weed control through an agronomic service, cutting and removal through a custom harvester and marketing through a biomass aggregator," Shinners says.

But even though Wisconsin farmers may be very much at home with the types of crops involved and the mechanics of producing them, they'll be on less familiar ground when it comes to marketing, Shinners notes.

"If you're a cash crop farmer, you're used to marketing your corn and beans through multiple paths, selling some out of the field, storing some, selling futures, to optimize what you earn on an annual basis," he says. "For biomass, you'll have to change your mindset.

"If a firm builds a large cellulosic biorefinery here, it will need an absolute dedicated supply," Shinners says. "If half the people in the area decided not to produce biomass one year, that plant would be a dinosaur." Meaning that a critical mass of local farmers must be willing to lock into a long-term production contract.

The economics of biomass are driven by the fact that, pound for pound, the stuff isn't worth as much as other crops. Profit margins may be slim, so farmers will need to produce as efficiently as possible.

That's where Shinners comes in. His research centers on streamlining the harvest and handling a variety of biomass crops, including such perennials as switchgrass and reed canarygrass, and annuals such as sorghum. But his biggest push has been in corn stover—the stalks and leaves and cobs left when the kernels are removed—simply because there's so much of it.

"There are some 90 million acres of corn being grown in the United States this year, and with the prices we're seeing, there's going to be more and more of it grown. If you're really interested in biomass, it's right there at our doorstep," he reasons.

Since profit-minded crop producers aim to make as few trips across the field as possible, Shinners' first efforts focused on harvesting both corn grain and corn stover in one pass. Essentially, he grafted a forage harvester to the back of a combine and hitched a wagon behind to catch the chopped stover.

This impressive 50-foot train of machinery worked, he says, but handling two crops at the same time slowed down the grain harvest, putting both yield and quality at risk. "That's even more of an issue these days, when we have seen corn go over $7 per bushel," he says. "As corn grain increases in value, everything that slows the combine down has a much greater economic cost."

Shinners is focusing now on a system in which the combine harvests grain and leaves the stover behind in a long, neat row. "A custom harvester could come in behind and chop these windrows and store them for the farmer."

Since buyers will need year-round deliveries, storing biomass crop until it's needed is part of the equation. Shinners thinks the best approach is one that dairy farmers use for forage—seal it from the air in long plastic bags or covered bunkers and let it ferment. "We know this from dairying: You can open up a silo bag from two years ago and it's still good quality," he says.

That fermented biomass could be good enough to eat—by livestock, at least—which may offer farmers a way to take advantage of the bioenergy market without having to wait for a biomass refinery to be built nearby.

"If we apply amendments like lime right before we store corn stover, the feed value can increase substantially," says Shinners. "So instead of waiting for somebody to develop a biorefinery in Wisconsin to convert stover to ethanol, why not divert some of the grain normally used to feed cattle toward ethanol production and use the stover to replace the corn as animal feed?"

Photo courtesy POSOH

Middle-schoolers from the Menominee Indian School District examining bones they found in the forest. With them is POSOH team member Jerilyn Grignon, a Menominee elder and a professor at the College of Menominee Nation.

A NEW PROGRAM ENGAGES RURAL NATIVE AMERICAN KIDS IN REAL-LIFE BIOENERGY RESEARCH

Many ways of knowing

By Joan Fischer

"How do you take care of the forest—and how does the forest take care of you?"

Those questions might not spark a vibrant discussion among typical suburban middle-schoolers. But kids who grow up living, playing or hunting on the Menominee Indian Reservation in northeastern Wisconsin couldn't say enough.

"They had all kinds of stories about the plants and animals that live there," says CALS researcher Hedi Baxter Lauffer, who recently sat in on a talking circle with seventh- and eighth-graders from the Menominee Indian School District. "They were saying things like, 'I take my nephew into the forest and teach him to pick up his trash. He needs to know that it's a beautiful place to play.'"

Lauffer, along with biochemistry professor Rick Amasino and other researchers, was seeking student input for POSOH (poh-SOH)—the Menominee word for hello—a new partnership program between CALS (with the Great Lakes Bioenergy Research Center in a leading role) and the College of Menominee Nation.

The program, funded by a $4.7 million grant from the U.S. Department of Agriculture, will over the next five years prepare students for bioenergy- and sustainability-related careers. Unlike most science education programs, POSOH will include exploration of how Native American traditions contribute to understanding ecosystems and sustainability.

People from minority cultures often struggle finding a path into science because of conflicts with their heritage, notes Lauffer. POSOH researcher Robin Kimmerer, for example, says that as a professor of forest biology and as a Native American, she's had to work hard to reconcile two distinct ways of experiencing nature.

"In science we are asked to objectify the world, to view it in a strictly material, intellectual way," says Kimmerer, who earned her doctorate in botany at UW–Madison and now teaches at the State University of New York. "In indigenous ways of knowing, we're reminded that we can understand the world intellectually, physically, emotionally and spiritually—and that we can't really claim to understand something unless we engage all four elements," she says.

POSOH started field-testing teaching units this fall with 150 middle-schoolers, along with launching an after-school "sustainability club" and offering school-break research opportunities for kids on the UW–Madison campus. Over the next five years POSOH will provide numerous summer teacher training institutes to spread the program, which is expected to reach several thousand children in rural Wisconsin—and, researchers hope, provide a national model for bringing diverse ethnic groups into science.

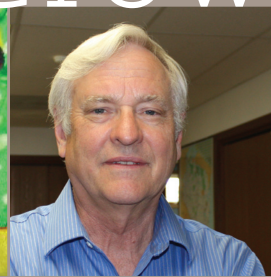
We have a lot to gain by doing this, notes Lauffer. "We need innovative solutions to energy and sustainability challenges," says Lauffer. "Broadening our knowledge and increasing access to scientific inquiry can help us meet those challenges."

The Grow Dozen

Francisco J. Arriaga

Nancy Bohl Bormann

Jaslyn Dobrahner



Peter J. Huettl

Michael D. Johnson

Terry Kurth

Francisco J. Arriaga PhD Soil Science • Arriaga is a research soil scientist with the USDA National Soil Dynamics Laboratory in Auburn, Alabama, where he works to develop row crop management systems that improve soil physical properties and overall soil quality. "The main goal is to increase organic matter content in the soil," says Arriaga. Arriaga also is an affiliate assistant professor at Auburn University—his research interests include bioenergy crops—and serves as an associate editor with the *Agronomy Journal* and the *Journal of Soil and Water Conservation*. Arriaga, who grew up in Puerto Rico, comes to Wisconsin often to visit his in-laws. His wife, Julie Sue Studnicka Arriaga MS Soil Science, was raised on a dairy farm in Muscoda.

Nancy Bohl Bormann MS Soil Science • As an agronomist in Iowa with Maschhoff Environmental Inc., Bohl Bormann helps swine producers with manure management planning and environmental compliance. "I enjoy working with farmers, and the variety and challenges the position brings," she says. In her spare time, Bohl Bormann is a farmer herself. She and her husband farm 1,100 acres of corn, soybeans and alfalfa hay along with raising and marketing about 1,500 hogs per year.

Jaslyn Dobrahner BS Soil Science and Agricultural Engineering, MS Soil Science • Among the satisfactions of Dobrahner's job as a Denver-based environmental protection specialist with the EPA is seeing the results of her work firsthand—for example, she says, "Witnessing a school go from having many pest problems and using a lot of pesticides to having very few pest problems with little to no pesticide use—that is rewarding to see!" In addition to reducing chemical pesticide use in schools, Dobrahner has worked to protect farmworkers and endangered species from pesticide exposure.

Peter J. Huettl MS Soil Science PhD Soil Science • Huettl is a principal scientist/engineer with Applied Science, Inc., a Madison-based engineering consulting firm that primarily serves agribusinesses (clients include food, feed and fuel producers and processors). The company creates systems for the sustainable treatment and utilization of by-products associated with processing and specializes in soil treatment and cropland recovery of plant nutrients. "Our philosophy is to achieve maximum economic recovery and reuse of production residuals and minimize the mass or concentration of residuals that enter the atmosphere, groundwater or surface water," says Huettl.

Michael D. Johnson MS Soil Science • Johnson is head of biological research and development for Syngenta Crop Protection, part of a global agribusiness company that markets seeds and pesticides. Johnson's department designs and conducts the efficacy and crop safety field-testing of research and developmental products for Syngenta's crop protection business in the U.S. "I enjoy being able to identify technical issues or opportunities facing Syngenta or our growers and then enable our talented team of field scientists to objectively break them into actionable pieces and address them," says Johnson.

Terry Kurth BS Agronomy • "Turfgrass is the Rodney Dangerfield of the environment. It gets no respect," Terry Kurth humorously observes. That said, Kurth has had a highly respectable career managing turfgrass, which he regards as a "simple environmental hero" for its properties as a soil pollutant sponge and filter of air impurities. He is currently the director of development for U.S. operations of Weed Man lawn care. Prior to that he spent decades building and expanding franchises of Barefoot Grass Lawn Service, which he operated in Wisconsin, Illinois, Kentucky and Texas before selling the business to TruGreen/Chemlawn. Kurth shows his dedication to quality research by partnering with the Wisconsin Landscape Federation to fund the Terry and Kathleen Kurth Wisconsin Distinguished Graduate Fellowship in Turfgrass Management.

Sabrina R. Mueller-Spitz BS Soil Science, MS Soil Science • Mueller-Spitz's interest in soil led to a fascination with the microbial communities found there—and to a Ph.D. in microbiology. As a professor at the University of Wisconsin–Oshkosh, Mueller-Spitz imparts those interests to her students. "My favorite part of teaching is fostering wonder and providing a wider understanding of new topics in microbiology, environmental problems that threaten human health and understanding how epidemiology is used to assess and improve human health," she says.

Donald W. Owens BS Soil Science, MS Soil Science • For 34 years Owens has headed Earth Dimensions, Inc., a soils

12 Alumni who are grounded in soil science






Sabrina R. Mueller-Spitz | Donald W. Owens | Zachary Reineking | Matthew Repking | Amy Sausen | Caroline van Schaik

and environmental consulting firm based in upstate New York. In one of his earliest projects, he conducted soil sampling at the Love Canal chemical waste dump that shed light on the seriousness of contamination there and helped lead to a national overhaul of sampling protocol at contaminated sites. Besides running his business, Owens is an avid traveler, often melding trips with his interest in soils. On a recent bird-watching tour in Antarctica he had hoped to get his first glimpse of gelisol (soils formed in permafrost), the only soil order that he has not yet seen, but that didn't happen. "What a great excuse for a tour to the Arctic in the future!" he says.

Zachary Reineking **BS Soil Science •** Reineking is head superintendent and project manager at Erin Hills Golf Course in Hartford, which in August hosted the U.S. Amateur Championship—the first to be played in Wisconsin—and in 2017 will host the U.S. Open, an honor that marks the course's "meteoric rise" in the golf world, noted the *Milwaukee Journal Sentinel*. Coordinating preparation with the U.S. Golf Association is part of Reineking's job, along with overseeing a staff of 35 in all ground maintenance and construction projects (recently he coordinated and supervised a $4 million course renovation). "On a daily basis I am required to be an HR director, accountant, plant pathologist, entomologist and soil scientist. Not many fields can give you that variety," Reineking says.

Matthew Repking **MS Soil Science •** Repking's "office" is the sprawling 2,000-acre complex that comprises CALS' Arlington Agricultural Research Station, where Repking works as assistant superintendent. As with the 11 other research stations, Arlington serves as an outdoor laboratory, classroom and community education center. Repking is responsible for nutrient management planning, soil fertility, crop rotations, crop production, assisting researchers and Wisconsin Pollutant Discharge Elimination System (WPDES) compliance. "My favorite part of the position is to see how things continually evolve and the wide variety of research that is performed at Arlington," he says.

Amy Sausen **BS Horticulture, Soil Science •** As a landscape and environmental projects coordinator for the Bruce Company, a landscape company and garden center in Middleton, Sausen wears a few different hats. On the landscape side, she designs and coordinates the installation of mostly residential landscape projects. On the environmental side, she oversees the company's organic product lines, which include rain garden design and construction and creating "living walls," which she calls "a green alternative to conventional slope stabilization." Sausen remains grateful that in her junior year she added a soil science degree to her degree in horticulture: "The extra knowledge I gained from learning about soil chemistry, soil physics and nutrition has been absolutely invaluable in my career," she says.

Caroline van Schaik **MS Soil Science •** As a community-based food systems program organizer for the Minnesota nonprofit Land Stewardship Project, van Schaik catalyzes farmer initiatives related to buying and selling good food grown close to home, focusing on distribution and infrastructure. She coordinates events that encourage eaters to buy that food—as parents, school cooks, food service workers and chefs—and trains farmers to take better advantage of the national interest in buying from them. "My driver is land use fueled by a zeal for practical applications that work for ordinary people and the myriad of small- and mid-sized farmers who raise a lot of food we ought to be eating," she says. In her free time, van Schaik and her family raise grass-fed sheep.

About the Dozen

These 12 alumni represent the depth and breadth of CALS graduates' accomplishments. Selections for the list are made by the *Grow* staff and are intended to reflect a sample of alumni stories. It is not a ranking or a comprehensive list. To read more about CALS alumni, go to www.cals.wisc.edu/alumni/

Next issue: Communication

Know someone who should be in the Grow Dozen? Email us at grow@cals.wisc.edu

Catch up with …

Richard Wagner MS'75, PhD'79 Food Science

TO THE DAIRY BORN— that's one way to describe Richard Wagner, who "grew up on top of a cheese factory," he says, in rural Waupaca County (his father was the factory operator). His family later founded Weyauwega Milk Products, which Wagner joined after earning a degree in industrial engineering. Wagner helped run the company for decades that included a merger and, later, a renaming as Trega Foods, which was sold in 2008. Along the way Wagner became a licensed cheesemaker and a leader in numerous dairy organizations, including serving as a member of the governor's Dairy 2020 Council. • Nine years ago Wagner began doing some of his most creative and satisfying work. He and his family purchased a 500-cow dairy located next to their farm and transformed it into a 2,200-cow operation that serves as a showcase of environmental innovation. Quantum Dairy, located just outside Weyauwega, includes an anaerobic manure digester, 7,000 feet of underground heat piping and state-of-the-art stormwater runoff and leachate control.

Photo Courtesy Richard Wagner

● You frequently open your farm for public tours. Why?

I feel the need to help people understand that a dairy farm may need to expand in order to be able to afford to adopt the best known practices and best technology to efficiently produce food and minimize use of water and loss of soil. Other benefits of expanding are to improve employee working conditions, to improve cattle health and treatment and to minimize the cost of manure handling while protecting our surface and ground water. I really like to point out that an operating dairy helps synergistically sustain the beautiful open countryside so that it can continue to exist for the enjoyment of Wisconsin's residents and tourists alike.

● How would you compare farming when you started to farming today? Does it feel like a new profession?

For more than 100 years, farming in Wisconsin has been involved in a slow paradigm shift that is nowhere near over and that has resulted in far fewer farms. These farms are more productive and larger, yet most still rely on a family unit for their management. Dairy farming is definitely a new profession that requires less physical labor but more management of employees, contractors, consultants, risk, finances, new technology adaptation and succession planning. Today's dairy operator has the option of planning for much more free time. The result is an exciting profession that is competing for the brightest and best rather than continuing to cause flight from the farm.

● What advice would you give future farmers?

I would advise future farmers to embrace change. There is nothing that can't be done if two generations of a family farm, or an older farmer and a young person, decide to do something together. It is important that the older person defer to the younger person as soon as possible. Of course, education is the key to the future. It can be helpful to buy land when it is available, even though it is always too expensive and never available at the right time. If you are trying to decide whether an idea is a good one or not—if it breaks down walls between people, it's a good idea. If it builds walls between people, it's a bad one.

Photo by Gerhard Fischer

MEET THE WINNERS: These young people from all over Wisconsin received the James Crowley award for their outstanding dairy projects. Top winners Bethany Dado and Morgan Behnke (front row, fourth and third from right, respectively) also won a scholarship.

give

A VERY DAIRY FUTURE

"I hope to pursue a career as a dairy geneticist or research the human genome," says Bethany Dado, 17, of Amery, who plans to double major in dairy science and genetics. And at the Wisconsin Junior State Fair in August, the high school senior won a statewide award to help her achieve those goals.

While 15 young people received the James W. Crowley State 4-H Dairy Leadership Award for their outstanding dairy projects, Dado was one of only two top winners—along with Morgan Behnke, of New Glarus—to also receive a $500 scholarship toward her dairy education.

"It's really a privilege to interview these young people who all wear their passion for the dairy industry on their sleeves," says award judge Ted Halbach, director of CALS' Farm and Industry Short Course. "Doc Crowley would be pleased with the leadership skills these young people have demonstrated both in school and with their 4-H project."

The award program is offered in memory of James W. Crowley, a longtime UW–Extension dairy specialist and a strong supporter of youth in dairy. In addition to the awards, the James W. Crowley Dairy Management and Extension Fund supports a robust summer internship program offering outstanding UW–Madison students a chance to work under the supervision of UW–Extension agents. Nearly two dozen students have benefited from this experience over the past 11 years.

Recipients of Crowley awards or internships often go on to become leaders in the dairy industry. Dado describes her award experience as highly motivating.

"Although I always try to do my best during my dairy activities, the Crowley award did motivate me to take it to the next level," she says. "It was always in the back of my mind as I served as a leader in 4-H activities."

The UW Foundation maintains more than 6,000 gift funds that provide critical resources for the educational and research activities of CALS. ***To help support the James W. Crowley Dairy Management and Extension Fund,*** *visit: http://www.supportuw.org/giving?seq=13137*

GET CHEESY at the **Third Annual Wisconsin Original Cheese Festival** on **Saturday, November 5,** noon to 5:30 p.m. at Monona Terrace in Madison. CALS cheese technologist Dean Sommer (Center for Dairy Research) presents the basics in "Cheese Making 101." Other seminars include how to best pair cheese with artisanal Scotches, rums and beers; exploration of the "new era" of Wisconsin cheddars; and a comparative tasting (call it a smackdown) matching Wisconsin cheeses up against their international counterparts. More info at **eatwisconsincheese.com.**

BUY A CHRISTMAS TREE from the UW Forestry Club at the **35th Annual Christmas Tree Sale December 2–4** in the Stock Pavilion, UW–Madison campus. Hours: Friday and Saturday 8 a.m.–8 p.m., Sunday 9 a.m.–3 p.m. Tree species include Fraser fir, balsam fir and white pine as well as Fraser fir wreaths. Proceeds support student educational opportunities in the Department of Forest and Wildlife Ecology.

CELEBRATE YOURSELVES with a virtual sneak peek at **Alumni Park,** a gift to the university from the Wisconsin Alumni Association in honor of WAA's 150th anniversary. The park will run between Memorial Union and the Red Gym and include a lakeshore promenade. Check out artist renderings at **uwalumni.com/alumnipark,** preferably while enjoying a bowl of **Mad Grad Medley,** a Babcock Dairy ice cream created in honor of WAA's 150th. Key ingredients: Door County cherries and chocolate flakes infusing Babcock's legendary creamy vanilla.

LEARN what the past year held for Wisconsin's $60 billion ag industry—and what the coming year may bring—on **Wednesday, January 25, 2012**, at the **Wisconsin Agricultural Outlook Forum**, an event held by CALS and UW-Extension. More info available soon at **news.cals.wisc.edu**.

BE INSPIRED by the latest recipients of the **WALSAA Outstanding Sophomore Awards.** Each of the 10 students receives a $2,000 scholarship for use in his or her junior year. The September edition of the *WALSAA Express*, posted at **walsaa.org**, profiles winners Jennifer Holle, Lauren Holterman, Bryan Menapace, Xiaoyi Qu and Kevin Yeska. The December issue will feature Mara Budde, Ronald Crandall, Sylvia Janicki, Amanda Miller and Jared Wendt.

UWMadisonCALS

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

Five things everyone should know about . . .

Bamboo

By Heidi Bissell

Photo by Andrew Dernie / Getty Images

1 | Bamboo is a grass. And all stalks are connected to each other by underground runners. The stalks are clonal, meaning that an entire bamboo grove covering many acres, or even an entire mountain, may be just one individual.

2 | It was bountiful here. The United States has only one species of native bamboo—rivercane. At one time rivercane covered the southeastern United States in impenetrably dense thickets covering hundreds of thousands of acres. These were home to many species of birds and mammals, many of which went extinct as rivercane was cleared for farmland and development. Now only about 2 percent of the original canebreaks are left.

3 | Bamboo grows really fast. The new shoots of some species can grow more than a yard a day. They do this by developing almost all of their new cells while underground and then grow just by filling up with water. Bamboo shoots are very strong—they can come up through concrete sidewalks and metal slabs. Bamboos are classified as either clumping or running. The latter send out long underground runners that can cover huge distances. They grow rapidly and often escape the area in which they were planted unless there is a water barrier.

4 | It is considered one of the world's most sustainable sources of hardwoods. Bamboo's circular structure makes it stronger than a similar weight of other woods, and for centuries it has been used as a construction material for houses, flooring and furniture. Because it grows quickly and in poor soils, without much care or chemicals, it is touted as a "green" wood and earns LEED (Leadership in Energy and Environmental Design) certification points for sustainable building. Bamboo fiber is used to make clothing, sheets and towels, and people seeking eco-friendly alternatives to metal and plastic are using bamboo to make machines, bicycles, pumps and other practical, everyday products.

5 | Pandas eat it—but they are not alone. Both giant and red pandas eat almost exclusively bamboo, even the woody parts. They eat bamboo leaves all summer and fall and switch to the woody central stalk in late winter, stripping off the outer green layer and eating the starchy insides. Pandas eat lots of bamboo—up to 25 percent of their body weight each day. All that eating might actually help the bamboo grow because damaged grasses grow faster.

Pandas share that bounty with bamboo lemurs and bamboo rats, both of them bamboo specialists. Being a bamboo specialist isn't easy. As with many grasses, bamboo releases cyanide when its cells are damaged, but these animals have the means to detoxify it (we don't yet know how). Many other animals eat bamboo as a small part of their diet. The beautiful golden monkeys of China, with their distinctive blue faces, feed on bamboo shoots when available and bamboo leaves year-round. Even humans dine on bamboo shoots. Cooking and processing gets rid of the cyanide, and some species of bamboo are thought to have medicinal benefits.

Heidi Bissell is a doctoral candidate in the department of zoology. She is studying the nutritional ecology of the black-and-white snub-nosed monkey in Yunnan Province, China, as part of the NSF IGERT program at CALS. You can learn more about her work at https://mywebspace.wisc.edu/hbissell/web/.

Take the Final Exam!

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

Nutritional Science

1. What do corn, beans, potatoes and amaranth have in common?

a. All are low in nutrient content
b. All are low-yielding crops
c. All are indigenous to the New World
d. All are poor protein sources

Dairy Science

2. How much revenue does dairy contribute to Wisconsin's economy?

a. $15.8 million
b. $50.5 billion
c. $26.5 billion
d. $84 million

Bioenergy

3. Why are perennial native grasses a promising biofuel crop?

a. They are highly productive.
b. They recycle ecosystem nutrients well.
c. They grow faster than annual biofuel crops.
d. A and B
e. B and C
f. A, B and C

Agronomy

4. Crop residue decomposition due to weather, tillage and burial varies greatly among species. For soil and water conservation planning, crop residues are classified as either fragile or non-fragile. Which answer below includes only non-fragile residues?

a. field corn, soybean, wheat
b. sweet corn, snap bean, potato
c. field corn, forage grasses, forage legumes
d. all of the above
e. none of the above

Poultry Science

5. Egg production in a laying hen is controlled mostly by:

a. temperature
b. humidity
c. day length
d. cage density
e. male roosters

LAST ISSUE: Answers were 1: B; 2: D; 3: C; 4: B; 5: C. Congratulations to librarian Susan Kalvonjian, who was the only person to ace our Final Exam. She wins a gift certificate to Babcock Hall.

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BE FRUITFUL AND SPORULATE

When amoebas run out of food, they sometimes gather together into multicellular structures called "fruiting bodies" in order to produce spores. Here, a single fruiting body—which looks something like a balloon on a string—has fallen over, spilling hundreds of thousands of spores across the surface of a Petri dish. You can watch videos of that process at youtube.com/user/UWMadisonCALS—and learn more about amoebas on page 12.

Photo courtesy Marcin Filutowicz