

grow

Wisconsin's Magazine for the Life Sciences • Summer 2015

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

Plant Prowess

*CALS scientists help forge
the future of a growing field*



College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN-MADISON

FOXES, COYOTES AND BADGERS • TURF SCIENCE AT WHISTLING STRAITS • P, FROM POLLUTANT TO PRODUCT



An array of cucumber diversity is represented in horticulture professor Yiqun Weng's research in the Walnut Street Greenhouses.

PHOTO BY SEVIE KENYON BS '80 MS '06



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Wisconsin's Magazine for the Life Sciences

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Growing populations of these animals on the UW–Madison campus and around town have inspired a new study aimed at living better together.

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On the Cover: CALS has a long track record of research with alfalfa, work that continues today. The alfalfa plant pictured here, taken in the Walnut Street Greenhouses on the UW–Madison campus, is part of a study by entomologist Johanne Brunet on interactions between varieties of alfalfa and bees. PHOTO BY SEVIE KENYON BS'80 MS'06

Dean Kate VandenBosch

Many Paths of Discovery



“The fruits of research are boundless, and often yield tremendous unexpected gifts along the way.”

Having an applied research goal can no doubt lend focus to the discovery process. For example, since its inception the charge of the Great Lakes Bioenergy Research Center here on campus, funded by the U.S. Department of Energy, has been to realize the grand vision of a biorefinery—the bioenergy version of the petroleum refinery. If we’re investigating biomass as a source of material that we’re going to get products from, we need to understand both how it’s put together and how to take it apart.

This quest has generated discoveries great and small, including CALS biochemistry professor John Ralph’s groundbreaking work in technologies to take apart lignin, a particularly tough compound in plant cell walls.

But pioneering discoveries don’t always happen with a specific application in mind—or applications are later found that are bigger and bolder than the researcher could originally conceive of. Take, for example, the late CALS genetics professor Ray Owen’s investigation of twin calves with different fathers that somehow were able to tolerate carrying each other’s differing blood cells—a mix that often triggers a severe immunological reaction. But when blood cells are exchanged early in development, Owen learned, each twin learns to tolerate the other’s cells.

By asking questions about a common occurrence in cattle, Owen had discovered the phenomenon of immune tolerance, which sparked a revolution in immunology and laid the foundation for the successful transplantation of human organs. His findings, published in 1945, paved the way for research involving induction of immune tolerance to transplanted tissue grafts by Frank Burnet and Peter Medawar. When those scientists received the Nobel Prize for that work in 1960, they noted it was Owen’s discovery that had set them on their way.

For another example, fast-forward to the present and consider the research of plant pathologist Aurélie Rakotondrafara, highlighted in our *Grow* cover story. While pursuing a basic science question—how plant viruses reproduce—she happened upon a very useful tool: a stretch of genetic material in a plant virus, known as an “IRES,” that is powerful at “recruiting” the plant’s natural machinery for making proteins.

It turns out there are huge biotech applications for this finding. “Rakotondrafara wasn’t looking for a more efficient tool to make proteins, but the IRES she found is perfect for it,” notes Jennifer Gottwald, a technology officer at the Wisconsin Alumni Research Foundation, which is working on a patent for this discovery.

That’s the excitement of scientific curiosity—and the best reason why we place such high value on both basic and applied research. One feeds into the other, and we cannot fully know the potential outcomes of discoveries we make today. We actively foster this curiosity about how living things work because the fruits of research are boundless, and often yield tremendous unexpected gifts along the way.

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Joan Fischer

WritersNicole Miller MS’06
Caroline Schneider MS’11**Editorial Assistants**

Rebecca Bock, Claudia Roen, Victoria Khoo, Isabella Cruz

Design

Diane Doering

Photography/MultimediaSevie Kenyon BS’80 MS’06
Uncredited photos are either stock or nonprofessional photography**CALS ADMINISTRATION****Kate VandenBosch**, Dean and Director**Richard Straub**, Senior Associate Dean**Sarah Pfatteicher**, Associate Dean for Academic Affairs**Rick Lindroth**, Associate Dean for Research**John Schutske**, Associate Dean for Extension and Outreach**Heidi Zoerb**, Assistant Dean for External Relations and Advancement**INTERACTING WITH CALS****Alumni:****Office of External Relations**,
1450 Linden Drive, Madison,
WI 53706
Phone: (608) 262-1461
Email: alumni@cals.wisc.edu
www.cals.wisc.edu/alumni/**Prospective students:****Office of Academic Affairs**, 1450
Linden Drive, Madison, WI 53706
Phone: (608) 262-3003
Email: undergrads@cals.wisc.edu
www.cals.wisc.edu/students/**Business contacts:****Office of Corporate Relations**,
455 Science Drive, Suite 230,
Madison, WI 53711
Phone: (608) 263-2840
Email: inquiries@ocr.wisc.edu
www.ocr.wisc.edu**To make a gift to CALS:****Tera Soltis**, UW Foundation,
1848 University Ave., Madison, WI
53726-4090
Phone: (608) 263-0863
Email: Tera.Soltis@supportuw.org
www.supportuw.org**To contact the magazine:****Grow Editor**, 136 Agricultural Hall,
1450 Linden Drive, Madison, WI 53706
Email: grow@cals.wisc.edu
www.grow.cals.wisc.eduCollege of Agricultural
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News from around the college

To Eat It—Or Not

Biosensors being developed for food products offer a vastly improved indicator of freshness and safety

Food engineer Sundaram Gunasekaran, a professor of biological systems engineering, works with gold. But you won't find the shiny yellow stuff in his lab; instead, the vials on his bench are mostly purple and red. Gunasekaran works with tiny pieces of gold—nanoparticles—that come in almost every color except gold. And those colors can tell a story.

Gunasekaran's research focuses on food safety concerns, such as whether a food product was transported and stored properly or whether it has become contaminated. But how can a producer or consumer easily know a product's history and whether it is safe to eat? That's where gold nanoparticles come in handy.

"The color of gold nanoparticles will change depending on the size and shape of the particle," explains Gunasekaran. "At different temperatures, depending on how long you let the particles grow, they acquire different sizes and shapes. And that changes their colors."

Gunasekaran's lab is using those color changes for a difficult task—tracking the time and temperature history of a food product as it is packaged, transported and stored. Up to now similar sensors have given consumers some of this information, but they can miss such critical events as, for example, a short temperature spike that could be enough to kick-start the growth of a dangerous microorganism.

The sensors that Gunasekaran and his team are developing provide a more complete and accurate story. The new sensor can differentiate between food stored at high temperatures first and low temperatures second versus a product stored first at low temperatures and then at high temperatures. And that's thanks to the properties of the gold nanoparticles. The color of the first sample would be different than that of the second because of how and when the particles changed size and shape.

"We're able to do this because the nanoparticle synthesis is affected by how the particles grow initially versus later," explains Gunasekaran. "We call this the thermal history indicator, or THI."

These gold nanoparticle sensors are being patented through the Wisconsin Alumni Research Foundation (WARF), and students in Gunasekaran's lab won a UW-Madison Discovery to Product award.

The student team also won a People's Choice award in the 2014 Agricultural Innovation Prize competition.

They are now working to further develop and optimize the system. Since different food products travel through different channels, some sensors will be best used to track long-distance travel over the course of a month, while others will track history for only a matter of hours. Some sensors will work best in frozen storage and others will be optimized for various room temperatures.

The goal of optimization is a simple-to-use biosensor customized for any given food product. Gunasekaran envisions the sensors—now being developed as self-adhesive dots or stickers—being used anywhere along the food production channel. Producers, packagers, transporters and even consumers could easily use the biosensors to understand the thermal history of their product, saving time and money and avoiding recalls and health issues.

"There are a number of ways to use this technology, and making a food product's history easy to see is the key," says Gunasekaran. "Food is being wasted because people are throwing it out according to an expiration date, or people are getting sick because they eat food that's gone bad. Those things can be avoided by having a better product safety indicator."

—CAROLINE SCHNEIDER MS'11

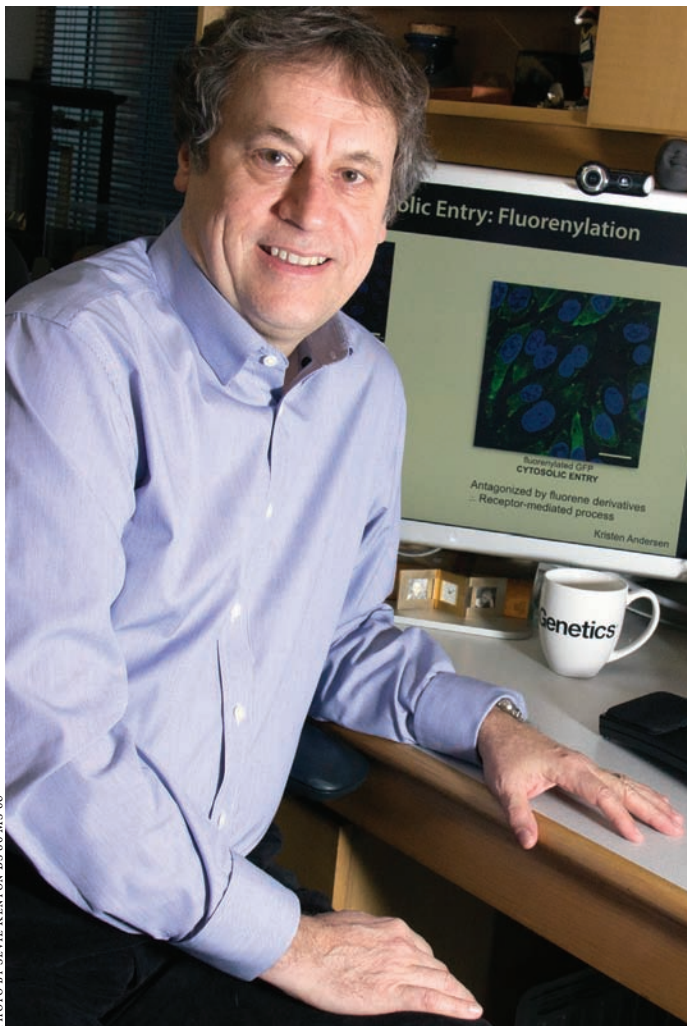


PHOTO BY SEVIE KENYON BS'80 MS'06

Better than an expiration date: Sundaram Gunasekaran's biosensors will help consumers know what's still good to eat.

Stealth Entry

A novel method for replacing defective proteins offers a new way to treat diseases



potential intruders—including uninvited proteins—from entering.

Raines and his team have found a way around this in what amounts to a kind of biochemical calling card. They can attach “decorations,” using what is called an ester bond, to the protein to change its characteristics. The ester bonds link the protein to a “moiety,” a molecule that gives the protein a desired attribute or function.

“Moieties could encourage cell entry, which is one of our major goals,” says Raines. “But moieties could also enhance the movement of the protein in an animal body. Or they could be agents that target the protein, for example, to cancer cells specifically.”

Modifying proteins to give them these attributes has been done using other approaches, but those changes are permanent and can cause problems. The modified protein might not function normally, or the immune system might see the protein as foreign and mount an attack.

Raines’ strategy avoids these problems by using reversible modifications. Because the moieties are added using ester bonds, they are removed once inside a target cell. Naturally occurring enzymes in the cell—called esterases—sever the ester bonds and break off the moieties. What’s left is the normal protein without any decorations. That protein can then do its job.

“We don’t have the problem of damaging the function of the protein or of an immune response because what we ultimately deliver will be the wild-type protein, the protein as it’s naturally found in cells,” explains Raines.

The strategy is promising, and the Wisconsin Alumni Research Foundation (WARF) already has patent applications for it on file. Raines’ lab is now working to make adding the decorations as straightforward and user-friendly as possible. That way, scientists and clinicians could add a moiety of their choosing and get the protein to perform its desired function.

Raines sees innumerable possibilities.

“We’re very excited about this because it has a lot of potential,” he says. “We can now decorate proteins reversibly with pretty much any molecule you can imagine. We are exploring the possibilities to try to bring something closer to the clinic.”

—CAROLINE SCHNEIDER MS’11

Going straight to the proteins: Ron Raines’ new technology promises a breakthrough in treating diseases.

Many human diseases—including cancer—are caused by protein malfunctions. Those malfunctions, in turn, are caused by damaged DNA that gets translated into the damaged proteins. While many clinicians and scientists are trying to treat those diseases by fixing the DNA, Ron Raines is taking a different approach—he’s looking to replace the proteins directly.

“Our strategy is to do gene therapy without the genes,” explains Raines, a professor of biochemistry. “We want to skip the genes and go right to the proteins.”

The strategy is intriguing, but there’s a problem. Proteins have a hard time getting into cells where they would do their work. The lipid bilayer of a cell membrane serves as a barrier that keeps the inside of the cell in and the outside out. That membrane stops

The MBA of Dairy

A CALS partner program trains aspiring—and much-needed—farmers

The average age of a Wisconsin farmer is over 56 and rising, and the state has been losing around 500 dairy farms per year. It's no surprise, then, that experts say it's critical to prepare young people to step into farm roles in order to keep the state's \$88 billion agricultural economy strong into the future.

But making the transition into dairy farming is complicated, and aspiring farmers often don't have the capital or the experience to take over an established operation.

Enter the Dairy Grazing Apprenticeship (DGA) program, which is working to address the issue by providing support for young people interested in becoming dairy farmers. Started in 2010, the first-of-its-kind program is administered by the Wisconsin-based nonprofit GrassWorks, Inc., with CALS as a key partner.

Earlier this year, DGA received \$750,000 from the U.S. Department of Agriculture's Beginning Farmer and Rancher Development Program. The funding will enable organizers to improve and expand the program in Wisconsin, as well as explore the possibility of rolling it out to other dairy states.

"It's a meat-and-potatoes program that really takes people up to the level where they can own and operate their own dairy," says DGA director Joe Tomandl. "It's the MBA of dairy."

Program participants complete 4,000 hours of paid training over two years, most of it alongside experienced dairy farmers, and work their way up from apprentices to Journey Dairy Graziers and Master Dairy Graziers. Although most of that time is spent in on-the-job training, there's also a significant requirement for related instruction. That's where CALS comes in.

As part of the program, apprentices attend a seminar about pasture-based dairy and livestock through the Wisconsin School for Beginning Dairy and Livestock Farmers (WSBDF), which is co-sponsored by the CALS-based Center for Integrated Agricultural Systems and the Farm and Industry Short Course. The seminar involves a 32-hour commitment, which is generally fulfilled through distance education and includes instruction from CALS professors from dairy, animal and soil sciences.

"We believe in the Wisconsin Idea and want to make sure our classes are accessible to people who want more education, but preferably close to where they live and work," says Nadia Alber, a WSBDF outreach coordinator who helps organize the seminar and also serves on the DGA board.

In 2009, GrassWorks, Inc. turned to WSBDF director Dick Cates PhD'83 for guidance and access to a well-respected educational curriculum to help get the DGA up and running—and the WSBDF team has been involved ever since.

"We were just this little nonprofit with a very small budget trying to compete for a big federal grant," says Tomandl. "For us, it was important to have UW–Madison as a strategic partner."

As part of the most recent round of funding, DGA's partners at CALS will lead an effort to quantify the program's broader impacts.

"They have already proven that participants are moving along to their own farms after the apprenticeship, so they have an established track record," says Alber. "This new study will look at some of the program's other impacts, including economic, environmental and social."

—NICOLE MILLER MS'06

For more information, visit dairygrazingapprenticeship.org



PHOTO BY SEVIE KENTON BS'80 MS'06

Let them eat grass: Grazing apprenticeships help ease the way into dairy farming.

Second Life for Phosphorus

Soil science professor and students turn a sometime pollutant into a valuable product

Phosphorus, a nutrient required for growing crops, finds its way from farm fields to our food and eventually to our wastewater treatment plants. At the plants, the nutrient causes major problems, building up in pipes or going on to pollute surface waters.

But soil science professor Phil Barak has an idea about how to retrieve the nutrient from wastewater in a valuable form—and it started from a basic lab experiment. “I was doing some work on crystallizing phosphorus, just out of pure academic interest,” explains Barak. “That led me to crystallize a mineral

called struvite. Then I realized it was forming in wastewater treatment plants as a nuisance.”

If he could form crystals in the lab, he reasoned, why couldn’t it be done in the wastewater treatment plants in a controlled way? It could. And, even better, if he collected the phosphorus early on in the treatment process in the form of a mineral called brushite, he could harvest even more of it.

Beyond removing phosphorus from wastewater, brushite can serve as a nutrient source for growers. While Barak will do further testing to prove its utility, brushite is a phosphate mineral that’s actually been found in agricultural fields for years.

“When conventional phosphorus fertilizers are added to soil, brushite forms. I maintain that we’ve been fertilizing with brushite for decades, but nobody’s been paying attention to it,” says Barak.

Being able to remove phosphorus from wastewater and supply it back to growers is a win-win situation, Barak notes. “We’re collecting phosphorus where it’s localized, at really high concentrations, which is the most economical place to collect it,” says Barak. “This works out in just about every dimension you can consider, from the treatment plants to the cost of recycling phosphorus as opposed to mining it new.”

Graduate students in Barak’s lab suggested that he commercialize the technology and start a company. After the Wisconsin Alumni Research Foundation (WARF) passed on the patent, Barak and his students sought help from the UW Law and Entrepreneurship Clinic. They received two federal Small Business Innovative Research grants, and, with some additional funds from the state, including the Wisconsin Economic Development Corporation, their efforts have turned into a spinoff company: Nutrient Recovery & Upcycling, LLC (NRU).

The company’s next step was a big one. This past spring a phosphorus recovery pilot plant was implemented in a wastewater treatment plant in Illinois. The pilot project will test the research ideas on a larger scale.

Additionally, the NRU team will participate in the Milwaukee Metropolitan Sewerage District’s granting system to determine if a pilot project would be a good fit in Milwaukee. They hope to start collecting and analyzing data from Illinois by September, using that pilot system to lay the groundwork for others in Milwaukee and beyond.



Brushite bounty: Phil Barak displays brushite produced during trials at the Nine Springs Wastewater Treatment Plant of the Madison Metropolitan Sewerage District. Each jar contains brushite harvested from 30 gallons of anaerobic digest.

—CAROLINE SCHNEIDER MS'11

UGANDA



The Benefits of Biogas

Generating enthusiasm for a new kind of technology is key to its long-term success. Rebecca Larson, a CALS professor of biological systems engineering, has already accomplished that goal in Uganda, where students at an elementary school in Lweeza excitedly yell “Biogas! Biogas!” after learning about anaerobic digester systems.

Larson, a UW–Extension biowaste specialist and an expert in agricultural manure management, designs, installs and upgrades small-scale anaerobic digester (AD) systems in developing countries. Her projects are funded by the Wisconsin Energy Institute at UW–Madison and several other sources. Community education and outreach at schools and other installation sites are an important part of these efforts.

Children get excited by the “magic” in her work, she says. “It’s converting something with such a negative connotation as manure into something positive,” Larson notes. In an AD system, this magic is performed by bacteria that break down manure and other organic waste in the absence of oxygen.

The resulting biogas, a form of energy composed of methane and carbon dioxide, can be used directly for cooking, lighting, or heating a building, or it can fuel an engine generator to produce electricity.

Larson’s collaborators in Uganda include Sarah Stefanos and Aleia McCord, graduate students at the Nelson Institute for Environmental Studies who joined forces with fellow students at Makerere University in Kampala to start a company called Waste 2 Energy Ltd.

Along with another company, Green Heat Uganda, which has built a total of 42 digesters, Waste 2 Energy has helped install four AD systems since 2011.

“Most of these digesters are locally built underground dome systems at schools and orphanages,” Larson explains. Lweeza’s elementary school is a perfect example.

The AD systems use food waste, human waste from pit latrines and everything in between. The biogas generated by the digester is run through a pipeline to a kitchen stove where the children’s meals are prepared. Compared to traditional charcoal cooking, the AD systems greatly reduce the school’s greenhouse gas emissions.



PHOTOS COURTESY OF REBECCA LARSON

Larson and her team are now focusing on enhancing the efficiency and environmental benefits of these systems. Their goals are to improve the digester’s management of human waste, reduce its water needs, increase the amount of energy it produces and generate cheap fertilizer to boost food crop yields.

“Our overall goal is to create a closed-loop and low-cost sustainability package that addresses multiple local user needs,” Larson says.

The beauty of the project is that all these needs can be met by simply adding two new components to the existing systems: heating elements and a solid-liquid separator.

To help visualize the impact of the fertilizer, Larson set up demonstration plots that compare crop yields with and without it. Down the road, a generator could be added to the system to provide electricity in a country where only 9 percent of the population currently has access.

As a next step, Larson hopes to replicate the project’s success in Bolivia. She is finalizing local design plans with Horacio Aguirre-Villegas, her postdoctoral fellow in biological systems engineering, and their collaborators at the Universidad Amazonica de Pando in Cobija.

—SILKE SCHMIDT



(Top) An anaerobic digester under construction in Lweeza, Uganda.

(Above) Rebecca Larson (second from left) with colleagues. No one is disturbed by those rhinos in the background.

classAct

Keven Stonewall Taking on Cancer



PHOTO BY JOAN FISCHER

Some researchers first find success late in their careers. And then there's Keven Stonewall.

Now a rising junior majoring in biology, Stonewall made news with research he did while still in high school. A headline in the *New York Daily News* declared, "Meet the Chicago Teen Who May Cure Colon Cancer."

Stonewall's research, which he conducted

as an intern at Rush University while he was a senior at the Chicago High School for Agricultural Sciences, revealed that an experimental colon cancer vaccine effective in younger mice did not work in older mice. Stonewall won numerous awards for his work and was selected as a finalist for the Intel International Science and Engineer Fair in 2013.

Stonewall, the child of two public school teachers, had always loved science, but while in high school, a close friend's painful experience losing an uncle to colon cancer made Stonewall determined to fight the disease. "It motivated me to say, 'Enough is enough, I want to step up and do something about it,'" he says.

More recently Stonewall's interest has moved toward curing cancer in children. He spent his sophomore year as a student researcher in the lab of Christian Capitini, a pediatric oncologist with the UW-Madison School of Medicine and Public Health. There he worked with mice to study the use of natural killer cells to treat neuroblastoma, a cancer frequently seen in children.

"He has a very advanced understanding of immunology and the immune system," Capitini says of Stonewall. "He understood the concepts of the project from the beginning, so he could get his hands dirty a lot faster than the typical student."

And this summer he's interning with AbbVie, a research-based biopharmaceutical company, at its North Chicago headquarters.

Stonewall is in cancer research for the long haul, and he wants to pursue it as a physician. "My goal is to go to medical school, and I am thinking of going into pediatric oncology afterward," he says.

—JOAN FISCHER

APPOINTED chair of the Laboratory of Genetics, genetics professor **John Doebley**, taking over from longtime leader **Michael Culbertson**, now retired. The laboratory includes the School of Medicine and Public Health's Department of Medical Genetics and the CALS Department of Genetics.

SELECTED for a UW-Madison Entrepreneurial Achievement Award, animal sciences professor **Mark Cook**, for turning his research and 20 patented technologies into start-up companies. Cook's patents include a technology that improves animal growth and feed efficiency, around which he founded successful spinoff Aova Technologies in 2001. Cook also co-founded Isomark LLC, for the early detection of infectious disease using biomarkers in breath.

NAMED a Fellow of the American Statistical Association, **Jun Zhu**, a professor with appointments in entomology and statistics. The honor was granted based on her outstanding contributions to the statistical profession.

HONORED by the American Meat Science Association, meat science professors **Jim Claus** (with the Distinguished Teaching Award) and **Jeff Sindelar** (with the Distinguished Extension Industry Award).

AWARDED by the American Society for Nutrition, **Denise Ney**, Billings-Bascom Professor in Nutrition. Ney received the Mary Swartz Rose Senior Investigator Award, which recognizes outstanding research on bioactive compounds and their safety and efficacy for human health.

WINNERS of Forward under 40 awards from the Wisconsin Alumni Association, CALS alums **Jay Blasi BS'00**, a golf course architect, and medical microbiologist **Omai Garner BS'01**. After a stint with Robert Trent Jones II, Blasi started his own firm and now has projects all over the country. And when Garner is not busy in the lab, he's helping other young men of color achieve success as co-founder of the California-based nonprofit Social Justice Learning Institute. Learn more about them and other recipients at <http://go.wisc.edu/forward40>.

Number Crunching

100 PATENT APPLICATIONS

have now been filed by the Great Lakes Bioenergy Research Center (GLBRC) since its founding at UW-Madison in 2007. The patents represent a range of discoveries in support of producing biofuels and chemicals from the nonedible, or cellulosic, portion of plants. A number of them come from CALS-based researchers like biochemistry professor John Ralph, who with colleagues engineered poplar trees with modified plant walls (see photo) that make them easier to degrade for conversion to fuel.

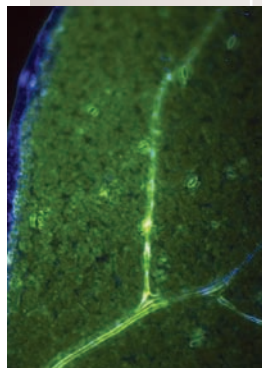


Photo courtesy of Dr. Ji-Young Park and Dr. Shawn Mansfield, UBC

Five things everyone should know about . . .

Unmanned Aerial Vehicles (aka “Drones”) in Agriculture

By Brian Luck

1 | Agriculture is poised to become the biggest market for unmanned aerial vehicles (UAVs). Up to 80 percent of the commercial market for UAVs will eventually be for agricultural uses, predicts the Association for Unmanned Vehicle Systems International. Industry analysts expect more than 100,000 jobs to be created and nearly half a billion dollars in tax revenue to be generated collectively by 2025, much of it from agriculture.

2 | UAVs have great potential use in monitoring crop health. During the growing season, producers spend time and resources scouting crops to identify issues that might impact growth or yield. Such monitoring is done mostly through manned planes, satellites—or, very often, a good old-fashioned walk through the field. But data collected through these methods can take a long time to process, making it hard for farmers to address problems in a timely, cost-effective manner. UAVs can allow producers to cover and analyze a greater area in more detail and in less time.

3 | Ag UAVs can be loaded with game-changing technology. UAVs may be equipped with infrared cameras, vegetative indices sensors and other technology, collecting all manner of relevant data (presence of insects or disease, amount of water or dryness, location of livestock). Farmers also can use UAVs to tailor their use of such inputs as pesticides or fertilizer based on how much is needed at a specific point in a field, a process known as variable rate application. This practice can save the grower money while maintaining yield and also reducing the amount of potential runoff into nearby streams or lakes.

4 | But simpler and less expensive models can be very helpful as well. Utilizing a UAV with a visible light camera (what we use for normal pictures and/or video) can give producers a bird’s-eye view of what is happening in their fields. Anomalies such as color variations in the crop canopy, winter kill areas and animal damage can be seen from the air. Once identified, these damaged areas can be verified on the ground more easily.

5 | Wisconsin UAV interest is high. Most grower and commodity group presentations I have given with UW–Extension in the past year have been about UAVs and their uses. From the perspective of crop management and spatial variation management, our ability to collect data has been somewhat limited to the beginning of the growing season (spring soil sampling, for example) and the end of the growing season (yield monitoring). Any further data collection would require walking the field or extra passes over the field with equipment. UAVs have the potential to allow us to collect data about the health of the crop over the entire growing season.

Brian Luck is a CALS assistant professor of Biological Systems Engineering and a Machinery Systems/Precision Agriculture educator with UW–Extension. His UAV research focuses on applied uses of current UAV technology for production agriculture.



PHOTO BY SEVIE KENYON BS'80 MS'06

Brian Luck demonstrates use of a UAV, something he's doing a lot for farmers and other groups around the state.

For the Love of Plants

Students from all backgrounds are invited to a class that explores, questions and celebrates our connections to the vegetable kingdom.

Interview by Claudia Roen BS'15

IRWIN GOLDMAN PhD'91, professor and chair of the Department of Horticulture, is an eminent researcher in vegetable breeding and genetics, with a particular interest in carrot, onion and table beet. His lab has bred numerous cultivars that have been used to make commercial hybrids grown by farmers all around the world. He and his laboratory currently hold more than 75 active germplasm licenses, some of which are handled through the Wisconsin Alumni Research Foundation.

But in spite of Goldman's prowess in both research and administration—he has served CALS as an associate dean and a vice dean, and as interim dean some five years ago—teaching remains one of his greatest passions. “Our most important job in serving the public is to make sure our students can obtain what they came to the university to get: a top-notch education,” says Goldman. “I see this as one of the primary reasons for being placed here by the people of Wisconsin.” He brings that devotion to the many kinds of students he teaches: from the graduate students under his research wing and the horticulture majors he advises to undergraduates and other learners who may not be science majors at all.

And students clearly benefit from his dedication. Claudia Roen BS'15, until recently a student assistant in the CALS communication office, was a senior biology major last fall when she took Goldman's class, “Plants and Human Wellbeing.” She found it so enlightening that she was moved to conduct the following interview to learn more about both a fascinating subject—and what excites Goldman about teaching it.

What inspired you to teach Plants and Human Wellbeing?

I have been desperate to teach this class for probably 10 years, and I love this material, but it hadn't previously fit into any of the courses I was teaching. I remember very clearly one January day over winter break sitting at my dining room table reading about the spice trade—and thinking, if I don't just say I'm going to do this and put this class together, it won't happen.

At that moment I began to write a syllabus and presented it to the department with the hope of teaching it the following fall. That was a few Januarys ago.

What do you hope students will take away from this course?

The whole point is connecting to plants and plant-derived materials and asking, where does this come from? How does it serve us? It's a way of thinking about the world. If you approach the world that way, it's part of being an educated person.

For example, one topic covered in the course is aspirin. There are natural compounds in plants that serendipitously have these health-improving effects on humans. What did we do with that information? There's an industry created around it, and what does that look like? We can apply these questions to a number of plants used in pharmaceuticals.

Or in another lecture we discussed the tale of Johnny Appleseed and the history of the apple in America. Afterward we sampled more than a dozen apple varieties. Partly it's a gimmick, but for people who have only ever eaten a Red Delicious, it may be surprising to try something very different.

When I was 18 or 19 I lacked exposure to a lot of things. One of my professors brought in mate. In Argentina it's like drinking coffee, but to me at the time, it was so exotic. I feel that if I can supplement the lessons with things to eat, things to try and taste, I can provide some exposure to the diversity of what's out there.

Have you found that there is one topic in particular that seems to excite or engage the students?

The treatment of human beings in the production of food that we consider to be delicacies is probably the most important to them, and it's the single most recurring topic that students write about in their reflection papers. And that's a good sign—the fact that they have begun to think critically about food production in ways that may change their behavior or make them think differently about the world.



PHOTO BY SEVIE KENTON BS80 MS06

A good example is the lecture on chocolate, which I think for many students is the first time they had heard about chocolate production and the negative working conditions, essentially slavery, associated with it. It is remarkable to listen to a worker from the cacao plantations who toils all day to produce chocolate for the Western world but who has never tasted chocolate. We discussed chocolate cultivation and its importance in our society, sampled several varieties of chocolate, and watched a video that featured cocoa farmers in the Ivory Coast—which produces more cocoa than any country in the world—tasting chocolate for the first time after a lifetime of harvesting the crop.

Has teaching the class provided any surprising or unexpected lessons?

Regarding students, probably the most surprising thing for me is the tenderness—and I have to use that word—that people feel for plant materials. When you get them alone or uninhibited, it brings them to tears. At the end of the semester students are asked to present to the class something they've made from plant materials. Students have presented food, musical instruments, body lotions and more. They are deeply connected to certain things, and that comes across when they're talking about something that is important to them, some dish that their mother makes. There's something there that is very profound.

What kinds of students take the course?

I've had students from a wide range of backgrounds. People from Letters and Science, people from all over campus and beyond. I've had a handful of returning adult students, and I also had some senior auditors who were taking it because they thought it was an interesting subject that they could sit in on. It was a much wider array of students than I would typically have in a normal horticulture class.

People connect to this subject in different ways. Some people are interested in aromatherapy, or they're interested in gardens—it's a catch-all for all things that connect to plant materials.


How do you see this course as a reflection of the goals and the values of CALS?

A big part of our college's mission has always been to make science and scientific knowledge accessible to a broad audience, and this course certainly accomplishes that. No prerequisites are required; it's open to anyone who wants to explore the topic. Obviously a deeper understanding of how food is made and where it comes from is an integral part of CALS. CALS contains the whole spectrum, from the soil that we grow things in all the way to policy and legislation around food and everything in between—the genetics and the biochemistry involved in breeding and growing. I love that about CALS.

And the connection between plants and human wellbeing is a recurring theme across that spectrum. What we study and teach in CALS often connects to outcomes that impact humans, and one of the most fundamental impacts we should consider is their wellbeing. In fact, I find that it may often guide some of our most important projects.

What are your hopes for the course, and where do you see it headed?

Up to now the course has been listed as a 375, meaning it's an experimental course. When I presented the idea to the Department of Horticulture, I pledged to teach it for two years as an experimental course and if it worked out, I'd ask to make it a permanent number. Now I'm pleased to say that this course has been given the permanent number Horticulture 350, and it will be taught every fall semester.

Ultimately, I would like to make it available online or through some other medium—as a MOOC, perhaps—because I do think students and a wide range of other learners could get something out of this even if they weren't in the room. I want to make it available to as many people as possible. 



The Fox, the Coyote—and

Growing populations of these animals on campus and in the city have inspired a new



PHOTO BY E. ARTI WULANDARI

Life is good here:
A fox family on campus last year.

Once upon a time during the last few years, a red-haired girl new to the University of Wisconsin–Madison crested Bascom Hill and cast her eyes upon the cozy arrangement of buildings and lawns, the tree-lined city by the fair lake. Her nature and upbringing led her to think: *Yes, this is good. I should meet the right boy here. I hope the food is good.*

The UW–Madison campus is a well-worn locale for such scouting. Last year 31,676 prospective students scoped out dorms and classrooms. Hundreds of elite athletes measured the environment against their precise needs. Thousands more informal visits were made, all driven by the same question: Can I thrive here?

But our young visitor is in a new class altogether—wild members of the canid clan. As it happens, their food is quite good, and she—technically a vixen, or female fox—did find the right dog. After spending a winter holed up under Van Hise Hall, she gave birth to a litter of eight, and in early March of 2014 began to let the young kits gambol about.

They were a campus sensation—stopping lectures, cars and buses, inspiring a popular Tumblr blog, drawing hundreds of rapt spectators. Their appearance provided a fortuitous teachable moment for David Drake, a professor of forest and wildlife ecology and a UW–Extension wildlife specialist, who was just beginning to delve deeper into studying the foxes and coyotes of Madison.

We Badgers

study aimed at living better together

By Erik Ness



(Left) Researchers found this adult male coyote waiting patiently in his restraint this past winter.

(Right) Wildlife ecologist David Drake, standing, and graduate student Marcus Mueller in the field, setting and checking cable restraints.

Coyotes have been intermittent, if secretive, Madisonians for more than a decade. In the last few years reports of coyotes by visitors to Picnic Point have been rising, and people from the Lakeshore Nature Preserve asked Drake if he could investigate. But the rise of the urban fox population is a relatively new canine twist.

"It's very timely," says Dan Hirschert, urban wildlife specialist with the Wisconsin Department of Natural Resources. While no comprehensive data have been collected, from where he sits foxes and coyotes are gaining throughout the state. And while the coyotes have been present for a couple of decades, the fortunes of the fox seem to be following the rise in urban chicken rearing.

Because most wildlife research happens in rural areas, we may not know as much as we think about our new neighbors. "Does what we've learned about these animals in the wild apply in urbanized settings?" asks Drake. Most major cities employ a forester, but very few cities have a wildlife biologist on staff. Much more common is the pest management paradigm: animal control.

"It doesn't make any sense to me," Drake says. "If 85 percent of Americans live in cities, why aren't we doing more? That's where people are interacting with wildlife."

These questions prompted Drake to found the UW Urban Canid Project, a hyperlocal study with far-reaching implications.

"The number of urban canid sightings on campus, primarily red fox and coyote, have been on the rise and have been met with mixed emotions

from all different members of society," notes Drake. "This research aims to understand more about the complex interactions between coyotes, foxes and humans in this urban area—as well as provide information and resources for residents to reduce the potential for conflict with these amazing creatures."

As morning light seeped into a cold January dawn, David Drake and his grad student Marcus Mueller prepared to lead a small convoy from Russell Labs, winding toward the wild corners of campus to check 18 restraint traps that had been set the evening before.

"Are you feeling lucky today?" Drake asks, climbing into the truck.

"Always," says Mueller.

"I had a hard time getting to sleep last night," says Drake. "This is like the anticipation of Christmas morning. Every day you go out to see if you caught something."

First stop is the old Barley and Malt Laboratory, between the retaining wall of University Avenue and the physical plant. It hardly seemed like habitat, but Mueller traced a clear track laid down by the repeated passage of many small feet. The animals were using the buildings for cover, in transit to someplace else.

Drake is hopeful—he'd already seen a fox at 5:20 a.m. on the football practice field. "They were running through Breese Terrace all last year," he says. At least one fox was digging in an area under the west side bleachers of Camp Randall for a possible den, notes Drake, but no kits were ever seen there. "It is funny to find these spaces on campus

that the animals are using," says Drake. "I ride my bike by here every day and never really thought about it."

And in one of the three traps an annoyed raccoon waits impatiently. Donning protective gloves, Drake and Mueller release the coon, who scuttles away, anxious for cover.

Next stop is a small cattail marsh next to Willow Beach, behind the new Dejepe Residence Hall. The day before, Drake and Mueller had baited the marsh with parts of a deer carcass. On the short trail we flush an eagle from its perch, perhaps planning its own morning snack of carrion.

This little ecological pocket typifies the habitat opportunities that fox and coyote are exploiting. It's not big enough to call home, or even to get a regular meal. But link it together with dozens of other nooks and crannies and dumpsters around campus, and the sum total is a complex and productive niche.

Fox and coyote are urban adapters: flexible enough to range across a variety of landscapes, from rural to urban. For animals to survive in a city, they typically need to be this kind of habitat generalist, able to exploit a range of hunting and scavenging environments.

The other part of the equation is habituation—how animals get accustomed to human activities. As a species moves into the city, those who survive realize over time that bad things don't necessarily happen when they encounter humans. Instead of running at the first sign of people, they sit and watch. This knowledge gets passed down from mother to pup, eventually leading to the Van Hise foxes romping in full view of adoring crowds.

The restraints behind Dejepe are set for fox, and this morning there is nothing. Drake looks around and connects the dots in the surrounding environment. West across the ice is University Bay Marsh, where four more restraints await. A few ticks to the north is Picnic Point, and the lake beyond.



The last traps of the day are located in the Biocore Prairie, where the research began when a few trail cams confirmed that a group of coyotes were ranging through the preserve, and probably enjoying the fruits of the Eagle Heights gardens as well.

Drake hopes to learn how urban agriculture is influencing canid behavior. Backyard vegetable gardening is flourishing, and each year more city dwellers add chicken coops to their homesteads.

The chickens are an obvious attraction—chickens have probably been preferred canid targets since even before their domestication. Gardens also attract the small mammals that canids prefer. They will even snack on berries and vegetables.

Last year Drake secured four radio collars—two for each species—and, with the assistance of Lodi trapper Mike Schmelling, researchers were able to collar a pair of coyotes and one fox. Among the first discoveries was that the animals are running the frozen lake. The researchers learned this when one collared coyote disappeared. At first they suspected a malfunction, but a citizen report led them to Maple Bluff, where they reestablished radio contact. The coyote had apparently run all the way across the lake, possibly snacking on ice-fishing gut piles along the way. Another ran north and was killed by a car on County M, near Governor Nelson Park.

This year the research hits full speed, with 30 fox collars and 30 coyote collars available. The ambitious work plan includes collaring an entire fox family, kits and all.

And in the snow-covered landscape of the Biocore Prairie, the first glimpse of the third restraint trap offers a rush of hope. The area around the restraint is beaten up, with dark leaves interrupting the white. An animal was clearly held at some point, but all that's left is a bit of hair and a kinked and ruined cable.

Back in the truck, Drake teases Mueller. “Marcus, I don’t have a good feeling about your luck.”

“Not yet, anyway.”

“You’re not an unlucky person, are you?”

“I hope not.”

“Because I have fired more than one graduate student for being unlucky . . .”

It's just as dark and even colder the next morning, yet the party adds an undergraduate wildlife ecology student, Cody Lane, and Laura Wyatt MS'87, a program manager with the Lakeshore Nature Preserve. John Olson, a furbearer biologist for the DNR, is in town, and has come to check out the project before putting in a day of lab work.

Behind the Barley and Malt Laboratory, Olson kneels down to evaluate the tradecraft of the empty

restraint—a simple loop of airline cable noose suspended from a dark length of stiff wire. “They don’t even see these as traps. They see them as sticks,” Olson explains. These unique cable restraint traps were named and developed with DNR assistance as part of a national humane trap research program in the early 2000s. “The important thing with these kinds of sets is non-entanglement,” he says. The radius of the multistrand wire must be clear of any potential snags. The size of the loop is determined by the animal you’re selecting, while a stopper keeps it from getting too tight. It works much like a choker collar.

During testing they trapped just over 200 coyotes, and only two died. One had a bad case of mange and died of exposure. The other was shot by someone who didn’t realize the animal was restrained. “It’s a very safe tool,” Olson says. “Cable restraints never damaged any coyotes in the three years that we studied them.”

The convoy moved on to Willow Beach—and, finally, success. A young male fox waits suspiciously, huddled in the reeds. The wind probes at his deep winter coat while the party retreats and summons Michael Maroney BS'85, a veterinarian with the UW-Madison Research Animal Resources Center.

Together Mueller and Maroney estimate the fox’s weight at 12 pounds, and draw a mix of ketamine and xylazine.

Veterinarian Michael Maroney draws a blood sample from a sedated fox, one of several measurements he'll take before the animal is radio-collared and released.

Mueller secures the animal with a catch pole while Maroney injects the cocktail into the rear leg muscle, provoking an accusing glare from the fox. The clock starts. Within six minutes Maroney looks at Mueller and announces: "He's clearly gorked."

Everybody laughs at the non-technical yet thoroughly accurate terminology, and the work begins. They figure they have about 40 minutes. Laying the animal out on a white towel atop a blue tarp, Mueller secures a cordura muzzle, then pulls out electric clippers and shaves one dark foreleg to make it easier to find a vein. Maroney watches his technique while the undergraduate Lane records data.

The fox breathes steadily, and the three talk quietly, as if he were only asleep. Without the wind ruffling his coat, the fox seems smaller, more vulnerable. After the blood draw, nasal and fecal swabs are taken, and the mouth examined. Finally, they weigh the animal—a sturdy 13.5 pounds—and affix the radio collar.

Removing the muzzle, they carry him away from an opening in the marsh ice—a gorked animal doesn't always behave rationally—and lay him out again on the tarp, out of the wind. A few minutes later and a dark ear twitches, as if to displace a fly. A few more minutes, and the ear twitches pick up. Suddenly the fox stands up shakily, and surveys the audience of onlookers. He quickly takes cover in the marsh, where he gathers his wits for a few more minutes, then slips from view.

Mueller and Drake are giddy, ebullient. "We are off and running," says Drake. "That was pretty cool." Last year it took forever to catch a fox; this year they begin with one. "Great start," says Mueller, and then recounts the steps to himself in a low voice, as if to help remember: the sedation, the blood draws, the recovery.



PHOTOS BY JEFF MILLER/UW-MADISON COMMUNICATIONS

Mary Rice first saw the coyote in her backyard sometime in the summer of 2012. It was getting dark, and first she wondered, "Whose dog is that?", followed quickly by: "Oh, my god, a coyote."

"We were a little alarmed," she says.

Rice canvassed the neighbors, warning them there was "a coyote lurking" about. Some didn't know, others did, and some even thought they'd seen wolves. She was wondering how to deal with it, who to call, when she saw another one, smaller. "Remove one, there will be another," she realized.

A graduate coordinator in the Department of Food Science, Rice remained somewhat unsettled for a few months, worrying about her cats and unsure about her own safety. Then one day at work she learned about Drake's UW Urban Canid Project and decided to give them a call.

"Can you try to track it and figure out what it's doing here?" she asked. "We can hopefully live with it. If we're not going to be able to remove it, maybe we can learn from it and learn how to live among them."

Before long, with the cooperation of another neighbor, a restraint trap was set. This was Mueller's first solo set: he decided where to put it, and configured and camouflaged it. Within a week, in early March they had a 36-pound male coyote who had been cutting behind a brush pile. On her way to work, Rice stopped to see the animal and help the team record its vitals. She couldn't wait to tell her coworkers why she was late.

Rice's coyote experience is a perfect example of how the project can work,

says Drake, with outreach engaging members of the public and connecting them with scientists in the field. On most trap-checking mornings Drake's team has company—each day a new handful of visitors. Sometimes they're wildlife students or other friends of the program, but often they're just curious early risers who follow the group's progress on social media.

And with hundreds of followers on Facebook and Twitter, public fascination is strong. Because of our strong cultural connection to dogs, our affinity may even be a little hardwired. From Wile E. Coyote and fox or coyote tricksters in folklore to the Fantastic Mr. Fox, these are animals we all know on some level, however mythic.

Still, fox and coyote don't get quite the same reception. The fox is easy to anthropomorphize. It's small, cute and generally non-threatening. Coyotes aren't typically seen as often, and your first thought can be, like that of Mary Rice: Whoa, that's a pretty big animal.

"Just because you see a coyote doesn't mean it's a bad animal, and doesn't mean it's going to create problems for you or that you should be afraid of it," says Drake. The key is to not create, or exaggerate, a conflict. And that's almost always about food. It's important to secure bird feeders and outside pet food, and to take care with pets out of doors. If the coyotes become too bold, make an effort to scare the animals away. "We're really trying to help people to understand how wonderful it is to have these animals here, but also to be vigilant," Drake says.



Marcus Mueller gently relocates the still-sedated fox to a more sheltered area near the Lakeshore Nature Preserve on campus.

“Are you nocturnal yet?”

I ask Mueller as I climb into a white UW van at 9 p.m. in early March. He laughs—it won’t be long now. As soon as early-morning trap checks are done, he’ll be swinging full-time on the second shift. These dogs are nocturnal, and if you want to learn where they are at night, you’ve got to get out there with the radio tracker.

The research plan calls for tracking each animal at least once a week. Some nights it’s boring, and Mueller catches naps between hourly triangulations. But the newly collared fox has been a real challenge. He was tracked one night moving from south of Fish Hatchery Road and Park Street all the way up to John Nolen Drive, where he spent time on frozen Monona Bay and eventually made it to Muir Woods on campus. That’s about four miles as the crow flies—never mind the urban labyrinth he had to navigate between those points. He did all that traveling within a five-hour period. “It truly was a game of cat and mouse trying to keep up with him that night,” says Mueller. Is he a young transient who hasn’t yet established a home range? Is he trying to find a mate? Or can home ranges for urban foxes really be that big?

Some nights Mueller can track only one animal, but on others they are close to each other. On one recent night the fox and the coyotes were all on campus, just a short distance from each other. “I was flying all over campus,” says Mueller. “It was a crazy night of telemetry.”

It was a perfect scenario for answering a really big question. In wilder terrain foxes and coyotes are mutually

exclusive, but Madison is different. “We know from the animals we’ve got on radio that the fox and the coyote are sharing the same space, and sometimes they are sharing the same space at the same time,” says Drake. “They are cross-ing paths.”

Are the foxes using humans and elements of our built environment to protect themselves from coyotes? Or are there simply enough resources that they don’t have to compete as strictly—more rabbits and squirrels, more compost piles and chicken coops?

The scientists are a long way from answering those questions. First they need to relocate the coyote.

Mueller parks around the corner from Mary Rice’s house in a residential pocket south of the Beltline and raises the antenna, a three-element Yagi that looks like a refugee from the old days of analog TV.

The first reading comes from the west, and from the strength of it Mueller guesses we’re a mile or more away. Crossing back over the Beltline, a little under a mile as the crow flies, and another reading: now the signal’s coming from the east. Another three-quarters of a mile into a dead-end parking lot, and the signal is now east and south. But back over the Beltline.

In quarter-mile and half-mile increments Mueller is in and out of the van, swinging the antenna around, squawk box to his ear, taking compass readings.

After a few more readings he final-izes the coyote’s location in a small wet-land not far from one of the many bike paths that probe south from the city. He stayed put until 2 a.m., when Mueller called it a night.

“I can’t wait,” says Mueller, think-ing ahead 12 months, when he’s got hundreds of hours of data plotted on a map and can begin to see patterns. “The underlying goal of this project is to be able to coexist with these animals more effectively, to avoid conflicts,” he says. “We don’t want to have to remove coyotes from a population because they are too habituated to people.”

As a summer job during college, Mueller used to take calls at a wildlife rehab center in Milwaukee. “A lot of times people just don’t know much about the ecology and life history of these animals, and that lack of under-standing leads to fear,” he says. One call in particular stuck with him, a man worried about a turkey walking around in Milwaukee. “He said, ‘You’ve got to take it back to nature. It’s not supposed to be here,’” Mueller remembers. But the turkey had already redefined nature—and so have coyotes and foxes and deer and raccoons and . . .

“Cities aren’t going anywhere,” says Mueller. “And the way that these animals are adapting, I think it’s only going to allow for more animals to continue this trend.” 📷

PHOTO BY E. ARTI WULANDARI



Keep up on all the latest information from the UW Urban Canid Project on Facebook and on Twitter: @UWCanidProject. If you have any ques-tions, or are interested in observing or volunteering, please email: uwurbancanidproject@gmail.com. To see more campus fox photos by E. Arti Wulandari, visit: <http://go.wisc.edu/campusfoxes>.





Plant Prowess

CALS scientists from a wide range of disciplines help forge the future of a growing field

By Nicole Miller MS'06

It may look jury-rigged, but it's cutting-edge science.

In a back room in the university's Seeds Building, researchers scan ears of corn—three at a time—on a flatbed scanner, the kind you'd find at any office supply store. After running the ears through a shelling machine, they image the de-kerneled cobs on a second scanner.

The resulting image files—up to 40 gigabytes worth per day—are then run through a custom-made software program that outputs an array of yield-related data for each individual ear. Ultimately, the scientists hope to link this type of information—along with lots of other descriptive data about how the plants grow and what they look like—back to the genes that govern those physical traits. It's part of a massive national effort to deliver on the promise of the corn genome, which was sequenced back in 2009, and help speed the plant breeding process for this widely grown crop.

Agronomist Shawn Kaeppler is testing corn for drought resistance in the Walnut Street Greenhouses on the UW–Madison campus.

PHOTO BY SEVIE KENYON BS'80 MS'06

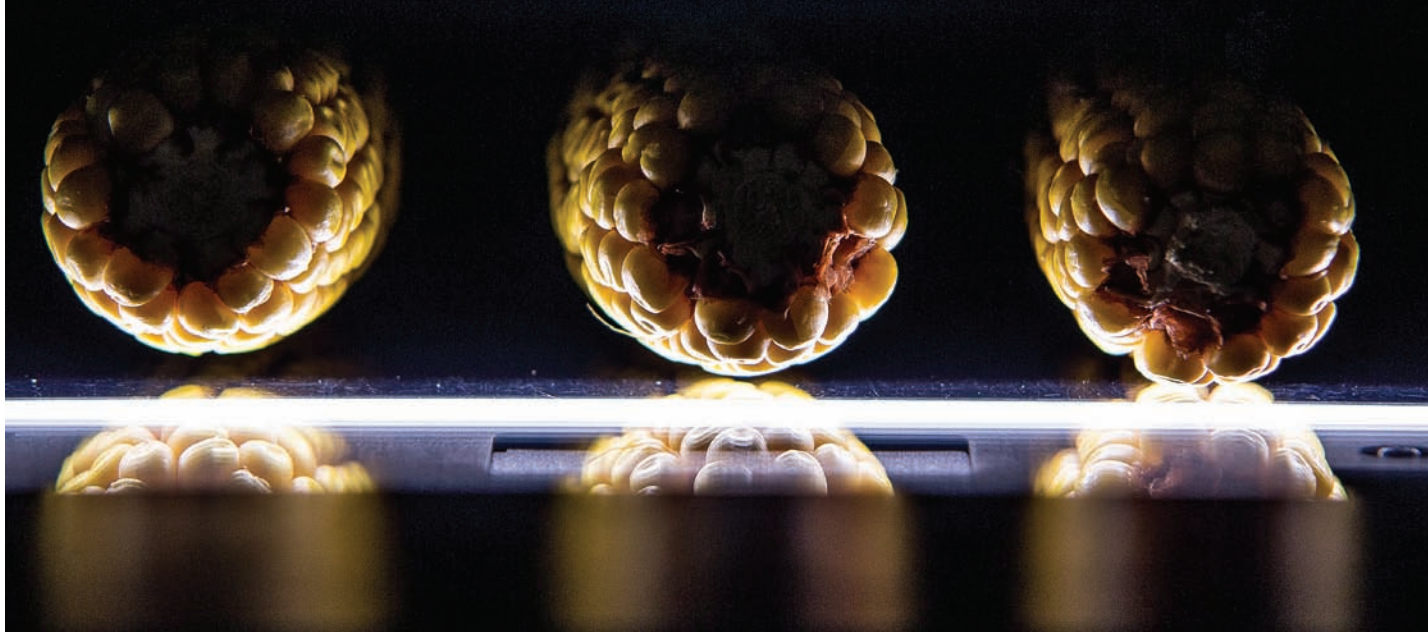


PHOTO BY SEVIE KENTON BS'80 MS'06

“When it comes to crop improvement, the genotype is more or less useless without attaching it to performance,” explains Bill Tracy, professor and chair of the Department of Agronomy. “The big thing is phenotyping—getting an accurate and useful description of the organism—and connecting that information back to specific genes. It’s the biggest thing in our area of plant sciences right now, and we as a college are playing a big role in that.”

No surprise there. Since the college’s founding, plant scientists at CALS have been tackling some of the biggest issues of their day. Established in 1889 to help fulfill the University of Wisconsin’s land grant mission, the college focused on supporting the state’s fledgling farmers, helping them figure out how to grow crops and make a living at it. At the same time, this practical assistance almost always included a more basic research component, as researchers sought to understand the underlying biology, chemistry and physics of agricultural problems.

That approach continues to this day, with CALS plant scientists working to address the ever-evolving agricultural and natural resource challenges facing the state, the nation and the world. Taken together, this group constitutes a research powerhouse, with members based in almost half of the college’s departments, including agronomy, bacteriology, biochemistry, entomology, forest and wildlife ecology, genetics, horticulture, plant pathology and soil science.

“One of our big strengths here is

that we span the complete breadth of the plant sciences,” notes Rick Lindroth, associate dean for research at CALS and a professor of entomology. “We have expertise across the full spectrum—from laboratory to field, from molecules to ecosystems.”

This puts the college in the exciting position of tackling some of the most complex and important issues of our time, including those on the applied science front, the basic science front—and at the exciting new interface where the two approaches are starting to intersect, such as the corn phenotyping project.

“The tools of genomics, informatics and computation are creating unprecedented opportunities to investigate and improve plants for humans, livestock and the natural world,” says Lindroth. “With our historic strength in both basic and applied plant sciences, the college is well positioned to help lead the nation at this scientific frontier.”

It’s hard to imagine

what Wisconsin’s agricultural economy would look like today without the assistance of CALS’ applied plant scientists.

The college’s early horticulturalists helped the first generation of cranberry growers turn a wild bog berry into an economic crop. Pioneering plant pathologists identified devastating diseases in cabbage and potato, and then developed new disease-resistant varieties. CALS agronomists led the development of the key forage crops—including alfalfa and corn—that feed our state’s dairy cows.

Fast-forward to 2015: Wisconsin is the top producer of cranberries, is third in the nation in potatoes and has become America’s Dairyland. And CALS continues to serve the state’s agricultural industry.

The college’s robust program covers a wide variety of crops and cropping systems, with researchers addressing issues of disease, insect and weed control;

PHOTO BY WOLFGANG HOFFMANN BS'75 MS'79



(Left) Information gained from scanned images of corn helps researchers connect various traits back to specific genes.

(Below) Agronomist Bill Tracy (in blue shirt) assesses corn traits at the West Madison Agricultural Research Station.

water and soil conservation; nutrient management; crop rotation and more. The college is also home to a dozen public plant-breeding programs—for sweet corn, beet, carrot, onion, potato, cranberry, cucumber, melon, bean, pepper, squash, field corn and oats—that have produced scores of valuable new varieties over the years, including a number of “home runs” such as the Snowden potato, a popular potato chip variety, and the HyRed cranberry, a fast-ripening berry designed for Wisconsin’s short growing season.

While CALS plant scientists do this work, they also train the next generation of researchers—lots of them. The college’s Plant Breeding and Plant Genetics Program, with faculty from nine departments, has trained more graduate students than any other such program in the nation. Just this past fall, the Biology Major launched a new plant biology option in response to growing interest among undergraduates.

“If you go to any major seed company, you’ll find people in the very top leadership positions who were students here in our plant-breeding program,” says Irwin Goldman PhD’91, professor and chair of the Department of Horticulture.

Among the college’s longstanding partnerships, CALS’ relationship with the state’s potato growers is particularly strong, with generations of potato growers working alongside generations of CALS scientists. The Wisconsin Potato and Vegetable Growers Association (WPVGA), the commodity group that supports the industry, spends more than \$300,000 on CALS-led research each year, and the group helped fund the professorship that brought Jeff Endelman, a national leader in statistical genetics, to campus in 2013 to lead the university’s potato-breeding program.

“Research is the watchword of the Wisconsin potato and vegetable industry,” says Tamas Houlihan, executive

Plant pathologist Aurélie Rakotondrafara found genetic material in a plant virus that may be a boon for biotechnology.

director of the WPVGA. “We enjoy a strong partnership with CALS researchers in an ongoing effort to solve problems and improve crops, all with the goal of enhancing the economic vitality of Wisconsin farmers.”

Over the decades, multi-disciplinary teams of CALS experts have coalesced around certain crops, including potato, pooling their expertise.

“Once you get this kind of core group working, it allows you to do really high-impact work,” notes Patty McManus, professor and chair of the Department of Plant Pathology and a UW–Extension fruit crops specialist.

CALS’ prowess in potato, for instance, helped the college land a five-year, \$7.6 million grant from the U.S. Department of Agriculture to help reduce levels of acrylamide, a potential carcinogen, in French fries and potato chips. The multistate project involves plant breeders developing new lines of potato that contain lower amounts of reducing sugars (glucose and fructose) and asparagine, which combine to form acrylamide when potatoes are fried. More than a handful of conventionally bred, low-acrylamide potato varieties are expected to be ready for commercial evaluations within a couple of growing seasons.

“It’s a national effort,” says project manager Paul Bethke, associate professor of horticulture and USDA-ARS plant physiologist. “And by its nature, there’s a lot of cross-talk between the scientists and the industry.”

Working with industry and other partners, CALS researchers are responding to other emerging trends, including the growing interest in sustainable agricultural systems.

“Maybe 50 years ago, people focused solely on yield, but that’s not the way people think anymore. Our crop production people cannot just think



about crop production, they have to think about agroecology, about sustainability,” notes Tracy. “Every faculty member doing production research in the agronomy department, I believe, has done some kind of organic research at one time or another.”

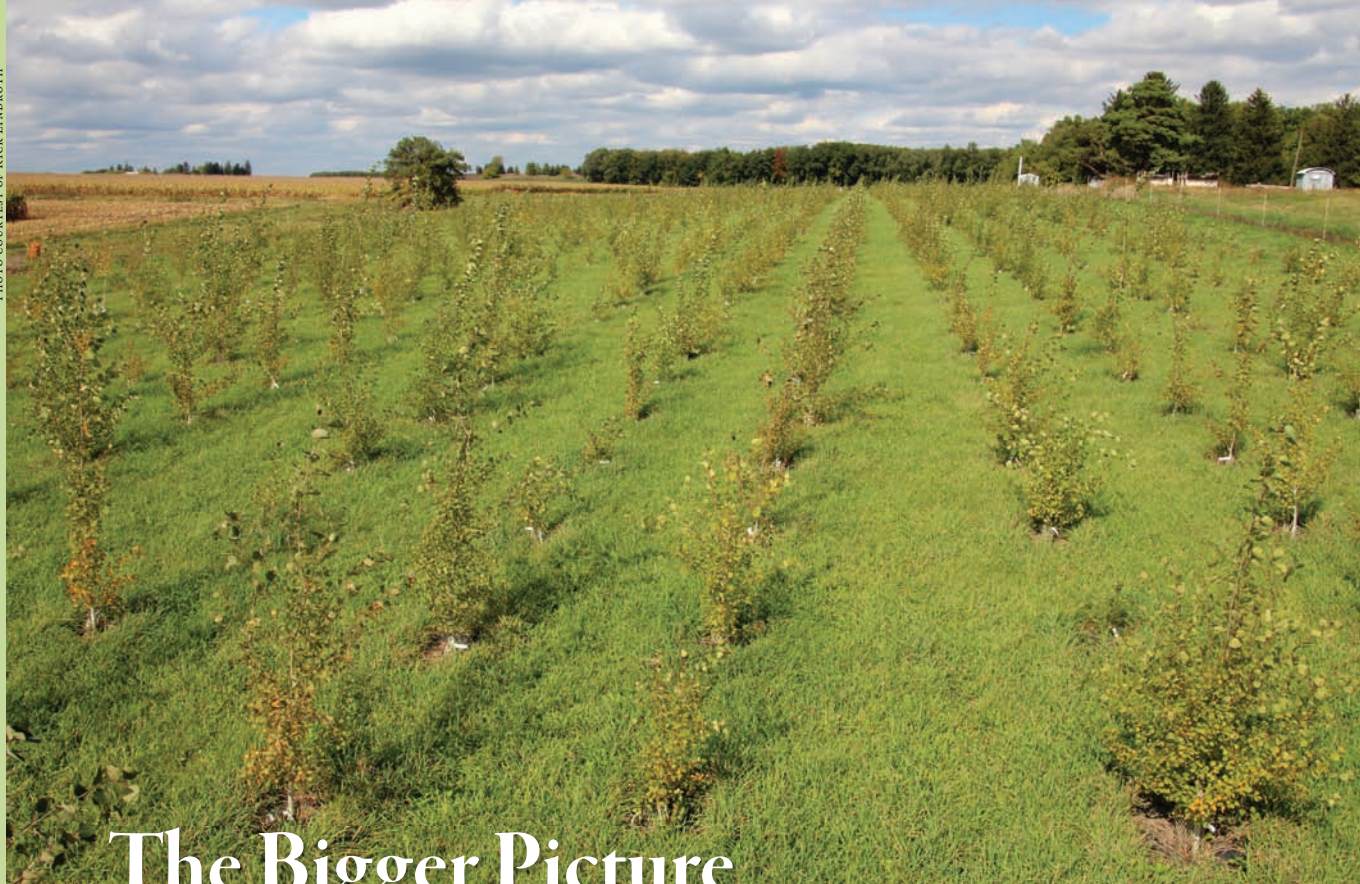
Embracing this new focus, over the past two years CALS has hired two new assistant professors—Erin Silva, in plant pathology, who has responsibilities in organic agriculture, and Julie Dawson, in horticulture, who specializes in urban and regional food systems.

“We still have strong partnerships with the commodity groups, the cranberries, the potatoes, but we’ve also started serving a new clientele—the people in urban agriculture and organics that weren’t on the scene for us 30 years ago,” says Goldman. “So we have a lot of longtime partners, and then some new ones, too.”

Working alongside

their applied colleagues, the college’s basic plant scientists have engaged in parallel efforts to reveal fundamental truths about plant biology—truths that often underpin future advances on the applied side of things.

For example, a team led by Aurélie Rakotondrafara, an assistant professor of plant pathology, recently found a genetic element—a stretch of genetic code—in an RNA-based plant virus that has a very useful property. The element, known as an internal ribosome entry site, or IRES, functions like a “landing



The Bigger Picture

Crop breeders aren't the only scientists doing large-scale phenotyping work. Ecologists, too, are increasingly using that approach to identify the genetic factors that impact the lives of plants, as well as shape the effects of plants on their natural surroundings.

"Scientists are starting to look at how particular genes in dominant organisms in an environment—often trees—eventually shape how the ecosystem functions," says entomology professor Rick Lindroth, who also serves as CALS' associate dean for research. "Certain key genes are driving many fantastically interesting and important community- and ecosystem-level interactions."

How can tree genes have such broad impacts? Scientists are discovering that the answer, in many cases, lies in plant chemistry.

"A tree's chemical composition, which is largely determined by its genes, affects the community of insects that live on it, and also the birds that visit to eat the insects," explains Lindroth. "Similarly, chemicals in a tree's leaves affect the quality of the leaf litter on the ground below it, impacting nutrient cycling and nitrogen availability in nearby soils."

A number of years ago Lindroth's team embarked on a long-term "genes-to-ecosystems" project (as these kinds of studies are called) involving aspen trees. They scoured the Wisconsin landscape, collecting root samples from 500 different aspens. From each sample, they propagated three or four baby trees, and then in 2010 planted all 1,800 saplings

in a so-called "common garden" at the CALS-based Arlington Agricultural Research Station.

"The way a common garden works is, you put many genetic strains of a single species in a similar environment. If phenotypic differences are expressed within the group, then the likelihood is that those differences are due to their genetics, not the environment," explains Lindroth.

Now that the trees have had some time to grow, Lindroth's team has started gathering data about each tree—information such as bud break, bud set, tree size, leaf shape, leaf chemistry, numbers and types of bugs on the trees, and more.

Lindroth and his partners will soon have access to the genetic sequence of all 500 aspen genetic types. Graduate student Hilary Bultman and postdoctoral researcher Jennifer Riehl will do the advanced statistical analysis involved—number crunching that will reveal which genes underlie the phenotypic differences they see.

In this and in other projects, Lindroth has called upon the expertise of colleagues across campus, developing strategic collaborations as needed. That's easy to do at UW–Madison, notes Lindroth, where there are world-class plant scientists working across the full spectrum of the natural resources field—from tree physiology to carbon cycling to climate change.

"That's the beauty of being at a place like Wisconsin," Lindroth says.

—NICOLE MILLER MS'06

(Left) A “common garden” of 500 kinds of aspen trees at the Arlington Agricultural Research Station provides data on genetic versus environmental differences.

Horticulture professor Jiwan Palta working with potatoes at the Hancock Agricultural Research Station, a locus of potato activity for CALS.

pad” for the type of cellular machine that turns genes—once they’ve been encoded in RNA—into proteins. (A Biology 101 refresher: DNA → RNA → Protein.)

This viral element, when harnessed as a tool of biotechnology, has the power to transform the way scientists do their work, allowing them to bypass a longstanding roadblock faced by plant researchers.

“Under the traditional mechanism of translation, one RNA codes for one protein,” explains Rakotondrafara. “With this IRES, however, we will be able to express several proteins at once from the same RNA.”

Rakotondrafara’s discovery, which won an Innovation Award from the Wisconsin Alumni Research Foundation (WARF) this past fall and is in the process of being patented, opens new doors for basic researchers, and it could also be a boon for biotech companies that want to produce biopharmaceuticals, including multicomponent drug cocktails, from plants.

Already, Rakotondrafara is working with Madison-based PhylloTech LLC to see if her new IRES can improve the company’s tobacco plant-based biofarming system.

“The idea is to produce the proteins we need from plants,” says Jennifer Gottwald, a technology officer at WARF. “There hasn’t been a good way to do this before, and Rakotondrafara’s discovery could actually get this over the hump and make it work.”

While Rakotondrafara is a basic scientist whose research happened to yield a powerful application, CALS has a growing number of scientists—including those involved in the corn phenotyping project—who are working at the exciting new interface where basic and applied research overlap. This new space, created through the mind-boggling advances in genomics, informatics



PHOTO BY SEVIE KENYON BS'80 MS'06

and computation made in recent years, is home to an emerging scientific field where genetic information and other forms of “big data” will soon be used to guide in-the-field plant-breeding efforts.

Sequencing the genome of an organism, for instance, “is almost trivial in both cost and difficulty now,” notes agronomy’s Bill Tracy. But a genome—or even a set of 1,000 genomes—is only so helpful.

What plant scientists and farmers want is the ability to link the genetic information inside different corn varieties—that is, the activity of specific genes inside various corn plants—to particular plant traits observed in the greenhouse or the field. The work of chronicling these traits, known as phenotyping, is complex because plants behave differently in different environments—for instance, growing taller in some regions and shorter in others.

“That’s one of the things that the de Leon and Kaeppler labs are now moving their focus to—massive phenotyping. They’ve been doing it for a while, but they’re really ramping up now,” says Tracy, referring to agronomy faculty members Natalia de Leon MS’00 PhD’02 and Shawn Kaeppler.

After receiving a large grant from the Great Lakes Bioenergy Research Center in 2007, de Leon and Kaeppler decided to integrate their two research programs. They haven’t looked back. With de Leon’s more applied background in plant breeding and field evaluation, plus quantitative genetics, and with Kaeppler’s more basic corn genetics expertise, the two complement each other well. The duo have had great success securing funding for their various projects from agencies including the National Science Foundation, the U.S. Department of Agriculture and the U.S.

Bill Kojis, a researcher in agronomist Shawn Kaeppler's lab, uses a hyperspectral camera to take photos of corn from Kaeppler's study on drought stress. The photos reveal drought stress before it is visible to the naked eye.

(Right) The newest section of the Walnut Street Greenhouses, shown here shortly after opening in 2005, has automated climate control and other features needed for modern research. Plans are under way to replace older parts of the complex, which date back to the 1960s.



PHOTO BY SEVIE KENTON BS'80 MS'06

Department of Energy.

“A lot of our focus has been on bio-fuel traits, but we measure other types of economically valuable traits as well, such as yield, drought tolerance, cold tolerance and others,” says Kaeppler. Part of the work involves collaborating with bioinformatics experts to develop advanced imaging technologies to quantify plant traits, projects that can involve assessing hundreds of plants at a time using tools such as lasers, drone-mounted cameras and hyperspectral cameras.

This work requires a lot of space to grow and evaluate plants, including greenhouse space with reliable climate control in which scientists can precisely measure the effects of environmental conditions on plant growth. That space, however, is in short supply on campus.

“A number of our researchers have multimillion-dollar grants that require thousands of plants to be grown, and we don’t always have the capacity for it,” says Goldman.

That’s because the Walnut Street Greenhouses, the main research greenhouses on campus, are already packed to the gills with potato plants, corn plants, cranberries, cucumbers, beans, alfalfa and dozens of other plant types. At any given moment, the facility has around 120 research projects under way, led by 50 or so different faculty members from across campus.

Another bottleneck is that half of the greenhouse space at Walnut Street is old and sorely outdated. The facility’s newer greenhouses, built in 2005, feature automated climate control, with overlapping systems of fans, vents,

air conditioners and heaters that help maintain a pre-set temperature. The older houses, constructed of single-pane glass, date back to the early 1960s and present a number of challenges to run and maintain. Some don’t even have air conditioning—the existing electrical system can’t handle it. Temperatures in those houses can spike to more than 100 degrees during the summer.

“Most researchers need to keep their plants under fairly specific and constant conditions,” notes horticultural technician Deena Patterson. “So the new section greenhouse space is in much higher demand, as it provides the reliability that good research requires.”

To help ameliorate the situation, the college is gearing up to demolish the old structures and expand the newer structure, adding five more wings of green-



house rooms, just slightly north of the current location—out from under the shadow of the cooling tower of the West Campus Co-Generation Facility power plant, which went online in 2005. The project, which will be funded through a combination of state and private money, is one of the university's top building priorities.

Fortunately, despite the existing limitations, the college's plant sciences research enterprise continues apace.

Kaeppler and de Leon, for example, are involved in an exciting phenotyping project known as Genomes to Fields, which is being championed by corn grower groups around the nation. These same groups helped jump-start an earlier federal effort to sequence the genomes of many important plants, including corn.

"Now they're pushing for the next

step, which is taking that sequence and turning it into products," says Kaeppler. "They are providing initial funding to try to grow Genomes to Fields into a big, federally funded initiative, similar to the sequencing project."

It's a massive undertaking. Over 1,000 different varieties of corn are being grown and evaluated in 22 environments across 13 states and one Canadian province. Scientists from more than a dozen institutions are involved, gathering traditional information about yield, plant height and flowering times, as well as more complex phenotypic information generated through advanced imaging technologies. To this mountain of data, they add each corn plant's unique genetic sequence.


"You take all of this data and just run millions and billions of associations for

all of these different traits and genotypes," says de Leon, who is a co-principal investigator on the project. "Then you start needing supercomputers."

Once all of the dots are connected—when scientists understand how each individual gene impacts plant growth under various environmental conditions—the process of plant breeding will enter a new sphere.

"The idea is that instead of having to wait for a corn plant to grow for five months to measure a certain trait out in the field, we can now take DNA from the leaves of little corn seedlings, genotype them and make decisions within a couple of weeks regarding which ones to advance and which to discard," says de Leon. "The challenge now is how to be able to make those types of predictions across many environments, including some that we have never measured before."

To get to that point, notes de Leon, a lot more phenotypic information still needs to be collected—including hundreds and perhaps thousands more images of corn ears and cobs taken using flatbed scanners.

"Our enhanced understanding of how all of these traits are genetically controlled under variable environmental conditions allows us to continue to increase the efficiency of plant improvement to help meet the feed, food and fiber needs of the world's growing population," she says. 

Want to help? The college welcomes your gift toward modernizing the Walnut Street Greenhouses. To donate, please visit: supportuw.org/giveto/WalnutGreenhouse. We thank you for your contribution.

A scene from The Straits' last PGA
Championship in 2010.

Eyes on the Green

By Ron Seely



How CALS scientists help the world-renowned Whistling Straits golf course get ready for this summer's PGA Championship



PHOTO COURTESY OF KOHLER CO.

Traveling around the windswept golf course called The Straits, with its massive greens of bentgrass and rumpled, horizon-bound fairways of fescue, it's easy to see why course manager Michael Lee BS'87 would arrange to keep his own yardwork to a minimum.

"My lawn takes me 20 minutes," says Lee. It's a cool spring morning, and we're bouncing his pickup around the stunning environs of The Straits, one of two Kohler Company 18-hole courses that comprise Whistling Straits on the shores of a steely-surfaced Lake Michigan in Haven, Wisconsin.

"I have mostly mulch and woody ornamentals," Lee says of his home lawn. "Everything I have to do for weed control I can do while I mow my lawn."

This is in great contrast to the daunting challenge Lee faces in maintaining what has been deemed one of the country's great championship golf courses.

And now the task has become almost herculean. The Straits, built and owned as part of The American Club by the Kohler Company, is hosting the prestigious PGA Championship this summer. From August 10 to 16, the eyes of the world will be on that course.

Though Lee will be toiling anonymously that week, guiding a staff of hundreds, his hard-earned skills as a golf course manager will be very much on display. Few, however, will truly understand what Lee and his staff do behind the scenes to maintain fairway and tee and rough and allow the television cameras to create what, in effect, is golf course art on our screens—sweeping vistas of perfectly tended dune and grass and emerald greens, with the big lake shining in the background.

But more than artful views are at stake. Lee, personable and easygoing and quick to smile, stands up well to pressure,

those who know him say. And pressure there will be.

The PGA Championship, which dates back to 1916, is one of the most heralded events in golf. Each of the last two PGA Championships played at Whistling Straits, in 2004 and in 2010, drew upward of 300,000 people, and millions of households around the world tuned in to television broadcasts. The Wisconsin economy benefited to the tune of more than \$76 million for each of the tournaments.

Lee is the first to say he could not shoulder the responsibilities of preparing The Straits for such worldwide scrutiny without plenty of help. And one of the places he counts on most for guidance in dealing with the course's fussy turf is his alma mater, the College of Agricultural and Life Sciences at the University of Wisconsin–Madison—and, more specifically, the CALS-affiliated O.J.



PHOTOS BY WOLFGANG HOFFMANN BS'75 MS'79

Noer Turfgrass Research and Education Facility, named for Oyvind Juul Noer, a CALS alumnus and one of the earliest internationally known turfgrass agronomists.

The facility, where scientists use tools ranging from high-powered microscopes to lawn mowers, opened in Verona, Wisconsin, in 1992 as a partnership between the Wisconsin Turfgrass Association, the University of Wisconsin Foundation, and the CALS-based Agricultural Research Stations.

Toiling in its maze of test plots, often on their hands and knees, are researchers who study everything from insects

and soil to plant disease. For Lee, they are like a staff of doctors who can, at a moment's notice, diagnose what is ailing a green or a fairway and prescribe a treatment. The Kohler Company (like many other golf course operators) contracts with the facility annually for these services.

Before and during the PGA championships, that role becomes even more crucial. The university specialists help Lee keep disease and insect problems at bay throughout the year. But in the weeks leading up to the championship they become his urgent care clinic, providing immediate help if something suspicious shows up. During the week of the championship they staff on-site, portable laboratories.

"We're kind of at Mike's beck and call," says Bruce Schweiger BS'84, a CALS plant pathology researcher who serves as manager of the Turfgrass Diagnostics Lab housed at O.J. Noer. "If he calls, we'll be there. We're CSI Turf! That's who we are."

Of course, such high-profile events are just a small—albeit exciting—part of the facility's wide-ranging mission. And you certainly don't have to be running a world-class golf course to seek help from the scientists at O.J. Noer.

The turfgrass industry is a \$1 billion-a-year business in Wisconsin and keeps about 30,000 people in jobs. Chances are, if you manage a sod farm or a park, maintain an athletic field, try to keep a 9-hole golf course at the edge of town up and running, or just wonder why your lawn looks like a bombing range, you could benefit from expert advice.

Paul Koch BS'05 MS'07 PhD'12, a CALS professor of plant pathology and a UW–Extension turf specialist who once worked as an intern for Lee, says the broad reach of the CALS turfgrass program, throughout the state and the country, is a fine example of the Wisconsin Idea at work.

"Just think of all the mom-and-pop

Whistling Straits course manager Michael Lee (blue jacket) talks turf pests with CALS/ UW–Extension entomologist Chris Williamson on the fairway and on a putting green, with Lake Michigan at their backs.

All hands on deck: A PGA Championship means intense activity at Whistling Straits. This scene from 2010 shows a maintenance and grooming crew, tools at the ready.

golf courses around the state,” Koch says. “There are all these excellent little 9-hole courses. The owners have to manage their problems within the confines of the budgets they have. They really rely on our experts.”

Lee, preparing his course for the world stage, takes full advantage of the sharing of knowledge upon which the Wisconsin Idea is based. He long ago learned how important the concept is to people in all corners of the state. It was part of his education at UW–Madison, he says. Lee graduated in 1987 with a degree from CALS in soil science, specializing in turf and grounds management. He also worked as a student hourly helping conduct research in the Department of Plant Pathology.

Lee credits that education and several crucial golf course jobs—including five years as assistant superintendent at the Blue Mounds Golf and Country Club in Wauwatosa—with equipping him to handle the rigors of managing a course such as The Straits.

It was mostly his work afield at CALS that best prepared him, Lee says. He remembers long days spent crawling around test plots with a magnifying glass looking for diseases with names like dollar spot or nearly invisible insects such as chinch bugs. He literally learned his craft on the ground, he says.

“I learned the technical side of the business,” Lee says. “The need to know what’s going on at deeper and deeper levels.”

The willingness to work hard and learn has long been one of Lee’s most noticeable traits. At age 14, he went to work at the Blackhawk Country Club golf course in the Madison suburb of Shorewood Hills. His boss was Monroe Miller BS’68, now retired but for many years the respected and colorful superintendent at Blackhawk.

“He was a real special kid,” Miller says. “There were two things about Mike. He was smart and he had a great



work ethic. He was probably never, ever, ever once, late for work.”

Miller recalls that off-season was always a time for catching up on chores such as painting. Around Thanksgiving in 1982, he told Lee and another young worker that among the jobs on their list was painting the inside of a pump station.

“They went down there on Thanksgiving Day and went to work,” Miller says. “I had to go down and kick them out so they would go home and spend time with their families.”

As for Lee, he says of Blackhawk and his apprenticeship with Miller: “I learned to work. I learned discipline.”

It was apparent even in those days, Miller says, that Lee had a special talent for everything to do with maintaining a golf course, from a love of the machinery to understanding the special care grass needs to become the meticulously groomed stage necessary for the game.

“Mike is one of those guys you could call a turfgrass clairvoyant,” Miller says.

Whistling Straits is a world unto itself, a haunting landscape that seems to have been dropped from the ancient countryside of the British Isles onto the Lake Michigan shoreline. That was exactly the intent of Kohler Company CEO Herbert Kohler and legendary golf course designer Pete Dye when they created both The Straits and The Irish, the other 18-hole course on the property.

The Straits, especially, evokes the rugged environs of renowned seaside courses such as the Old Course at St. Andrews in Scotland, frequent site of the British Open. These are known in the golfing world as links courses, dramatically different from the grassy, intensely manicured courses most Americans are familiar with. Greens are connected less by fairways than by long reaches of rugged, seemingly unkempt terrain pocked by deep, cylindrical bunkers known as pot bunkers. These are



“CSI Turf”: Whistling Straits course manager Michael Lee (left) and Turfgrass Diagnostics Lab manager Bruce Schweiger check out some pink snow mold on a turf plug at the O.J. Noer research facility near Madison.

another naturally occurring feature of the old courses, terrifying hazards into which unlucky golfers can disappear for long moments before chopping their wayward ball out again.

The old links courses in Ireland, Scotland and England are characterized by a coastal topography of dune and scrub-covered ridges. They evolved as the setting for a terribly frustrating game called golf because they were good for little else other than grazing the sheep that chomped away while early golfers swung away.

Though some may associate the word “links” with linked golf holes, the word actually comes from Old English and predates the game. It is the name given to that particular harsh and scrubby landscape behind a beach.

This is the world that Dye wanted to create with The Straits. He started with a wasteland along the shore of Lake Michigan, a flat and dismal area that had been the site of a military antiaircraft training range. He ordered up 7,000 truckloads of sand and went to work.

What emerged was a course of bluff and dune along two miles of Lake Michigan shoreline with holes named Gremlin’s Ear and Snake and Cliff Hanger and Widow’s Watch and Pinched Nerve. Each hole has a view of the lake. There are four stone bridges and a stone clubhouse that looks as

though it were transported rock by rock from the Scottish countryside. A flock of Scottish blackface sheep roam the grounds.

“We had to hire a shepherd,” Lee says. “Sometimes one of the sheep gets lost and we all have to look for it. You can spend hours out there looking for that one last sheep. It’s like something straight out of the Bible.”

But few characteristics connect The Straits to the old-style links courses more strongly than the wind. Lee, traveling the course, seemed almost always aware of the wind off the big lake.

“Out of the north today,” he says, during our drive. “Look at those waves.”

The wind gave the course its name. Herbert Kohler was walking the property during construction and, apparently teetering in a steady gale that whistled along the course’s heights and raised whitecaps on the lake, the name came to him very naturally.

The attention to detail in the course’s design, construction and maintenance has impressed the world’s best golfers. Lee keeps a file of comments from professional golfers, and he pulled out one from Tom Lehman, three-time winner of the PGA’s Player of the Year, who was interviewed about the course during the 2004 PGA Championship.

“It’s quite a feat of construction,” Lehman said. “I mean, it’s quite a vision

they had . . . This golf course is almost otherworldly.”

Lehman also spoke of the course’s ruggedness. Players and spectators alike generally come off The Straits exhausted, Lee notes. During the 2010 championship he spent part of his time giving rides to exhausted spectators worn out by walking the up-and-down course.

Lee enjoys banging around the course in his truck, sharing its charms and its quirks, especially now as preparations for this summer’s championship are well under way. On one jaunt he points out the paths that are designed like narrow country lanes (no carts here; every golfer walks with a caddy). He pauses at the large staging areas for gravel and sand that will serve as platforms for the big corporate suites and viewing stands.

The course is being set up, Lee says, to make it more spectator-friendly, with better walking areas and viewing locations that place golf fans close to the action.

And Lee shares an interesting and somewhat startling detail that, upon reflection, makes perfect sense for a course owned by the Kohlers of bathroom fixture fame. He stops his pickup truck and points to what looks like gravel along the side of the road.

“We used crushed toilets to make that,” Lee says matter-of-factly, but with a faint smile playing on his face.

On this early spring day, the bentgrass on the greens and the fescue in the fairways has yet to begin changing from winter’s browns to the green of spring. But that green will soon enough begin creeping across the course—and Lee will be paying close attention to any disease

A grid marks different treatments of turfgrass at O.J. Noer. Mike Lee (center) and other golf course clients meet regularly with CALS' Bruce Schweiger (left) and Tom Schwab (right), O.J. Noer's facility manager, to discuss options.

PHOTOS BY WOLFGANG HOFFMANN BS'75 MS'79



or other problems that may try to establish a foothold.

For Lee and his staff, preparation for the PGA Championship has been going on for years: the close monitoring and treatment for disease and insects, the careful maintenance of the course throughout the playing season, when Lee's crews are out morning and night raking, mowing and grooming.

Staff with the PGA have been on the site for two years, working from a large office trailer and keeping track of preparations, figuring out such details as where structures are going to go and where ropes will be placed to guide and control spectators.

The PGA course conditioning guidelines for championship competition give some indication of just how much attention to detail is necessary—consistent green speeds that are calculated with an instrument called a stimpmeter, mowers that are very precisely calculated to mow greens between .150 and .100 of an inch, the required use of bunker sand with grains that are measured so that no more than 25 percent of them are .25 mm or smaller.

"We go out all day with the guys from the PGA," says Lee. "We've learned to pack a lunch."

So it's easy to see why Lee's relationship with the experts at CALS becomes even more important as the championship draws near. Though Lee is adept at dealing with most of the challenges turf has to offer, the researchers at the Turfgrass Diagnostics Lab can often spot problems that remain invisible to most.

Back at the lab, Bruce Schweiger remembers puzzling over disease samples sent in by another client. To the client, the problem looked like dollar spot, but Schweiger knew that was not the issue. CALS entomology professor and UW-Extension specialist Chris Williamson was working nearby, and Schweiger asked him to take a look.

"Oh," Williamson said. "Ants."

It turned out that Williamson had done research on the problem some time before and had discovered that, during the mating season, some ant species go to war. They attack each other by spraying a nerve toxin that contains formic acid. That acid burns the turf and leaves lesions that look suspiciously like dollar spots, Schweiger recounts.

Such are the strange problems that could arise to plague Lee and his crew as they tend the course during the championship.

And those worries are on top of the intense maintenance that requires around-the-clock diligence once the event begins. Most crew members stay on-site working hours on end during championship week, Lee says, sleeping in big shelters set up for that purpose, snoozing in reclining chairs and watching the golf action on television screens.

Plant pathologist Paul Koch worked during the 2004 championship as an intern on one of the two- and three-person green crews that are charged with caring for a particular green and making sure during the week that it is cut morning and night and maintained to the PGA's exacting specifications.

Sometimes, Koch says, that requires a cut of a mere sliver, no more than the depth of three credit cards or so stacked one upon the other.

One damp early morning during the championship, Koch recalls, Lee dispatched crews to squeegee the dew from tees. Koch was met during the chore by one of the professional golfers, who marveled at what Koch was doing.

"He said, 'I can't believe you guys are doing this so that we don't have to walk in dew,'" Koch recalls.

Through the entire championship, Koch says, Lee remained cool and collected.

Of course, going into the week of a championship, Lee has already made sure there is little that can go wrong. A recent tour of the course included a visit to the maintenance building garage, located just outside the door from Lee's spartan office (aerial shots of the course being the most elaborate decoration).

Lee walked to one of the 60 big mowers lined up and gleaming in neat rows. He tilted one up and suggested running a finger across one of the blades.

It was razor sharp. 📷

Learn more at the following websites:

O.J. Noer Turfgrass Research and Education Facility: <http://ojnoer.ars.wisc.edu>

Whistling Straits: www.americanclubresort.com/golf/whistling-straits

PGA Championship: www.pga.com/pgachampionship

in the Field



Sid Cook *



Pat Doell



Alan Gruenke *



Kerry Henning *



Pam Hodgson

Sid Cook (first certified in 2002)

- Having won 569 national and international awards within the past 14 years, Sid Cook's Carr Valley Cheese just might rank first in the world for number of awards. Cook's passion for cheese began at a very young age. He remembers opening the kitchen door in his childhood home to find vats of cheese—no surprise given that his family owned Irish Valley cheese. By age 16 he had become a licensed cheesemaker, and just seven years later he and his brother purchased Irish Valley. In 1986 Cook became sole owner of Irish Valley and bought Carr Valley in LaValle, Wisconsin. A two-time graduate of the Master Cheesemaker program, Cook is certified in four cheeses. The education he gained in the program went “beyond the practical,” Cook says; it gave him the chance to work alongside and learn from cheesemakers from around the world. And that training no doubt contributed to the huge success of Carr Valley, which today produces more than 95 cheeses, purchases milk from nearly 100 farm families, and encompasses four factories and eight stores. Cook's been producing cheese for some 50 years, but when he's asked if he will retire, he simply says, “I'm not done yet.”

Pat Doell (certified in 2014) • At Agropur, a Canada-based dairy cooperative, Pat Doell is responsible for cheese production, packaging and shipping at the company's plant in Luxemburg, Wisconsin. Doell grew up in a cheesemaking family and in high school spent weekends and summers working in the family plant.

Today Doell is among the newest of the Master Cheesemaker graduates, receiving certification just last year in provolone and mozzarella. Doell's certification is held in high regard by Agropur, which takes pride in displaying the Master's Mark®—an exclusive benefit for Wisconsin Master Cheesemakers—on its products. The three-year Wisconsin Master Cheesemakers program required Doell to attend classes, submit samples for review, have plant inspections and complete a rigorous final exam, training that was “challenging but invaluable,” says Doell.

Alan Gruenke (certified in 2013)

- Third-generation owner Alan Greunke always arrives at Maple Grove Cheese in Milladore, Wisconsin, well before dawn to begin preparations for the cheese to be made that day. The Greunke family has a long history with CALS—Greunke's grandfather graduated from the Dairy School in 1912, Greunke notes while admiring his grandfather's class picture. Having attained his cheesemaking license at age 13, Greunke had compiled more than 40 years of experience by the time he completed his Wisconsin Master Cheesemaker program in 2013. Greunke is certified in cheddar and Monterey Jack, two of the most popular cheeses at Maple Grove—and having the Master's Mark on their products has led to a significant increase in business, he says. His favorite part of the program was the cheese technology short course, which offered him and a broad spectrum of his peers a chance to share their knowledge and experiences.

Kerry Henning (certified in 1999)

- The day often begins at 3:20 a.m. for Kerry Henning, whose responsibilities at Henning's Wisconsin Cheese, based in Kiel, Wisconsin, include preparing ingredients for cheesemaking, packaging cheese and giving facility tours to visitors from around the world. Henning entered his undergraduate studies intending to pursue a degree in accounting until he met his wife and reevaluated his plans for the future. Eventually following in his family's footsteps, Henning became a Wisconsin Master Cheesemaker certified in cheddar, Colby, and Monterey Jack—the cheeses his parents made at the family plant. His favorite part of his work, he says, is the satisfaction and accomplishment he feels when people in the food industry express their appreciation for his product and share how they've used it. Looking back on his Master Cheesemaker training, Henning fondly remembers the camaraderie among students and the opportunity to discuss their trade. “Some of your best education comes from the hotel lobby bar once class is over,” Henning says.

Pam Hodgson (certified in 2013)

- At the Sartori cheese company, based in Plymouth, Wisconsin, Pam Hodgson is responsible for developing new cheeses to meet desirable specifications, researching cheesemaking methods, and evaluating and addressing issues of quality. After graduating from CALS with a degree in dairy science, Hodgson began her career as a dairy nutritionist for a large cooperative. After starting a family, Hodgson wanted a job that required less travel, which led her to the science

* Photos courtesy of Wisconsin Milk Marketing Board, Inc.

Meet some Master Cheesemakers

Graduates of the Wisconsin Master Cheesemaker® program run by the CALS-based Center for Dairy Research



Tom Jenny *



Gerard Knaus



Terry Lensmire



Bruce Workman *

and art of cheesemaking. Her passion is deeply rooted in her family's connection to the craft, she says. Her grandfather, a CALS Dairy School graduate, was an award-winning cheesemaker—and now her daughter is pursuing a career in cheesemaking as well. “Our cheesemaking genes must be pretty strong,” says Hodgson, who has Master Cheesemaker certifications in fontina and open hard cheeses.

Tom Jenny (first certified in 1997)

- Like many cheesemakers of his father's generation, Tom Jenny and his family grew up just upstairs from their cheese factory in rural Wisconsin. However, it wasn't until Jenny returned home from the U.S. Navy in 1973 that he decided to pursue a career in the trade. At the time his father and uncle owned Platteville Dairy and were able to offer Jenny the opportunity to develop his craft. After 26 years there, Jenny went on to manage the Carr Valley Wisconsin Pride plant under Sid Cook. Jenny's day-to-day responsibilities include production, packaging and shipping the plant's products. Jenny has Wisconsin Master Cheesemaker certifications in Swiss, fontina and Gouda—obvious choices for Jenny, who had been producing these cheeses for more than a decade. Jenny is enrolled in the program again with the goal of obtaining two more certifications. In addition to his role as manager at Carr Valley, Jenny is training several cheesemakers—and he looks forward to seeing how their careers develop.

Gerard Knaus (certified in 2012)

- Weyauwega Star Dairy has been owned and operated by Gerard Knaus' family for more than 30 years. Knaus is the first

cheesemaker there to become a Wisconsin Master Cheesemaker, with certifications in feta and parmesan. Knaus was introduced to the craft at 14, when his father first brought him to the plant and he had the opportunity to work hands-on alongside a cheesemaker. “I knew then that this was what I wanted to do when I grew up,” Knaus says. Knaus is again enrolled in the Master Cheesemaker program, this time aiming for certification in brick and Colby. Afterward, he plans to become certified in mozzarella and cheddar as well. “When you start this program, you quickly realize that despite the fact that you've been making cheese all your life, there's a lot you don't know,” Knaus says.

Terry Lensmire (first certified in 1997)

- Terry Lensmire is a third-generation cheesemaker whose passion for the craft was instilled at an early age. He started making cheese as a child and continued throughout high school. In 1974 he earned his cheesemaker license and in 1982 became a licensed cheese grader. His knowledge and experience have expanded in a career that has included work for the U.S. Department of Agriculture, Land O'Lakes—and, currently, serving as product development manager at Agropur, a dairy cooperative based in Canada. Lensmire has been active in his craft outside the plant as well, serving as a cheese judge at the Wisconsin State Fair, at the Wisconsin Cheesemakers Association U.S. and World Cheese Contest, and at the World Dairy Expo Championship Dairy Product Contest. Lensmire was in the first wave of Wisconsin Master Cheesemakers, receiving his certification in 1997 (the program started in 1994)—and he's been a

presenter at the Cheese Grading Short Course since it started at around the same time. He has since been certified in cheddar, Monterey Jack, mozzarella and provolone.

Bruce Workman

(first certified in 1999)

- As a five-time graduate of the program, Bruce Workman holds the most Wisconsin Master Cheesemaker certifications of anyone in the state. Workman is certified in a total of 11 cheeses: butterkase, baby Swiss, specialty Swiss, Emmentaler, raclette, Gruyere, Havarti, Gouda, brick, Muenster and cheddar. Workman began working in the industry before and after school at the age of 16, and at 18 he became a Wisconsin licensed cheesemaker. By 1999, when he received his first Wisconsin Master Cheesemaker certification, Workman had been working in a plant that produced mostly European cheeses. It was this experience that shaped his desire to pursue certification in European cheeses. At Edelweiss Creamery, located in Monticello, Wisconsin, Workman and his staff of 11 produce 23 cheeses, including many in which he is certified. Workman founded Edelweiss Creamery in the same location that has been home to cheesemaking since 1936. After 43 years of making cheese, Workman says he would like to slow down on his responsibilities in the production room and focus on training the next generation at Edelweiss.

—Claudia Roen BS'15

About *In the Field*

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

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

Catch up with ...

Luxme Hariharan BS'04 Biology

PHOTO COURTESY OF USC



As a pediatric ophthalmologist, clinical researcher and child advocate, Luxme Hariharan has set herself a challenging goal: To prevent childhood blindness globally and help those with imperiled vision to see better. Born in Hyderabad, India, Hariharan graduated with bachelor's degrees in biology from CALS and in Latin American, Caribbean and Iberian Studies from the College of Letters and Science. She went on to earn an M.D. at the UW School of Medicine and Public Health and a master's in public health from Johns Hopkins.

While still in medical school she helped establish an eye-care program in Mysore, India, with the organization Combat Blindness International. It was there that she recognized the global impact she could have as an ophthalmologist. "I will never forget witnessing the wonder of a man who received free cataract surgery and exclaimed, 'Now I can finally see what my granddaughter looks like!'" she says.

Hariharan also has worked on blindness prevention programs in Argentina, El Salvador and Niger and has collaborated on vision-saving initiatives in Armenia and the Philippines.

A recipient of a "Forward under 40" award from the Wisconsin Alumni Association, Hariharan is currently the Pediatric Cornea, Cataract and Glaucoma Fellow at the Children's Hospital of Los Angeles.

● **What led to your interest in pediatric ophthalmology?**

I truly love the opportunity to help change the trajectory of a child's life by helping to maximize their vision. I remember one child in particular who was held back a grade because teachers thought he was not interested in school. It turned out that he just could not see well. Once he got the correct glasses prescription he was the most lively and participatory child in the class, and his grades drastically improved. I saw the direct impact vision can have on a child's overall growth and development. I was also excited to learn the intricate surgeries involved to treat pediatric ophthalmic conditions in combination with clinical care.

● **What aspects of your work do you find the most challenging?**

When we are not able to offer a permanent treatment or cure for certain disorders, and despite our best efforts, a child may eventually go blind. This is very challenging to witness in a young child. According to the World Health Organization, every five seconds a child somewhere in the world goes blind. Over a third of these children never graduate from high school, and half will grow up to become part of the permanently unemployed. The burden that childhood blindness places on society extends far beyond vision impairment alone and has significant social and economic impacts on families, communities and countries worldwide.

● **What can we do to help address this problem, beyond making sure every child has regular vision screening?**

It's important for everyone to have an idea of the types of avoidable and treatable causes of childhood blindness. Eighty percent of childhood blindness is preventable. A child's visual system fully develops by the time he or she is 9 or 10 years old, and up until that time it is possible to improve vision via treatments such as glasses, patching and possible surgery to maximize visual potential. After age 10, however, whatever visual acuity a child has is not likely to change. Therefore, early detection of ophthalmic conditions in children is vital in preventing them from developing further visual impairment and blindness.

—JOAN FISCHER

To learn more or to donate to childhood blindness prevention programs, Hariharan welcomes your questions at lhariharan@chla.usc.edu.

Hands-On Fieldwork

Before last summer, Vera Swanson's only exposure to plant sciences had been through classes in introductory biology. That changed big-time when Swanson, a junior majoring in environmental sciences and Russian, signed on to intern at the CALS-based Arlington Agricultural Research Station as a crop scout.

Crop scouts are used in agricultural management to diagnose stress factors in a field—such elements as potentially negative soil and climate conditions, the presence of pests, and threatened crop performance—and determine which management practices are appropriate for the goals of a specific plot. As part of her training, Swanson spent copious hours learning to identify weeds by walking through the fields and the Weed Garden, which displays dozens of invasive plants accompanied by their names.

Swanson paired her internship, which was run through the Department of Agronomy, with an independent research project involving biofuel crops being tested at Arlington. For that work Swanson drew on her growing knowledge of weeds to test the effect of three biofuel crop systems—native prairie, switchgrass and continuous corn—on the soil's weed seed bank, or the viable seeds present in the soil and its surface. The project involved working one-on-one with research scientists in Randy Jackson's grassland ecology lab. Jackson is running the crop trials through his affiliation with the UW's Great Lakes Bioenergy Research Center, housed in the Wisconsin Energy Institute.



The intense focus on plants got Swanson thinking a lot more about soil. "It is such a finite resource, yet so much of what we depend on comes from it—our food, clothing and the materials that we build with," says Swanson.

It also got her more interested in food systems, to the point where she chose to make horticulture a disciplinary focus within her major and a possible new career direction. "I'd love to work for an organization where I would be able to

complement my interests in agriculture, development and language within a global context," she says.

Swanson's path exemplifies the power of "beyond classroom" experiences to dramatically shape, and in many cases transform, a student's education and career goals. These experiences—which include internships, research projects, study abroad, honors thesis stipends, field courses and more—are the hallmark of a CALS education.

"They're a big part of what makes CALS CALS—and they offer our students a major advantage in both their personal and professional development," says Sarah Pfatteicher, the college's associate dean for academic affairs. "Our goal is to ensure that each student can participate in at least four of these important opportunities."

—AISHA LIEBENOW BS'14

To help support the CALS Student Experience Fund, visit: <http://go.wisc.edu/student-experience>

CELEBRATE AG AROUND THE STATE

at Agricultural Research Station events for the public. Here's a partial list to get you started. (But remember, you don't have to wait for a field day; the stations have a year-round open-door policy.) **Arlington:** Agronomy/Soils Field Day, **August 19**, Organic Agriculture Field Day **TBD**. **Hancock:** Hancock Field Day, **July 25**, Garden Tour, **August 4**, Midwest Food Processors Association Days, **August 11–12**. **O.J. Noer:** Grandparents University Day, **July 23**, WI Turfgrass Association Summer Field Day, **July 28**. **Peninsular:** The Garden Door Open House, **July 11**, Taste of Garden Door, **September 12**. **West Madison:** Urban Horticulture Day, **August 15**. For more information, visit <http://ars.wisc.edu/>



QUAFF A NEW BEER made by food science students in partnership with the Wisconsin Brewing Company (WBC) as part of the fermented foods and beverages program. "Inaugural Red" lager, as it is called, will be on sale at the Memorial Union

Terrace all summer and possibly beyond, and WBC plans to bottle it for local distribution. Next time you're enjoying an evening on the lake, grab an Inaugural Red and savor the results of this exciting collaboration.

GET YOUR STATE FAIR ON with UW–Extension on **Tuesday, August 11**, 9 a.m. to 4 p.m. in the central mall. Festivities include hands-on displays and activity stations about nutrition, wildlife, gardening, water quality, cheese- and sausage-making, 4-H and more. Information at www.uwex.edu.

VISIT US at **Wisconsin Farm Technology Days**, this year taking place in Dane County at Statz Bros. Inc. Farm in Sun Prairie, **August 25–27**. More information at wifarmtechnology-days.com. And be sure to attend the **WALSAA Farm Technology Days Picnic** on **Wednesday, August 26**, at Renk Seed Farms in Sun Prairie. More info at www.walsaa.org.

MARK YOUR CALENDARS for **Football Fire-Up** on **Saturday, September 12**. Location: Parking lot of the University of Wisconsin Foundation, 1848 University Avenue. Time TBA. More information at walsaa.org. Also mark your calendars for **CALS Honorary Recognition** on **Thursday, November 12**. More info soon at cals.wisc.edu/honorary.

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



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Bioenergy research. Photo by Matt Wisniewski/GLBRC

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Soil Science

1. Agriculture's connection to cultural eutrophication is through:

- a. Harvested crops that remove phosphorus from the watershed
- b. The cultural shift from rural to urban values that increases phosphorus in diets
- c. Fertilizers and feed supplements that lead to phosphorus accumulation in the watershed
- d. Livestock removal of substantial amounts of phosphorus from the watershed
- e. Slowing the construction of homes that causes soil erosion

Food Science

2. The reaction responsible for the brown pigment in a bruised apple is:

- a. Maillard browning
- b. Caramelization
- c. Fennemazation
- d. Enzymatic browning
- e. Vacuole browning

Animal Sciences

3. What is the first sign of vitamin A deficiency?

- a. Night blindness
- b. Disruption of eye surface, causing blindness
- c. Degeneration of the optic nerve
- d. Eyes fall out of the socket due to dehydration

Entomology

4. What insect transmits bubonic plague?

- a. Louse
- b. Flea
- c. Tick
- d. Rats, not insects, transmit bubonic plague

Agronomy

5. Which of the following is not a major component of a plant cell wall?

- a. Lignin
- b. Crude protein
- c. Cellulose
- d. Hemicellulose

Last issue: Answers were: 1:A, 2:B, 3:A, 4:B, 5:E. Congratulations to Lisa Paul, BS'89 Food Science, who was randomly selected from 45 people who answered all questions correctly. She wins a Babcock Hall cheese box.

College of Agricultural and Life Sciences
University of Wisconsin–Madison
136 Agricultural Hall, 1450 Linden Drive
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A baby fox takes in the world near its den on the UW–Madison campus this spring.
Learn more about our campus foxes and coyotes starting on page 14.

PHOTO BY E. ARTI WULANDARI