grow

Wisconsin's Magazine for the Life Sciences • Spring 2015

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

Beer *and* Beyond

The rise of *yeasts* in food, fuel, pharmaceuticals and more

College of Agricultural & Life Sciences
UNIVERSITY OF WISCONSIN-MADISON

BUGS IN THE CLOUD • DECODING DIABETES • REPURPOSING ACID WHEY

Volume 8, Issue 2 • Spring 2015

Meet the wild and woolly at the Spooner Agricultural Research Station.

Photo by Sevie Kenyon BS'80 MS'06

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Wisconsin's Magazine for the Life Sciences

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Help Forge the Best Way Forward

Each issue of *Grow* magazine is a special treat for me because it is a powerful reminder of our impact throughout Wisconsin and around the world.

Those of you who live in Wisconsin may have seen recent media coverage surrounding the proposed $300 million budget cut to the University of Wisconsin System. This would be the largest reduction to the University of Wisconsin in history. At this magnitude, the share assigned to UW–Madison, and to CALS specifically, would be unprecedented.

Reductions of this size will make it more difficult for us to provide our students with a high-quality education. Sharing the classroom with globally recognized scientists is a hallmark of a CALS education. Professor John Doebley, a member of the National Academy of Sciences, teaches an undergraduate seminar titled "Genetics in the News." Our professors are committed to innovative teaching as well. Assistant professor Aurelie Rakotondrafara is redesigning the popular "Plant, Parasites and People" class as a blended course that mixes online and in-person instruction. Professor Bill Bland offered "Earth's Water: Natural Science and Human Use" as a flipped course for the first time this year, providing lectures online and using class time for hands-on work. A sharply declining budget will compromise our ability to offer such innovative instruction, and classes could increase in size or be offered less frequently.

"We are proud of our college's 125-year partnership with the taxpayers of Wisconsin."

I am extremely concerned that these cuts will diminish our impact outside of the classroom as well. The Wisconsin Idea—the concept that the university's impact extends throughout the state and beyond—is deeply embedded in our DNA. We take our public service mission very seriously, and we are proud of our college's 125-year partnership with the taxpayers of Wisconsin. I worry how a cut of this size will redefine that relationship.

This proposed reduction follows several prior cuts for the college. Since 2008, UW–Madison's share of general purpose tax revenue has dropped by 6.8 percent; CALS' faculty numbers have declined by 6.2 percent. Yet during this same time period, our student enrollments have increased by 34 percent. For any responsible manager, these opposing trends are troubling.

The proposal also includes additional flexibilities for the UW System, which we welcome. Our faculty and staff are creative and innovative, but organizational change requires time. Cuts of this size would seriously decrease our capacity to continue our existing programs—and implementing them in a short time frame would certainly prevent us from making the best strategic choices.

We want to continue to grow the future of our students and Wisconsin communities. I hope we can continue to partner with the people of Wisconsin to determine the best way forward.

Become a UW advocate at uwalumni.com/support/advocate

Learn more about the UW–Madison budget at budget.wisc.edu.

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Turning them on

A challenging after-school class keeps middle schoolers interested in science

Photo courtesy of Hazel Holden

Anything but boring: Middle schoolers take on challenging assignments in Hazel Holden's biochemistry lab.

CALS biochemistry professor Hazel Holden is excited about science. So when she witnessed science becoming "boring" in her daughter's classroom—a feeling several classmates shared—she decided to take matters into her own hands.

Some five years ago she created Project CRYSTAL—Colleagues Researching with Young Scientists, Teaching and Learning—a program designed to challenge middle schoolers who show an aptitude for science. The program is funded by the National Science Foundation.

Each school year, Holden takes four eighth-grade students under her wing for weekly hands-on sessions. "We're trying to de-stigmatize science by exposing kids to material they otherwise would never have been exposed to," she says.

And it's impressive stuff. The students start by extracting DNA from yeast cells they have grown themselves. They then use the extracted DNA to practice the art of polymerase chain reaction (PCR for short), the process by which a piece of DNA is replicated to produce thousands to millions of copies of a targeted DNA sequence.

Switching between 10-minute lecture and lab segments keeps the kids motivated, and with clever anecdotes sprinkled throughout the lecture material, the young students are never bored.

This class format is used to progress to more advanced skills such as protein purification—the isolation of proteins from, in this case, *E. coli* cells—and X-ray crystallography, a tool used by the students to identify the molecular structure of a crystalline protein. The year ends with a group poster presentation—a rite of passage that most students don't experience until much later.

"I was able to work in a real lab and gain lab experience. I do not think many 12-year-olds are able to have an experience like that," says Project CRYSTAL alumna Manpreet Kaur, now a high school senior. "Before the program I did not have any knowledge of X-ray crystallography, and now I am able to explain the process in science classes."

The program inspired Kaur to take several AP science classes and affirmed her plans to become a doctor.

Holden has published her curriculum as an 80-page book, and Project CRYSTAL was introduced at Indiana University–Purdue University Indianapolis during the current school year.

The program has benefited graduate students almost as much as the youngsters, giving them experience teaching complex science at the most basic level.

"This class puts our own graduate work in perspective. You get more excited about your own research by watching them get excited about the small things, like pipetting," reflects biochemistry doctoral student Ari Salinger.

Looking ahead, Holden hopes that what she has created will inspire other universities to implement similar programs.

"The students want to learn more—and they are ready for it," Holden says.

—Aisha Liebenow

Bridging the Gap

An international friendship program helps CALS students reach across borders, right here on campus

Photo by Joan Fischer

International support: Food science major Hannah Fenton (bottom left) carrying BRIDGE partner Kanokwan Duangkunarat, of Thailand; and Jenny Falt, from Sweden (bottom right), carrying her fellow landscape architecture student Sherry Yang.

Food science major Hannah Fenton gratefully recalls the kindness shown to her during the three years she and her family spent in Thailand. "I know what it's like to live in a foreign place and to feel lonely and in need of a friend," she says.

That's why Fenton joined BRIDGE—short for "Building Relationships in Diverse Global Environments"—a campus program that matches U.S.-born Badgers with students from around the world. "I wanted to give international students the love, support and guidance that I had when I was in Thailand," says Fenton.

Last fall Fenton was paired with Bangkok native Kanokwan "Kim" Duangkunarat, who credits BRIDGE with helping her make the most of her five months in Madison. "Before I came here, I thought that the international students would be treated differently," Duangkunarat says. "However, I was wrong."

The feeling of "fitting in" she describes is at the heart of BRIDGE's mission. Offered through International Student Services (ISS), BRIDGE seeks to ease the transition of foreign students to campus while giving U.S. students the opportunity to connect as cultural ambassadors. Each semester an interview process matches international and domestic students according to their interests and gathers these pairs into teams of 14 to 20 students.

To cultivate participants' leadership and cross-cultural communication skills, each BRIDGE team is assigned to design and host a special event for the others. Past activities have included tours of research labs, visits to a traditional Wisconsin farm, a trip to a corn maze, and even a tailgate party at Miller Park.

After a focus group of CALS undergraduates revealed that many students appreciated the diverse origins of their peers in the classroom but were unsure how to connect socially, CALS administrators reached out to ISS to sponsor a college-specific BRIDGE team.

Now in its fourth semester, the CALS team has attracted students from all corners of the globe, including Germany, Brazil, Malaysia, Singapore and China. Participants have included majors in biochemistry, animal sciences, microbiology, and community and environmental sociology, though the program welcomes international students from non-CALS majors as well. Inspired by CALS' success, two other colleges on campus are sponsoring college-specific teams this year.

"Now I have many good friends from different countries," says Duangkunarat. "I have learned that UW–Madison is a really great place to study and live."

Meanwhile, Fenton has enjoyed seeing her campus through the eyes of students for whom their time here is study abroad. "My favorite question to ask them is, 'How do you like Madison?'" she says. "I enjoy showing them my favorite things and hearing about their new adventures as well."

—Masarah Van Eyck

For more information about BRIDGE, visit http://apps.iss.wisc.edu/bridge/.

From Trash to Treasure

The Center for Dairy Research is turning a problematic by-product of Greek yogurt production into new cash streams

Photo by Sevie Kenyon BS'80 MS'06

CDR food technologist Dean Sommer showing a beaker of acid whey. The high-tech filters used to separate the various components are inside the metal pipes.

With exploding consumer demand for Greek yogurt, production is up. That's great for food companies' bottom lines, but it also leaves them dealing with a lot more acid whey, a problematic by-product of the Greek yogurt-making process.

Acid whey, if not properly disposed of, can cause environmental problems. Currently, companies typically pay to land-spread it on farmers' fields or dump it down the drain. Where the option is available, some plants are starting to send it to anaerobic digesters, where it's fermented to produce methane.

But scientists at the CALS-based Wisconsin Center for Dairy Research (CDR) are developing a better option, one that will transform this trash into treasure.

"The whole goal is to take this problematic mixture of stuff—acid whey—and isolate all of the various components and find commercial uses for them," says Dean Sommer, a CDR food technologist.

That's no easy task.

Food companies have been fractionating the components of sweet whey—the by-product of cheese production—for more than a decade now, extracting high-value whey protein powders that are featured in muscle-building products and other high-protein foods and beverages.

Compared to sweet whey, however, acid whey from Greek yogurt is hard to work with. Similar to sweet whey, it's mostly water—95 percent—but it contains a lot less protein, which is considered the valuable part. Some of the other "solids" in acid whey, which include lactose, lactic acid, calcium, phosphorus and galactose, make it more difficult to process. For instance, thanks to galactose and lactic acid, it turns into a sticky mess when it's dried down.

Instead of drying it, CDR scientists are developing technologies that utilize high-tech filters, or membranes, to separate out the various components.

"We're taking the membranes that are available to us and stringing them together and developing a process that allows us to get some value-added ingredients out at the other end," says dairy processing technologist Karen Smith, who is working on the project.

At this point, the CDR has set its sights on lactose, an ingredient that food companies will pay good money for in food-grade form.

"It's the lowest-hanging fruit, the most valuable thing in there in terms of volume and potential worth," says Sommer.

The technology is quite far along. While Sommer can't divulge names, a number of companies are already implementing lactose-isolating technology in their commercial plants.

Isolating the other components will come later, part of the long-term vision for this technology. When it's perfected, explains Sommer, acid whey will be stripped of its ingredients until there's nothing left. "It will just be water," he says.

—Nicole Miller MS'06

Pecatonica Without the "P"

Changes in farming practices have been shown to greatly reduce phosphorus runoff—without hurting the growers' bottom line

Photo by Pat Sutter / Dane County Dept. of Land and Water Resources

Preserving the Pecatonica: A multiyear project showed how changes in farming practices led to reduced phosphorus runoff.

Conservation experts and farmers alike are pretty pleased with the news from Pleasant Valley.

A seven-year pilot project in this 12,000-acre sub-watershed of the Pecatonica River showed that it's possible to significantly cut phosphorus and sediment losses from agricultural land by zeroing in on problem areas.

Changing farming practices on selected fields on just 10 of the valley's 61 farms reduced the amount of phosphorus entering the Pecatonica from Pleasant Valley during major storms by more than a third. Steps such as reducing tillage and planting crops that leave more residue to protect the soil caused estimated average annual losses of phosphorus and sediment entering the stream to drop by 4,400 pounds and 1,300 tons, respectively.

The project partners—UW scientists, public agencies, local farmers and The Nature Conservancy—began in 2006 by collecting baseline data on water quality in the Pecatonica below Pleasant Valley and below a nearby watershed that served as a control. From 2010 through 2012, conservationists worked with farmers to implement new practices. Data from 2013 showed that those efforts paid off.

"We can say with 90 percent confidence that this project made a real reduction in the phosphorus losses," says CALS soil scientist Laura Ward Good. "Farmers who changed their management practices reduced their estimated phosphorus and sediment losses by about half."

A key tool in the research was SnapPlus, software developed at CALS that estimates each field's potential for phosphorus runoff under various management scenarios.

"In many cases the higher-risk areas were fields on steep slopes, where silage had been grown in consecutive years so there wasn't much crop residue to hold the soil, and where soil phosphorus levels were high—possibly because past manure applications had supplied more phosphorus than crops required," Good says.

Once they'd identified high-risk fields, team members worked with landowners to assess the likely impacts of switching practices on that land—not just on runoff, but also on yields, expenses, feed supplies and other factors that govern the success of the enterprise.

Results to date indicate that farmers can make the needed changes without reducing their bottom line if the practices are tailored to the needs of the farm and growers can proceed gradually.

Photo courtesy of Jasmeet Lamba

Soil CSI: As part of the watershed study, doctoral student Jasmeet Lamba (here with undergraduate Kristi Barclay) tracked down where various sediments came from.

"No tilling is very good for the environment, for example, and you can get high production," points out UW–Extension specialist Jim Leverich, the project's on-farm research coordinator. "But you have to pay close attention to the details. You don't have as much latitude. You can't make any mistakes."

"The trick is to give farmers the time to adapt, to search among the best management practices to see how they fit into their systems. If they have time to utilize the practice on a small scale first, they'll start to see the advantages and maybe start to use it on more acres," Leverich says.

—Bob Mitchell BS'76

Soil Forensics

Sediment is sediment to you and me, but not to Jasmeet Lamba PhD'14, who as a graduate student worked with professors Anita Thompson and K.G. Karthikeyan along with soil and water conservation engineer John Panuska (all in the Department of Biological Systems Engineering). Lamba was able to "fingerprint" sediment suspended in the stream and figure out where it came from.

Lamba analyzed soil samples from throughout the Pleasant Valley watershed for naturally occurring metals and radioisotopes. Soil from different types of land—stream banks, woodlands and farm fields—has different concentrations of these telltale markers. By comparing those samples to others collected from the river, he determined that about 70 percent of the sediment exiting the Pleasant Valley watershed in the stream originated from farm fields, while about 30 percent came from stream banks.

New "Bug Guy" on Campus

PJ Liesch and insect friend

Photo by Bryce Richter/UW–Madison Communications

Are bed bugs getting you down? Is a hard-to-identify pest ravaging your vegetable garden? You can get in touch with PJ Liesch MS'10, manager of the UW–Madison Insect Diagnostic Lab, where he succeeds the retired Phil Pellitteri BS'75 MS'77.

Liesch (sounds like "leash"), who earned his master's degree in the lab of entomology professor and UW–Extension specialist Chris Williamson, has been working as a research scientist on campus for the past few years and served as interim manager of the Insect Diagnostic Lab before being named to the position permanently.

He greatly enjoys interacting with the public. When he receives an inquiry, he not only does his best to answer the question, he also tries to provide more information about the insect and to share additional photos and links to help people learn more.

Liesch started a blog, "What's Crawling in the Lab," to share what people in Wisconsin are finding in their homes, backyards, forests and fields—you can see it at http://go.wisc.edu/insectblog. He also started a Twitter account people can use to reach him, @UW_InsectLab.

And you can always reach him by phone at (608) 262-6510.

classAct

Lily Mank
Soothing Landscapes


Lily Mank at Allen Centennial Gardens, UW–Madison

Some gardens are created to cultivate or showcase particular kinds of plants, others to grow food. But landscape architecture student Lily Mank is most interested in gardens designed to aid healing.

Last summer Mank had an opportunity to learn with a master: Hoichi Kurisu, an international leader in Japanese gardening who counts the Anderson Japanese Gardens in Rockford, Ill., among his works. Under his tutelage, Mank completed an internship there allowing her to participate in all aspects of garden maintenance and management—the first time the facility had ever offered one. She also worked at the nearby Rosecrance Griffin Williamson teen substance abuse rehabilitation center, which features a healing garden designed by Kurisu. The garden is an integral part of the facility's treatment program.

"Seeing the benefits of the therapeutic garden firsthand was incredible," she says. "It was probably my favorite experience."

Mank, who holds a certificate in healthcare garden design from the Chicago Botanic Garden, wrapped up her internship with a report on therapeutic gardens. For her senior capstone project she's taking what she's learned to Rogers Memorial Hospital in Oconomowoc, which offers treatment for people with eating disorders, OCD and anxiety, depression and addiction.

When first-timers visit a Japanese-style therapeutic garden, one feature stands out: it's primarily green. "A frequent comment is that there aren't a lot of flowers, that everything is monochromatic green," says Mank.

Yet most people feel the tranquility. It's the special way that plants and other elements—paths, rocks, bodies of water, resting places—are brought together, and the emotions these landscapes evoke, Mank says.

A growing body of research about the benefits of therapeutic landscapes has changed how we look at healthcare, much of it stemming from a study decades ago showing that patients recovered from surgery faster and required less pain medication if they were placed in rooms with a view of nature, Mank says.

She hopes to hone her craft in the realm of therapeutic landscape architecture after she graduates in May.

ELECTED fellows of the American Association for the Advancement of Science (AAAS) for distinguished contributions to their fields, CALS professors **Alan D. Attie** (biochemistry) and **Andrew F. Bent** (plant pathology). Learn more about Attie's work starting on page 28.

APPOINTED Campbell-Bascom Professor, **Shawn Kaeppler**, a professor of agronomy. The professorship was established by the Campbell Soup Company and is awarded to CALS faculty who have made outstanding contributions in the field of agriculture.

WINNERS of "The Amazing Race," a CBS reality show with a $1 million prize, food science Ph.D. students **Amy DeJong** and **Maya Warren** (photo, left and right). The pair, whose social media handle is #SweetScientists, completed challenges in eight countries spanning 26,000 miles, claiming victory against 10 other teams. The Babcock Hall Dairy Plant is creating an ice cream flavor in their honor this spring—and you can help name it! Submit your suggestions to http://go.wisc.edu/amazingrace.

HONORED, **William F. Tracy**, chair and professor of agronomy, with the 2014 Public Plant Breeding Award from the National Council of Commercial Plant Breeders, for his contributions to the advancement of plant breeding and genetics in the public sector.

Photo by Sevie Kenyon BS'80 MS'06

450 GALLONS of "Happy Cranniversary" ice cream from the Babcock dairy plant—comprising about 8,000 servings—were dished out last year at CALS events marking the college's 125th anniversary, the occasion for which the flavor was created and named. The concoction, which included cranberry syrup, a cranberry sauce and sweetened cranberries, not only was delicious, but also highlighted the importance of cranberries in the Badger State. Here's another number: Wisconsin is the nation's top cranberry grower, producing 67 percent of the nation's total, according to the report *2014 Wisconsin Agricultural Statistics*.

A Look at Wisconsin's Latino Population

A new report sheds light on Latinos in the Badger State

Wisconsin's Latino population is 74 percent larger and significantly more homegrown today than it was at the beginning of the century, according to a report by CALS demographers.

The number of Latinos residing in Wisconsin increased from 193,000 to 336,000 between 2000 and 2010, and the share of those who were born in Wisconsin rose from 40 percent to 45 percent, according to the report by the CALS-based Applied Population Laboratory. The share born outside the United States dropped from 40 percent to 36 percent, while the portion born in other states remained around 20 percent.

Ninety percent of Wisconsin's Latinos live in urban counties—37 percent in Milwaukee County alone—compared to about 70 percent of all Wisconsin residents, the report notes. But while relatively few Latinos live in rural areas, some of the highest rates of growth are occurring far from urban centers. In Trempealeau County the Latino population rose from 240 to 1,667, a sixfold increase. In Lafayette County it went from 92 to 522, a fivefold increase.

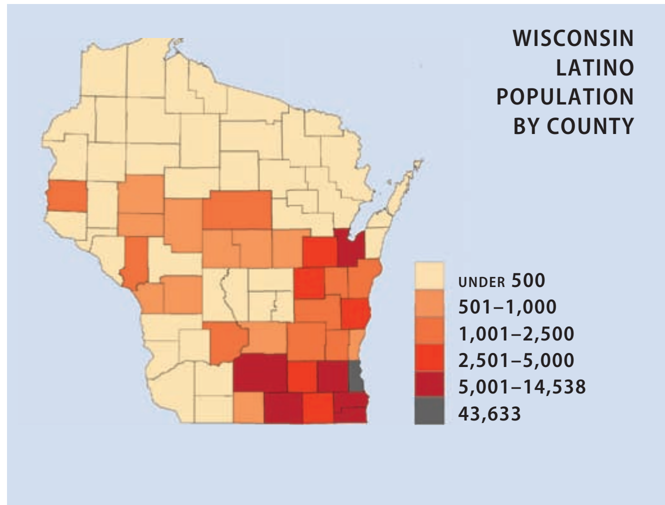
"In many rural counties, in-migration by Latinos has stemmed population declines and filled gaps in the labor market caused by young non-Hispanic whites moving out," says report co-author David Long, a researcher in the Department of Community and Environmental Sociology.

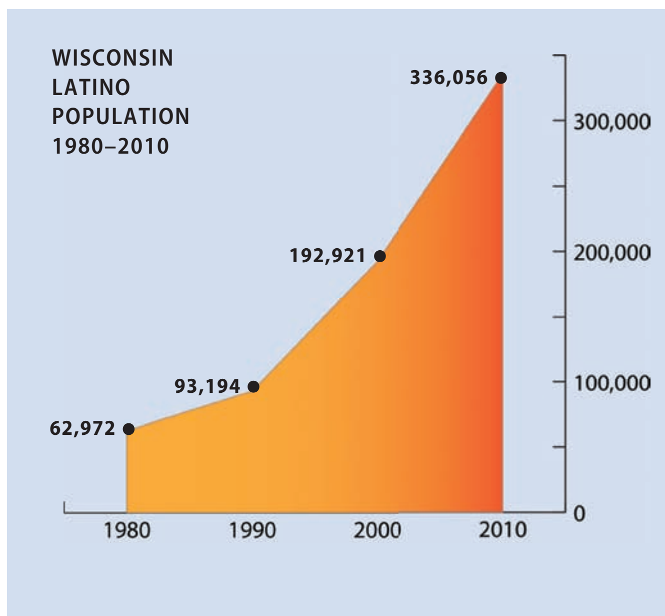
The 58-page report, *Latinos in Wisconsin*, uses graphics and text to provide a statistical portrait of Latinos across the state, with details on such factors as income, employment, education, language proficiency, housing and health insurance. There's also a companion set of "Latino Population Briefs," one for every county.

Among other findings in the report:

- The age distribution of Latinos differs markedly from that of the state as a whole. While the biggest age groups in the general population consist of baby boomers—ages 46–64—the largest among Latinos are children under age 10.

- Trends in education are in the right direction, but Latinos still lag behind the general population. "The estimated share of Latinos with less than a high school diploma declined from 45 percent to 40 percent, but that's still four times greater than the share of the total population without a diploma," Long notes.





- The poverty rate among Latinos is more than twice that of the overall population, and while the state's median household income has more than kept pace with inflation since 2000, Wisconsin Latinos' buying power fell by more than $10,000.

Data in the report came from the 2010 census and the Census Bureau's American Community Survey and various state agencies. The report and briefs are available online at www.apl.wisc.edu.

—Bob Mitchell BS'76

Five things everyone should know about . . .

Stevia

By Irwin Goldman

1 | It's not just a sweetener. The plant genus *Stevia* includes more than 200 species of herbs and shrubs native to South America and Mexico. Yet only two species, *Stevia rebaudiana* and *Stevia phlebophylla*, produce steviol glycosides in their leaves. These glycosides are the source of the plant's sweet compounds.

2 | But as a sweetener, it's nothing new. *Stevia rebaudiana* has been used for more than 1,500 years by various indigenous peoples in South America both to treat diabetes, obesity and hypertension and to provide a sweetening effect for food and drink. Commercial use of stevia took off when sweeteners such as cyclamate and saccharin were identified as possible carcinogens. Japan became the first country to introduce commercial use of stevia in the early 1970s and still consumes more of it than any other nation. Stevia has been available for several decades in natural food stores but in recent years has increased greatly in popularity as a sweetener for processed foods. Today, stevia can be found in many U.S. supermarkets under a variety of brand names, such as Truvia and PureVia.

3 | Why use stevia instead of sugar or other sweeteners? Stevia is significantly sweeter than table sugar, and comparable in sweetness to products such as aspartame, saccharin and sucralose, but it is metabolized differently. Stevia is perceived as sweet but does not cause a rise in blood glucose like sugar, making it a promising food for diabetics. It is a natural rather than an artificial sweetener.

4 | How is stevia processed within the body? The glycosides in stevia are primarily known as rebaudioside (or rebiana) and stevioside. They have some bitterness associated with them and can be blended with other compounds to minimize this effect. Once consumed, the glycosides break down into steviol, which is simply excreted; and glucose, which is used by intestinal bacteria and does not go into the bloodstream. So eating foods sweetened with stevia means a sweet taste without added calories.

5 | Can I grow stevia in Wisconsin? Stevia plants are not adapted to cold conditions but may be grown as annual plants in temperate regions (including in Wisconsin). However, growing plants from seed as an annual crop generally does not result in satisfactory results. Stem cuttings from mature stevia plants may be rooted and used to propagate stevia for growth in spring and summer.

Irwin Goldman is a professor and chair of the Department of Horticulture.

Photos courtesy of Anna Pidgeon

RUSSIA

Monitoring Russia's "rewilding"

Doing fieldwork in the remote wilderness of Russia isn't for the faint of heart. There are long distances to travel on deeply rutted roads, bleak outpost towns with meager accommodations, and bears and wolves to contend with. Plus—in the case of visiting American scientists—the constant presence of an armed guard who wasn't there to protect them from large carnivores.

"He was there in case we encountered illegal poachers," explains forest and wildlife ecology (FWE) professor Volker Radeloff, who has been visiting Russia in a research capacity for a dozen years, most recently with his fellow FWE professor Anna Pidgeon.

According to the duo (who are married), the opportunity to visit two of Russia's protected areas—the Kologrivksi Forest northeast of Moscow and the Caucasus Mountains in the south—is worth the trouble.

That's because Russia offers a unique case study for conservation scientists interested in studying the impact of land use changes on wildlife populations. After the fall of the Soviet Union, citizens abandoned the state's collectivized farms, leaving many of the agricultural fields to revert to a more natural state—and opening up new space for animals to live and roam.

"Their forests are regrowing and their wildlands are coming back, which is something we don't see in many other places on the planet—especially at that magnitude," says Radeloff.

Radeloff, an expert in using satellite imagery to monitor land use changes, can look at his remote sensing data and see that forests are expanding in Russia. But the images don't tell Radeloff and Pidgeon much about what's happening "on the ground" with local wildlife populations. For that, they need to partner with Russian scientists, working with them on their turf.

As an example, while satellite imagery can help identify promising habitat for the reintroduction of European bison into new areas within the Caucasus Mountains, many other factors will determine a herd's ultimate success.

"We identified an area that looked like good habitat, but the local scientists made it quite clear that this would not work because of the human context," says Radeloff. "They told us the bison would all be shot there within a week; they'd never survive. That's the kind of information we need that we cannot learn remotely and that nobody is publishing about in scientific journals."

That "human context" is a significant factor, even within the nation's protected areas. Animals are hunted for food by locals and for trophies by affluent sportsmen. In the southern Caucasus Mountains, ibex, a type of wild goat, are killed for their horns, which are used as wineglasses during traditional Georgian wedding ceremonies. The Saiga antelope of the Kalmykia are likewise poached for their horns, which are sold on the Chinese medicine market. These forces must be factored in.

Trips to Russia also enable Radeloff and Pidgeon to develop important scientific relationships. They regularly host Russian conservation scientists in their Madison labs, giving visitors the opportunity to work on short projects that can aid their efforts back home in Russia.

"Both of us are interested in capacity building, particularly in countries where the resources or training may not be quite as comprehensive as it is here in the United States," says Pidgeon. "These relationships lead to a cross-pollination that benefits both sides as we work to study and support wildlife populations in Russia."

—Nicole Miller MS'06

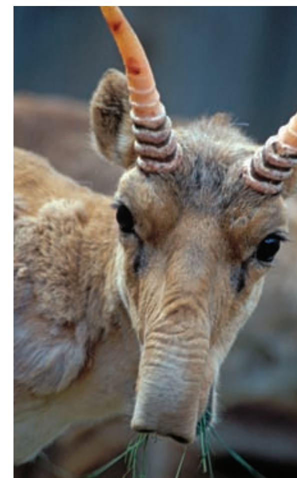


Photo by Igor Shpilenok/naturepl.com

(Top left) Wildlife ecologist Anna Pidgeon, in yellow cap, setting off in a skiff to reach Russia's Kologrivski Zapovednik, a protected area accessible only to staff and scientists. There and in other parts of Russia, she and colleague Volker Radeloff have been monitoring the presence and well-being of such animals as the European bison (top) and the Saiga antelope (above).

More Milk for China

CALS experts, led by dairy science professor **Pam Ruegg**, are providing training to help the Chinese meet a growing demand for dairy

Interview by Sevie Kenyon BS'80 MS'06

Tell us what you are doing in China.
I'm leading an interdisciplinary team from UW–Madison in working with the Nestle company to help develop a $400 million Dairy Farming Institute (DFI) in northeastern China. Our role in this, through a three-year, $1.7 million agreement, is to develop a teaching curriculum for farmers, consultants, veterinarians and others throughout China.

Can you describe what the Chinese are trying to address with these dairy initiatives?
There is an enormous demand for animal proteins, specifically milk protein, in China. People want to feed their children high-quality proteins, just like we want to feed our children high-quality proteins. And one of the best ways to do that is with our very nutritious product, milk.

This growing demand in China is so large that they're estimating that, by 2020, meeting that need would require an additional volume of milk equal to the entire output of the dairy industries in Australia and New Zealand combined. And that need can't be met entirely by imports. So there's a need to develop the Chinese dairy industry. The U.S. dairy industry and Wisconsin dairy suppliers are engaged in that work, and we are as well.

What can we here at CALS and in Wisconsin offer this new initiative?
Our role is a unique example of how the status of the Wisconsin dairy industry is recognized globally. We're recognized here in Wisconsin as being leaders in the dairy industry, and they came to us because of that. The Chinese industry is seeking that knowledge base that we have here, they're seeking the technology, and, specifically, the education we have here. They came to us and asked, "Could you help us develop a curriculum to help raise the overall level of our science knowledge base in a way that will result in safer and higher-quality food products?"

Please describe the project—how long is it going to last, how many people does it involve?
It will ultimately involve most people in the Department of Dairy Science and many people outside of it—for example, from the School of Veterinary Medicine and the CALS departments of biological systems engineering and agricultural economics. We've also got some curriculum designers from other colleges involved.

As noted, our initial contract is for three years. The first courses took place this past fall—a three-day, introductory-level feeding course and a more advanced course about reproductive management of dairy cows. It is very likely that the project will go well beyond the three-year initial course development period. The institute itself is meant to be permanent.

How did the first courses go? Who taught them and what did they report back?
Both initial courses were fully subscribed, and all indications are that they were very well received. The learners especially liked the practical, on-farm training and case studies that reinforced the scientific principles that made up the lecture portions.

For the first offering of these courses, several of

PAMELA RUEGG, DVM, is a CALS/UW–Extension dairy science professor and milk quality specialist whose expertise has taken her around the world. She has done international consulting work on milk quality and safety as well as enhancing on-farm implementation of best management practices to improve herd health.

Her latest work has taken her to the northeast province of Heilongjiang, China, where the Nestle company is establishing a dairy training facility. The Dairy Farming Institute is a key element of Nestle's effort to establish a larger, more reliable source of high-quality milk to supply its processing facilities in China. The institute will include a training center and three demonstration farms to teach farmers and dairy industry professionals the skills needed to manage larger, more sophisticated dairy operations. We sat down with Ruegg to discuss the university's role in it.

Photo by Wolfgang Hoffmann BS'75 MS'79

our faculty and staff from dairy science—professors Dave Combs and Milo Wiltbank, along with outreach program manager Karen Nielsen—flew to China to participate in the opening ceremony for the DFI and to work alongside industry partners and Chinese DFI trainers in delivering the classes.

Ultimately, after the trainers are fully competent with the course material, level 1 and 2 courses will be offered without direct teaching by UW faculty. We will continue to develop and revise curriculum for these levels and provide oversight and quality control. Higher-level courses for veterinarians and top managers will continue to be taught by UW faculty.

Describe the partnership with Nestle.

Nestle is the leader and the primary initial investor in the Dairy Farming Institute, but there are partners from all around the world, including our own dairy farmers here in Wisconsin. Land O'Lakes, which is, of course, a cooperative, is the feed partner at the Dairy Farming Institute. And there are other companies in Wisconsin as well who have invested in the Dairy Farming Institute. Our participation is also meant to support their success.

How may this benefit the state of Wisconsin?

It will certainly lead to additional opportunities for our students here. We're hoping that as this institute gets off the ground, we'll be able to offer internships and have student exchanges. We also, through our participation, are supporting the Wisconsin businesses and coops who are partnering with Nestle in the Dairy Farming Institute. We're hoping that our participation will ultimately enhance the markets for Wisconsin agribusinesses planning to contribute to the development of the dairy farming infrastructure in China.

> "We're hoping our participation will enhance the markets for Wisconsin agribusinesses."

Can you please look into your crystal ball for a moment and imagine what the Chinese dairy business might look like five years, 10 years, 20 years from now?

The first time I went to China was 10 years ago, and in that 10 years it's just been remarkable, the transformation of that industry. The industry is rapidly growing. There's a lot of investment in it. This particular project is meant to stimulate the development of Wisconsin-style farms—midsize dairies, for the most part, that are owned by private entrepreneurs, private farmers just like here. The goal of Nestle is to kind of replicate what we've got here that's so beneficial for our state and our industry, where we have a lot of independent producers producing milk in a very sustainable fashion.

Forever Rising

We depend on yeasts for products ranging from beer and biofuel to forage and pharmaceuticals. But according to Chris Todd Hittinger and his colleagues at CALS, we've only begun to understand and mine the possible uses of these hardworking model microbes.

by Terry Devitt

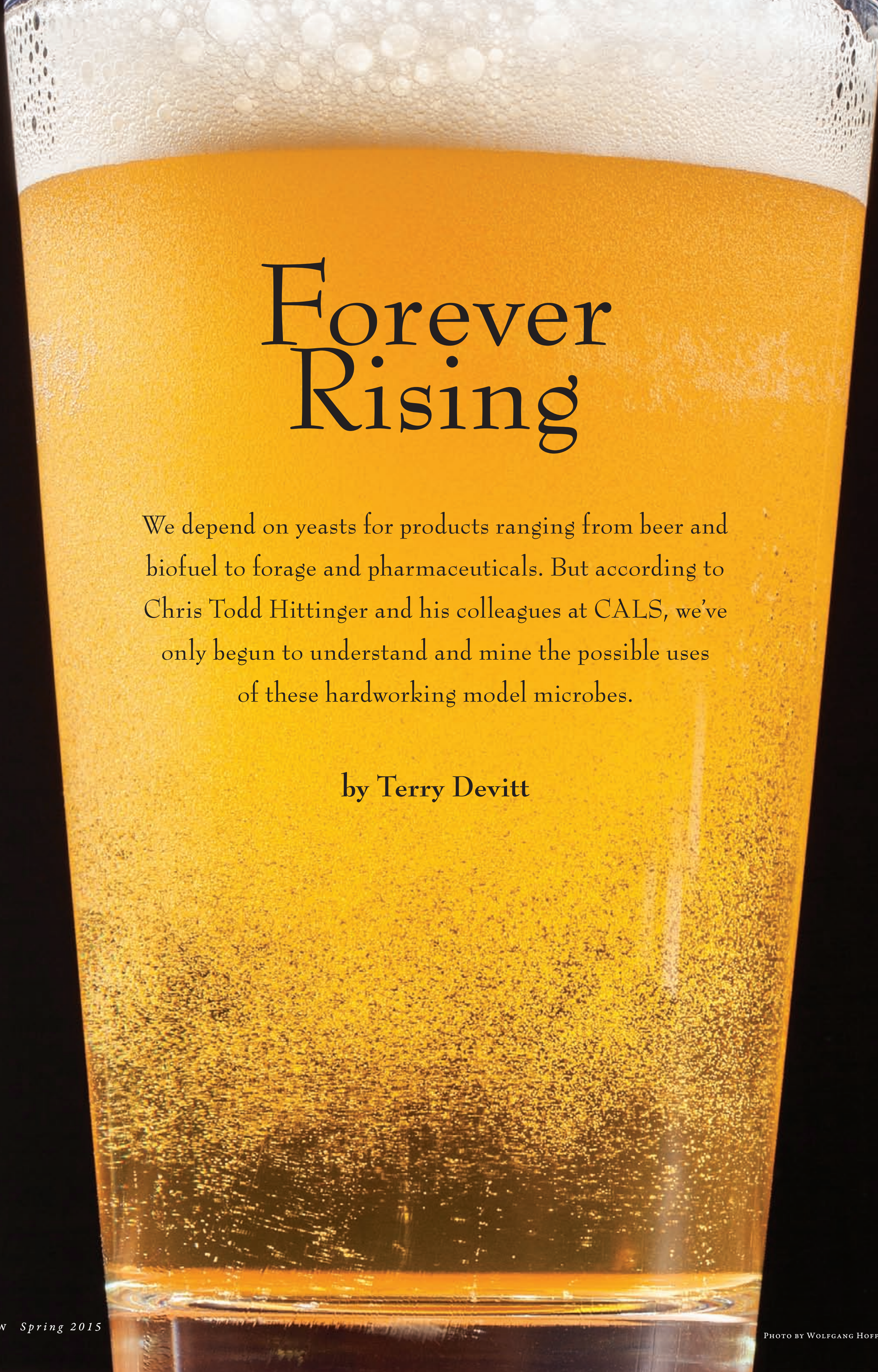


Photo by Wolfgang Hoffmann BS'75 MS'79

To begin to understand the outsized potential and sheer weirdness of yeast, it helps to consider the genetics behind one of the world's most successful and useful microorganisms. It also helps to consider lager.

Lager, or cold-brewed beer, is made possible by the union of two distinct species of yeast. About 500 years ago, these two species, *Saccharomyces eubayanus* and *Saccharomyces cerevisiae*, joined in a Bavarian cellar. They gave us a hybrid organism that today underpins an annual global market for lager estimated at one-quarter of a trillion dollars.

"We would not have lager if there hadn't been a union equivalent to the marriage of humans and chickens," notes Chris Todd Hittinger PhD'07, a CALS professor of genetics and a co-discoverer of *S. eubayanus*, the long-sought wild species of yeast that combined with the bread- and wine-making *S. cerevisiae* to form the beer. "That's just one product brewed by one interspecies hybrid."

Yeasts, of course, are central to many things that people depend on, and the widespread domestication in antiquity of *S. cerevisiae* is considered pivotal to the development of human societies. Bread and wine, in addition to beer, are the obvious fruits of taming the one-celled fungi that give us life's basics. But various strains and species of yeasts also are partly responsible for cheese, yogurt, sausage, sauerkraut, kimchi, whiskey, cider, sake, soy sauce and a host of other fermented foods and beverages.

Baker's yeast, according to yeast biologist Michael Culbertson, an emeritus professor and former chair of UW–Madison's Laboratory of Genetics, ranks as "one of the most important organisms in human history. Leavened bread came from yeast 5,000 years ago."

Beyond the table, the microbes and their power to ferment have wide-ranging applications, including in agriculture for biocontrol and remediation, as well as for animal feed and fodder. They are also widely used to make industrial biochemicals such as enzymes, flavors and pigments.

What's more, yeasts are used to degrade chemical pollutants and are employed in various stages of drug discovery and production. Human insulin, for instance, is made with yeast. By inserting the human gene responsible for producing insulin into yeast, the human variant of the hormone is pumped out in quantity, supplanting the less effective bovine form of insulin used previously.

Transforming corn and other feedstocks, such as woody plant matter and agricultural waste, to the biofuel ethanol requires yeast. Hittinger is exploring the application of yeast to that problem through the prism of the Great Lakes Bioenergy Research Center (GLBRC), a Department of Energy-funded partnership between UW–Madison and Michigan State University. Hittinger leads a GLBRC "Yeast Biodesign Team," which is probing biofuel applications for interspecies hybrids as well as genome engineering approaches to refine biofuel production using yeasts.

"There are lots and lots of different kinds of yeasts," explains Hittinger. "Yeasts and fungi have been around since Precambrian time—hundreds of millions of years, for certain. We encounter them every day. They're all around us and even inside us. They inhabit every continent, including Antarctica. Yeasts fill scores of ecological niches."

The wild lager beer parent, *S. eubayanus*, for example, was found after a worldwide search in the sugar-rich environment of Patagonian beech trees—or, more specifically, in growths, called "galls," bulging from them. (How *S. eubayanus* got to Bavaria hundreds of years ago and made the lager hybrid possible remains a mystery.) It is possible, notes Hittinger, to actually smell the *S. eubayanus* yeast at work, churning alcohol from the sugars in the galls themselves.

Though the merits of known yeast species for making food, medicines and useful biochemicals are numerous, there are likely many more valuable applications of existing and yet-to-be-discovered yeasts.

For Hittinger and the community of yeast biologists at UW–Madison and beyond, a critical use is in basic scientific discovery. The use of yeast as a research organism was pioneered by Louis Pasteur himself, and much of what we know about biochemical metabolism was first studied in yeasts.

Since the 1970s, the simple baker's variety of yeast has served as a staple of biology. Because yeasts, like humans and other animals, are eukaryotes—organisms composed of cells with a complex inner architecture, including a nucleus—and because of the ease, speed

Making lager beer possible: *S. eubayanus* yeast, a wild species that combined with *S. cerevisiae* to form lager, was discovered in these orange growths, or galls, on beech trees in Patagonia, at the southern end of South America. The yeast made its way to Europe some 500 years ago.

Photos by Diego Libkind/CONICET-UNComahue, Institute for Biodiversity and Environment Research, Argentina

and precision with which they can be studied and manipulated in the lab, they have contributed significantly to our understanding of the fundamentals of life. And because nature is parsimonious, conserving across organisms and time useful traits encoded as genes, the discoveries made using yeast can often be extended to higher animals, including humans.

"The model yeast, *S. cerevisiae*, has been instrumental in basic biology," says Hittinger. "It has told us something about the cell cycle, about cancer, about aging. In terms of understanding basic processes, it's a tough model system to beat. It's a champion model organism for genetics and biochemistry."

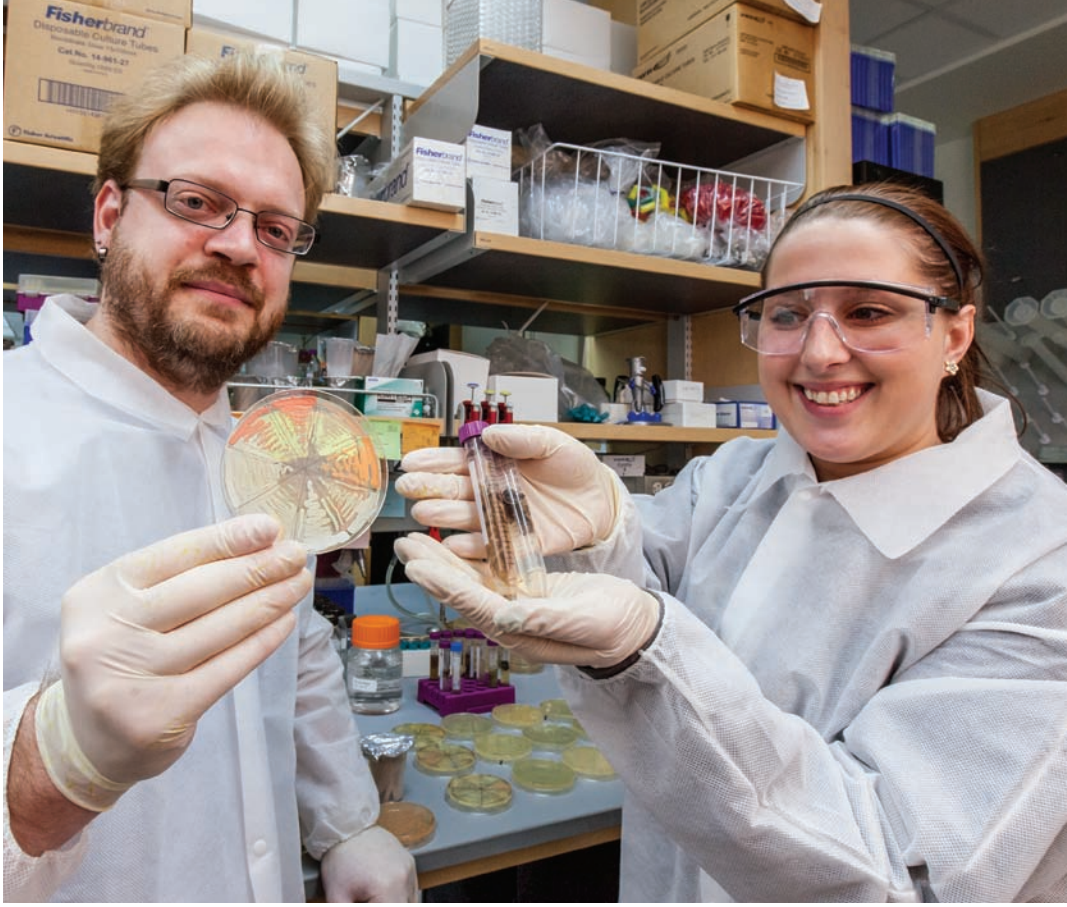
"It is widely unappreciated how the vast terrain of biology has been nourished by yeast," argues Sean B. Carroll, a CALS professor of genetics and one of the world's leading evolutionary thinkers. It was in Carroll's lab a decade ago as a graduate student that Hittinger first turned his attention to yeast, co-authoring a series of high-profile papers that, among other things, used the yeast model to catch nature in the act of natural selection, the proof in the pudding of evolutionary science.

Now the model is about to shift into an even higher gear. The work of Hittinger and others is poised to enhance the yeast model, add many new species to the research mix, and begin to make sense of the evolutionary history of a spectacularly successful and ubiquitous organism. The advent of cheap and fast genomics—the ability to sequence and read the DNA base pairs that make up the genes and genomes of yeasts and all other living organisms—along with the tools of molecular biology and bioinformatics promise a fundamental new understanding and order for yeast biology.

"This is all about weaponry," explains Carroll, noting that Hittinger, in addition to possessing "great bench-top savvy and skill," has armed himself remarkably well to exploit yeast genetics through the mutually beneficial prisms of molecular biology, evolutionary biology and bioinformatics (which harnesses computers to help make sense of the bumper harvests of data). "He has a determination and resolve to get the answer to any important question—whatever it takes," says Carroll.

The big questions on the table for Hittinger and others include ferreting out "the genetic factors that drive species diversification and generate biodiversity," and weaving that granular understanding into the larger fabric of biology. Because the functional qualities of all the various yeast species differ in order for the microbe to thrive in the many different environments it inhabits, the genetic code that underpins their different physiological and metabolic features varies accordingly.

In short, it takes a diversity of talents to inhabit every major terrestrial and aquatic environment the world has to offer. Species that thrive in South



Photos by Wolfgang Hoffmann BS'75 MS'79

Genetics professor Chris Todd Hittinger and research intern Kayla Sylvester BS'14 display a few of their many test tubes and petri dishes of wild yeasts. Hittinger's lab is making groundbreaking discoveries about yeast genetics and possible applications.

American tree galls and species that eke out a living on human skin require different skill sets in order to cope with vastly different environments and utilize different resources. Each of those skills is determined by the organism's genetic makeup, and as scientists discover and extract the lode of genomic data found in new species discovered in the wild, new and potentially useful genetic information and metabolic qualities will come to light.

These are big, basic biological questions. But their answers promise far more than simply satisfying scientific curiosity. Yeasts are big business. They are medically and industrially important. The secrets they give up will, without a doubt, amplify our ability to produce food, medicine and industrial biochemicals.

To lay the groundwork, Hittinger and an international collaboration of yeast biologists are setting out, with support from the National Science Foundation (NSF), to map the genetic basis of metabolic diversity by sequencing the genomes of the 1,000 or so known species of yeast in the subphylum that includes *Saccharomyces*. Three hundred times smaller than the human genome, a typical yeast genome consists of 16 linear chromosomes and, roughly, 6,000 genes and 12 million letters of DNA.

"This is the best possible time to be a yeast biologist," avers Hittinger. "Our collections have been vastly improved, and we can sequence genomes a hundred at a time. The important thing to know is that yeast is not just one organism or one species. There are thousands of yeasts, and they each have their own evolutionary history."

Acquiring new species from the wild and sequencing their genomes will enable Hittinger and his colleagues to construct an accurate yeast family tree.

"If we don't understand what's out there and how they evolved, we're not going to understand how to make use of them," Hittinger notes. "Now, we can rip 'em open, get a peek at their genomes and see what the differences are and how they've changed over time."

Thus stalking new strains and species of yeast in the wild is an essential part of the program, according to Hittinger, who routinely dispatches students, including undergraduates, to seek out new yeasts in nature. Half of all the known species of yeast have been described scientifically only within the past 15 years, meaning scientists have only a limited understanding of the world's yeast diversity.

"Until recently, most strain collections have been paltry and biased towards domesticated strains," says Hittinger. "If we can expand our understanding of the wild relatives, we can use them as an evolutionary model.

"Farm to Glass" and More:
Fermenting a Growth Industry

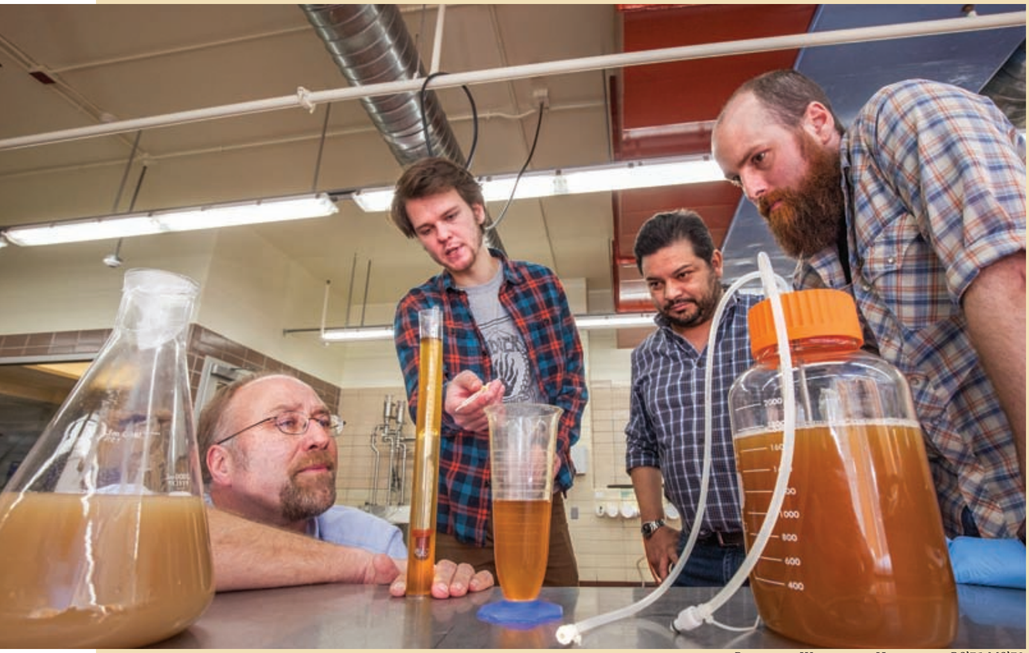


Photo by Wolfgang Hoffmann BS'75 MS'79

Food science professor James Steele (left) and students are creating a red lager to be brewed by the Wisconsin Brewing Company. Steele and colleagues are launching a fermented foods and beverages program to take research and teaching to the next level.

We all know Wisconsin as the land of beer and cheese. But in the not too distant future, Wisconsin may also become famous for other fermented products, notably wine and cider, thanks to growing public taste for those products and a blossoming wine- and cider-making culture in the Badger State.

Wisconsin now has about 110 wineries—up from 13 in 2000—and has been adding around a dozen new ones each year in recent years. Many of these operations could use some help, which is on the way in the form of a newly appointed CALS-based outreach specialist whose job is to support the state's wine and hard apple cider industry.

Leaders of the Wisconsin Grape Growers Association, the Wisconsin Vintners Association and the Wisconsin Winery Association worked with CALS faculty in food science and horticulture to apply for a Specialty Crop Block Grant to support the position through the Wisconsin Department of Agriculture, Trade and Consumer Protection, with the associations providing matching funds. The specialist is scheduled to start working in early 2015.

The position is part of a larger effort to boost fermentation in Wisconsin. CALS food science professor James Steele and his colleagues are laying the groundwork for a comprehensive fermented foods and beverages program through the Department of Food Science—a program that will take to the next level much of the research and teaching the department has been building on for decades.

Already the program is bearing fruit—or, one might more literally say, "bearing beer." Over the spring 2015 semester, students participating in Steele's Fermented Foods & Beverages Laboratory will create and develop a new red lager recipe to be brewed by the Wisconsin Brewing Company and sold at the Memorial Union.

A central goal of the program, Steele explains, is to help improve the quality of fermented food and beverage products. As such, the functional roles played by yeast to influence such characteristics as flavor, color and other attributes will be very much in the spotlight.

"Yeast is a key player, beyond the shadow of a doubt," says Steele. "It is extremely important, but from a food science perspective, it hasn't gotten a lot of attention."

With the help of yeast researchers such as Chris Todd Hittinger and his genetics colleague Audrey Gasch, Steele hopes to create an environment where the food science nuances of fermentation are teased out to the benefit of both growers and the producers of fermented foods and beverages.

The basic fermentation characteristics of various yeast strains are of interest, according to Steele: "For example, how does microbial physiology link to flavor in fermented beverages? These collaborations give us opportunities to look for new strains or develop new strains that could allow for the production of beverages with different flavors. And what we learn in one industry, we can apply to another."

Photo courtesy of A. B. Hulfachor

An array of foods and beverages powered in part by yeasts.

Yeasts have a much less well-developed history in ecology and natural history."

A recent yeast-hunting excursion in Wisconsin by one of Hittinger's students yielded three strains of the same *S. eubayanus* lager yeast parent found in tree galls in South America. Discovered near Sheboygan, the yeast has been cultured in Hittinger's lab and samples have been provided to CALS food science professor James Steele, whose group is setting up a new comprehensive program in fermentation science and, with the help of a gift from Miller-Coors, a new pilot brewery lab in Babcock Hall. (Steele is also looking to support other fermented beverages in Wisconsin—namely, wine and cider—in both production and education. See sidebar on page 20.)

"We grew up a few hundred billion cells, gave them to Jim Steele to brew beer, and we're eagerly awaiting the results," says Hittinger, who explains that another focus of his lab is making interspecies hybrids, such as the lager hybrid. "Now that we've identified the wild species, we can make crosses in the lab to make hybrids that produce flavors people are interested in."

In the food science realm, says Steele, yeast research is focused on the functional characteristics—fermentation qualities, sugar utilization, flavors—of a particular strain of yeast. "How does microbial physiology link to flavor in fermented beverages?" he asks.

Saccharomyces strains are the workhorse and best-known yeasts, including many of the most medically and biotechnologically important. With the $2 million award from NSF, Hittinger and his colleagues will use the genomes to develop a robust taxonomy of important yeasts and look for the genetic footprints that give rise to yeast biodiversity, an evolutionary history of their metabolic, ecological and pathogenic qualities. Such an understanding will elevate yeast to a new plane as a model and will undoubtedly serve as the basis of valuable new technologies.

Hittinger cautions, however, that sequencing yeast genomes is only a start: "We can very easily read gene sequences, but we don't yet know how to interpret them fully. We will need to read those bases and make functional predictions" to extend both the knowledge of yeast biology and their potential use in industry.

"But if it weren't for that natural diversity, we wouldn't be able to enjoy Belgian beers," says Hittinger, referencing the gifts conferred by different yeasts and their varied genetic underpinnings, resulting in the different flavors of ales, lagers and Belgians.

One of the central metabolic qualities of the familiar yeasts, of course, is their ability to ferment. Put simply, fermentation is a process by which cells partially oxidize or burn sugar. Among yeasts, the propensity to ferment in the presence of oxygen has evolved only in *Saccharomyce*s species and a few others.

"To make a living using this process, you have to be a glucose hog," says Hittinger. "But you don't burn it all the way. You leave some energy on the table. Ethanol burns because it is unoxidized fuel."

Different kinds of cells can perform fermentation if they become oxygen-starved. Human cells, for example, ferment when starved of oxygen, causing painful muscle cramps. Given enough sugar, cancer cells can ferment, and do so to survive in oxygen-poor environments.

Indeed, Hittinger's research on the cellular resemblance between *Saccharomyces* yeasts and cancer cells (for which he recently was named a Pew Biomedical Scholar) focuses on identifying which steps in yeast evolution were key to making the transition from respiratory to fermentative metabolic activity, as well as the sequence of those evolutionary events.

"Armed with that information, we should be able to shed some light on how cancer cells make that same transition over an individual's lifetime," says Hittinger.

Genes, Hittinger knows, hold the secrets to the functional qualities of yeast. Those microbial secrets, in turn, promise us food, fuel, pharmaceuticals—and, of course, beer. Like bread and wine, the gift of lager is no small thing. Who knows what other gifts, large and small, may lurk in the genes of these microorganisms?

Headed into the wild? If so, you could help Chris Todd Hittinger's team identify new yeast species and strains. To learn more, visit http://go.wisc.edu/wildyeast

To watch an interview with Chris Todd Hittinger, visit http://go.wisc.edu/hittingerinterview

INSECTS

Out of the drawers, into the cloud: Entomologist Daniel Young is directing an effort to put the University of Wisconsin Insect Research Collection online.

Photos by
Wolfgang Hoffmann BS'75 MS'79

ENTOMOLOGY PROFESSOR DANIEL YOUNG PRESIDES OVER A PRODIGIOUS COLLECTION OF BUGS ON CAMPUS. THANKS TO DIGITAL TECHNOLOGY, THIS COLLECTION AND MANY OTHERS WILL SOON BE AVAILABLE ONLINE FOR EVERYONE TO LEARN FROM AND ENJOY.

FOR ALL

By Ron Seely

LIFE'S ASTOUNDING DIVERSITY is rarely more apparent than on a warm summer night when the porch light glows and we are ensconced behind a protective mesh of screen, reading or dozing after dinner.

It is then that the din begins to rise in the gathering dusk.

From out there, beyond our domestic ramparts, the buzzing, fluttering horde is gathering. Soon the screen will billow and dance beneath their numbers—emissaries from a class that is as profligate and strange as any ever created by even the best of our science fiction masters.

June beetles. Katydids. Moths and crickets. Beetles. Mosquitoes and no-see-ums. Mayflies. Lacewings. The constant tick and ping of their assault on the screen is a reminder that we humans are but bit players in a world that really belongs to them—the insects.

Behind our screens we fight a nervous and mostly futile holding action.

Most of us have little idea what we're really up against when we array our meager weapons against the insects—our sprays and our treated jackets and head nets and our zappers and swatters.

But there is a place on the UW–Madison CALS campus that might give you a pretty good idea of why we are largely at the mercy of this winged, barbed, needle-nosed, multi-legged, goggle-eyed empire.

Welcome to the University of Wisconsin Insect Research Collection, one of those wonderful hidden gems of curated knowledge. Open the door and you drop down Alice's rabbit hole into a world of carefully preserved dung beetles, walking sticks and enough mounted lice to give even the most stoic grade-school mom nightmares.

Entomology doctoral student Craig Brabant demonstrates use of the department's new digitization camera, which quickly photographs entire trays of insects.

Stashed in a warren of rooms on the third floor of Russell Labs—and in an annex on the third floor of the Stock Pavilion—are more than 3 million curated insect specimens, along with 5 million more unsorted bulk samples preserved in jars and tiny vials of ethyl alcohol.

You will find hundreds of thousands of every kind of insect you can imagine, meticulously arrayed in glass-topped wooden drawers in rank upon rank of cabinets. Here are specimens from around the world collected over the last 170 years by a cast of brilliant characters ranging from an entomologist who was known internationally for studying and espousing insects as food to a curious young naturalist who tragically died in a car crash at age 33 and left behind as pets two parrots, a boa constrictor, and two large spiders.

In Russell Labs, the collection is approached down a hallway guarded by glass cases of mounted moths, butterflies and one giant walking stick large enough to hang laundry from. Inside are walls and aisles lined by so many cabinets and drawers that they challenge the extravagance of Kim Kardashian's walk-in clothes closet. But here, instead of the scent of perfume, you will be greeted by the distinctive but not altogether unpleasant lingering odor of naphthalene, once used to keep live bugs from eating the mounted dead bugs.

You will also likely be met by entomology professor Daniel Young, the collection's enthusiastic director. Chances are he will be wearing a T-shirt that depicts an insect of some sort. At our first meeting, he sports a shirt from the 2006 meeting of the Entomological Society of America. Once you get to know him, his wardrobe seems the least unusual thing about him. In fact, Young, like just about everyone who has anything at all to do with this remarkable collection of insects, seems as pleasingly eccentric as any of the myriad species in the giant insect mausoleum he tends.

On one visit, Craig Brabant, one of Young's graduate students, is busy in the lab and hardly looks up at an inquiry about his professor's whereabouts.

"Oh, he's back there with his beetles somewhere," Brabant said with the nonchalance of a dedicated and somewhat distracted bug person.

When Brabant refers to "Young's beetles," you have to understand what this truly means. Young has traveled the world in search of beetles—specimens of the order Coleoptera. This has been his passion since boyhood, when he fished for trout with his father in Michigan and paid close attention to the flies the fish slurped from the surface of such rivers as the Au Sable and the Pere Marquette.

Young's course as a prolific collector of beetles was set when he was an undergraduate at Michigan State University and a fellow student who collected beetles suddenly became more enamored with bees that pollinate cucumbers. He turned his beetle collection over to Young—and ever since, Young has never met a beetle he didn't want to name and classify.

Just how big a task does Young face in his chosen field of study? There are more than 300,000 species of beetles, he says, compared with 4,000 species of mammals. In his book *The Variety of Life*, Colin Tudge writes that about a fifth of all known animals are beetles. Yet Young keeps tilting at his own private windmill. For more than 40 years he has collected more than 200,000 specimens—and that collection now resides in the cabinets in Russell Labs.

Flower flies, from the family Syrphidae

Now young is faced with an undertaking that seems almost as daunting as putting the world's beetles in order. He is overseeing the Department of Entomology's ambitious effort to digitize the entire insect research collection, taking digital photos of all the insects and putting them online as part of a web-based project called InvertNet, which stands for Invertebrate Collections Network.

Lest you fear for Young's sanity, he will not be spending the rest of his career snapping photos of millions of insects. The project, a collaborative effort involving 22 Midwestern insect collections housing more than 50 million specimens, has been made possible by the development of a robotic digital camera that can image an entire drawer of mounted insects in seconds.

The department took delivery of the unique $6,800 camera in November and, like kids with a present on Christmas day, Young and his students began playing with it immediately. Installed in a place of honor on a desk in one of the research rooms next to its controlling computer, the camera is a marvel of robotic engineering. Ensconced in a steel frame and suspended from three arms that are outfitted with multiple springs and gears, the camera is designed to move precisely and rapidly above a brightly lit drawer of mounted specimens. Its movement, programmed by the computer, is mesmerizing. With a soft hum, it crawls back and forth and up and down, as insect-like in its movements as the creatures it photographs.

With the camera, the job of digitizing the Wisconsin collection, along with more than 20 other such collections throughout the Midwest, becomes not only manageable but also affordable, according to Young. Until now, such an effort was slow and costly, about $1 per specimen as opposed to 10 cents per specimen with the new camera. It also minimizes the risk of damaging delicate specimens. And the camera does not take just a single image of a specimen; it captures multiple angles so that a researcher will be able to manipulate the photograph to see different parts of each insect, almost as if it were in 3-D.

Even with the advanced camera, Young estimates that getting the entire collection photographed and onto the web could take as long as two years. But the benefits, he adds, are many. Fewer than 5 percent of invertebrate collections in the U.S. are available online. And making collections available at the click of a computer key will make the knowledge that they preserve much more broadly available, not only for researchers but also for a lay public that is endlessly fascinated by bugs—but frequently poorly informed about their value in the web of life.

"Many of the advantages are for the taxonomic community," Young says. "I can't just up and visit all the collections in the world. But if I can remotely see them, I can point out a drawer to a local curator. I can even point to a particular part of a drawer, specific specimens, and ask the curator to loan them to me."

"There is also a tremendous potential benefit for education and outreach," Young continues. "This adds a new dimension. We can export images to K–12 students so they can remotely visit the collection. They can pull out the drawers and look at that specimen that was collected in 1890. The bottom line is that we have to make this relevant beyond the taxonomic community."

Understanding the value of having the insect collection available online requires appreciating the value and intrigue of such collections to begin with. Such an appreciation comes not only from recognizing the wealth of scientific data they harbor, but also from hearing the stories of how a particular collection came to be. The Wisconsin lab is fairly haunted by all of those, professional and amateur, who at one time or another wielded their insect nets in a pasture or woodlot to add specimen after specimen, drawer after drawer, cabinet after cabinet—lately to the tune of about 21,000 specimens a year.

Their names are all there in the drawers, forever connected to their insects by the information on the tiny white tags attached to each pinned specimen. The slips of paper contain in black type the collectors' names and very concise descriptions of the insects and the details of their capture ("Found dead in the middle of a dirt road," reads the short story of one tiny, nondescript beetle). Now the names of insect and collector alike will be forever preserved in the digital ether of the World Wide Web.

Consider, for example, the 16,050 syrphid, or flower flies, collected by Charles L. Fluke, the first director of the research collection. His collection is considered among the best in the nation, according to Young, and Fluke's accomplishment is recognized by a room named in his honor.

Or there are the approximate 14,000 mounts and 6,000 slides of mosquitoes collected from around the world by Robert J. Dicke. And 175,000 aquatic insects, almost all of them from Wisconsin waters, collected by William Hilsenhoff. "There was hardly a lake, river or stream he didn't sample," says Young.

Metallic wood-boring beetles (*Euchroma gigantea*)

Of all the individuals who have contributed to the Wisconsin collection, few have a story that can match that of the late Gene DeFoliart, a long-time CALS professor of entomology who studied how insects spread viral diseases. In the early 1970s, however, DeFoliart became fascinated with insects as an important food source throughout the world. He developed an international reputation for his expertise on the subject. His work even got a comedic nod from Johnny Carson, who joked about DeFoliart and "roast of roach."

Young and others recall DeFoliart serving up various insect concoctions in the department. His daughter, Linda DeFoliart BS'81, who now lives in Alaska, remembers her father bringing home leftovers.

"I remember he brought us mealworm and sour cream potato chip dip," says Linda. "And deep-fried crickets. We reheated those in the microwave. They had the consistency of popcorn and they kind of stuck in your teeth."

But Linda also recalls her father's obsession with collecting and stories about him as a boy growing up in rural Arkansas, riding around on his bike with his butterfly net and a glass jar of cyanide—his "kill" jar. His passion and his insects are forever preserved in the Wisconsin collection—hundreds of mosquitoes, 1,500 slide-mounted lice, and 5,000 butterflies and skippers that Linda and her siblings donated after Gene DeFoliart's death in 2013.

"We decided to donate the collection to the university because we thought that was where Dad would have liked for it to reside," says Linda.

THE COLLECTING AND NAMING AND CLASSIFYING continue today. In Mequon, a dermatologist named Peter Messer is a well-known amateur taxonomist who has become a recognized expert on ground beetles, one of the most species-rich families in the entire beetle group. He is regularly published by entomological journals, and in a 2009 published survey he identified 87 species of Wisconsin ground beetles not previously recorded from the state, some of which he collected in his backyard. His beetles are well represented in the Russell Lab collection.

"There is great satisfaction in knowing almost everything about something that hardly anyone else knows about, and then conveying that knowledge to others," says Messer.

Young emphasizes that the digital images and online availability do not diminish the need for the actual physical collections gathered over the years by all of these dedicated souls. Today, for example, much of the research on insects involves studying their DNA for clues to mysteries ranging from identification and evolutionary change to the insect's potential role in understanding the spread and treatment of disease.

"Now that we have the image, we still need the specimen. The image isn't a substitute. Specimens can give you DNA," Young says. "Here's the thing—we don't even know what these collections can give us. We weren't even talking DNA 40 or 50 years ago."

According to Young, the collection has also become an important resource for scientists studying climate change, another phenomenon that could not have been foreseen in the early years of the collection. Each specimen, Young explains, represents not only the body of an insect but a preserved point in time. Knowing what insects existed in what places and at what periods allows researchers to trace changes on the landscape.

"Some see a dead beetle on a pin; we see a collection event, a rich story that continues to unfold with potential 'plot twists' we are not yet even aware of," says Young.

But just for purposes of identifying and classifying insects, collections are invaluable. Collecting involves the wonderfully strange discipline of taxonomy, the scientific process of placing organisms into established categories and the use of hierarchical groupings with names that we all struggled to memorize in high school biology—domain, kingdom, phylum, class, order, family, genus, species. Though it might seem an arcane art to some, taxonomy is a fundamental and essential step toward understanding the natural world and how it works.

"People are intimidated by it," Young says. "It looks like a tedious, potentially boring mystery. But we are all taxonomists. Let's say you want a box of butterscotch Jell-O pudding when you go to the store. Do you know what aisle to look in? Or is it just randomly placed in the store?"

"The first question everyone asks when they contact us about an insect is, 'What is it?' The second question is, 'What does it do?'" Young continues. "The first question is taxonomy. The second is about ecology and natural history—and without the taxonomy, you can't tell anything about the ecology and the natural history."

A close colleague of Young's—Darren Pollock, professor and head curator of collections in the Biology Department at Eastern New Mexico University—tells how he was able to use the Wisconsin collection to identify a previously undescribed species. Like Young, he specializes in beetles, specifically (among others) of the genus *Mycterus*. This particular taxonomic adventure started when Young sent

(Left and below) Ichneumon wasps, from the genus *Megarhyssa*

(Bottom) Beetles named for CALS' Daniel Young by colleague Darren Pollock: *Mycterus youngi* Pollock

Pollock some *Mycterus* specimens from the Wisconsin collection.

"Specimens can 'languish' in collections for years, decades or even centuries," says Pollock. "More than a few of these specimens were collected decades ago, in the late 1940s. And then they sat. And sat. Until I looked at them."

"It was obvious to me that these old Wisconsin specimens represented a totally new species, the closest relative of which is a species from southern Florida," says Pollock. "Now they are all labeled as type specimens of the recently described species *Mycterus youngi* Pollock!" (The "*youngi*" is for Daniel Young.)

This enthusiasm, so typical of those drawn to taxonomy and exemplified in collectors such as Pollock and Messer, seems to come not only from a preoccupation with order, but also from a deeper desire to acknowledge and name insect life even as we hasten its passing from the planet. Young says the most rational estimates place the number of insects with us right now at between 3 and 5 million. And, he says, only about 20 percent of them have been identified. It helps explain the almost manic drive of taxonomists to discover and describe and label.

"When there are 30 species in a genus and you've collected 29 of them," Young says, "guess what you're going to be doing next summer?"

Pollock praises the Wisconsin collection for its size and diversity. And, like Young, he sees such collections as arks that affirm our connections to the natural world and solidify those ties by giving even the tiniest speck of buzzing, darting life a name and a nod for just being.

And then there is the ticking clock.

Collections are also repositories for what we've lost. Though they seem ubiquitous, insect species are going extinct at an alarming rate, according to a study by entomologist Robert Dunn of North Carolina State University. He estimates that hundreds of thousands of insect species could be lost over the next 50 years. The reasons are many, but habitat loss is a major culprit. Monarch butterfly populations, for example, are suffering because of the destruction of the Mexican forests where they winter.

And Young says he knows many areas where he used to collect, especially in southeastern Wisconsin, that are now paved and developed, the insects he once found no longer in evidence.

Young doesn't know for sure how many extinct or extirpated species are represented in the Wisconsin collection. But he knows there are many resting in the drawers, their stilled, pinned forms a rebuke to a world that took little or no notice of their existence or their passing.

The UW Insect Research Collection (WIRC) may be found at http://labs.russell.wisc.edu/wirc/. The digitized collection from the Invertebrate Collections Network is at https://invertnet.org/.

If you wish to support the collection, please make your check payable to UW Foundation and send it to UW Foundation, US Bank Lockbox 78807, Milwaukee WI 53278-0807. On the memo line, write Entomology–WIRC.

Unpuzzling Diabetes

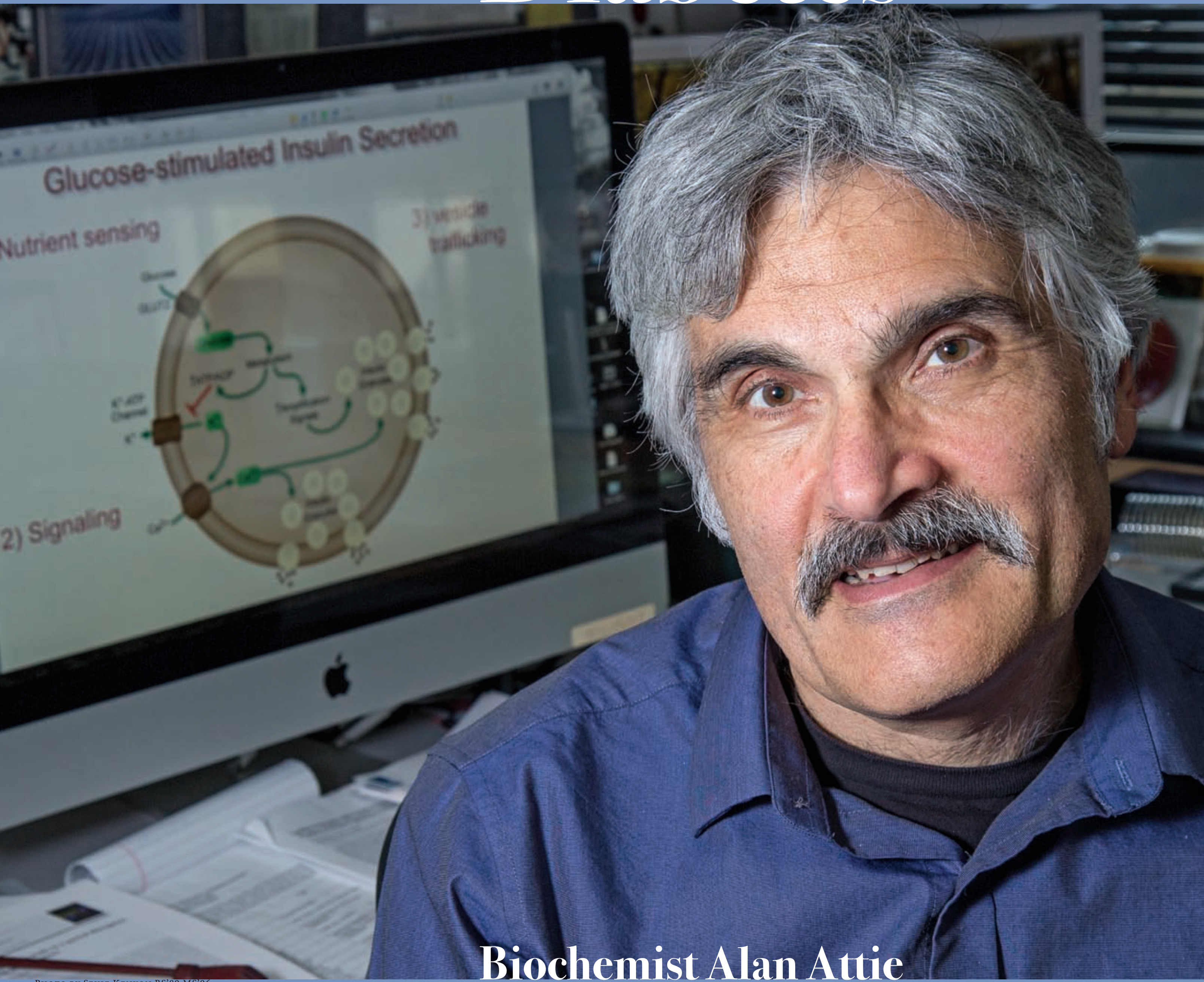


Photo by Sevie Kenyon BS'80 MS'06

Biochemist Alan Attie tracks the internal mechanisms behind a fast-growing disease that takes millions of lives each year

By Erik Ness

The body makes it seem so simple.

You take a bite of supper, and the black-box machinery of metabolism hums into life, transforming food into fuel and building materials. It's the most primal biology: Every living thing must find energy, and must regulate its consumption.

But for an alarming and ever-increasing number of people, the machinery breaks down. The diagnosis? Diabetes.

Alan Attie, a CALS professor of biochemistry, has been peering into the black box for two decades now, trying to identify the pathways in our bodies by which the disease is formed. "You can't find a better excuse to study metabolic processes than diabetes," he says. "It's very, very rich."

Type 2 diabetes, caused by an inability to produce enough insulin to keep the body's blood glucose at normal levels, is a global health crisis that has accelerated at a frightening speed over the last 20 years—roughly the same time Attie has been studying it.

It's an enormously complex disease driven by both genetics and the environment. A DNA glitch here, an external variable there, and the body slides irretrievably out of balance. But only sometimes. Most people who develop type 2 diabetes are obese, yet most people who are obese don't actually wind up diabetic.

Tracking this riddle has led Attie and his lab to several major discoveries, chief among them identifying two genes associated with diabetes: Sorcs1 and Tomosyn-2. Through years of elaborate experimentation, Attie and his team teased them from the genetic haystack and then relentlessly deciphered their role in metabolic malfunction.

Science has uncovered more than 140 genes that play a role in diabetes, yet genetic screening still has little value for patients. As with any part of a large and complicated puzzle, it's hard to see precisely how Sorcs1 and Tomosyn-2 fit in until we have more pieces. The biology of diabetes is so complex that we can't be certain what the discoveries may ultimately mean. But both genes have shed light on critical stages in metabolism and offer intriguing targets for potential drugs.

Attie need not look far to replenish his motivation. His own mother suffers from diabetes, and she used to quiz him weekly about when he would cure her. "The painful answer is that translation of basic research into cures takes a long time," Attie once told the American Diabetes Association. "The most important clues that can lead to cures do not necessarily come from targeted research or research initially thought to be relevant to the disease."

Alan Attie grew up an expatriate in Venezuela, where his father, Solomon, originally from Brooklyn, New York, ran a textile factory (Attie's mother had family in South America). Poverty and then World War II had kept Solomon from traditional schooling, but he managed to put himself through high school at night, and he nurtured a deep passion for literature, poetry, history and politics. At home he ran the family dinner table like a college seminar. "Our evening meal was like a 20-year course," recalls Attie. "It was the most stimulating part of our day growing up. I was reading Shakespeare with my father and my siblings when I was 10 years old."

Still, Attie wasn't quite prepared for the academic rigor of UW–Madison when he arrived in 1972. He'd never had to work particularly hard in high school and was shocked by how much time and effort college required. His grades were poor and his introduction to chemistry lackluster.

Why do some mice become diabetic when they are obese—like the mouse on the left—and others not? This pair carries a mutation in determining genes, such as Tomosyn-2 and Sorcs1, which Attie's lab identified.

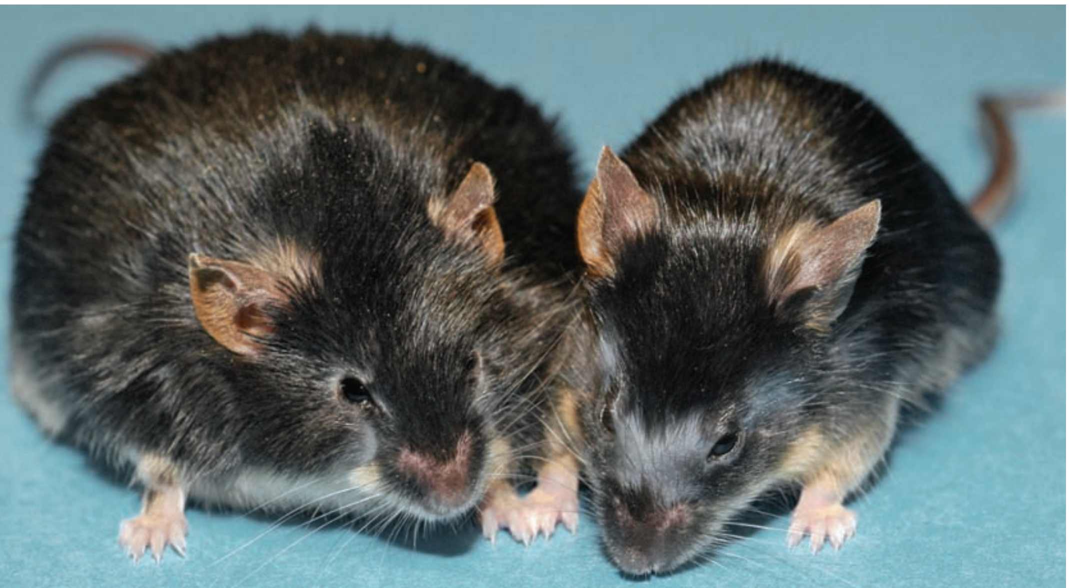


Photo courtesy of Alan Attie

But the BioCore curriculum—an intercollege program focusing on doing science, not memorizing facts—turned Attie's natural inquisitiveness and enthusiasm toward science. During a cell biology course where his lab reports had to be written like journal articles, Attie decided he really wanted to be a biologist. Following graduate school at the University of California, San Diego, he found himself back at UW–Madison as a young assistant professor. Ten years had passed since his freshman matriculation.

Attie's first research focus was cholesterol metabolism, but his curiosity led him elsewhere. Until 2001 he held a joint appointment with the School of Veterinary Medicine, where he taught an introductory class in biochemistry. While preparing for the class he read broadly in metabolism and found himself continually drawn toward the quandary of diabetes.

Increasingly he found himself suffering from "discovery envy," he says. "And then I finally decided one day I *do* want it to be me." Midcareer course changes are never easy, but Attie plotted a careful transition that gained momentum with hard work and good fortune.

In 1992 Dennis McGarry, a prominent diabetes scholar, published a provocative thought experiment in *Science*. It had been observed for centuries that diabetics had sweet urine, and one of the earliest researchers in the disease, Oskar Minkowski, had surmised that diabetes was therefore a dysfunction of sugar metabolism. McGarry speculated that if Minkowski had had no sense of taste and had relied instead on the smell of a diabetic's urine, he would have smelled ketone bodies, a hallmark of lipid metabolism. Might he have concluded instead that diabetes was a defect in lipid metabolism?

Soon afterward, McGarry and Attie wound up at the same research symposium in Edmonton and shared breakfast every morning. "I'm really interested in diabetes," said Attie. "Is there room for someone like me who has been working on lipid metabolism for 20 years?" McGarry encouraged Attie, a pep talk that gave him confidence that maybe he wasn't committing career suicide.

Gradually Attie's new focus gathered steam. When another UW diabetes researcher left for Washington state, Attie was able to bring on researcher Mary Rabaglia from that lab. She was highly skilled in the lab manipulation of pancreatic islets, the home of the beta cells that produce insulin. Her arrival jump-started Attie's efforts. "It was an unbelievable stroke of luck because she brought all that expertise," says Attie.

Attie also felt he needed a new analytical toolbox, and he saw real potential in using mouse genetics to study diabetes. With one small problem: He didn't know any genetics. So he went to the Jackson Laboratory in Bar Harbor, Maine—a global center of mouse research—and took a mouse genetics course (which he now teaches there).

The learning soon paid off. Gene chip technology was just becoming available, and industry pioneer Affymetrix was looking to commercialize the expensive technology. The company was interested in funding labs to demonstrate that the power was worth the price. Attie proposed looking at how genes were turned on and off in the fat-storing cells of diabetic mice, and Affymetrix approved the project.

Exploring gene expression—which genes get turned on and off—was an important first clue in figuring out which genes might contribute to diabetes. With thousands of proteins and a still unknown quantity of genes in play, diabetes is vexingly elaborate. Gene chip technology brought previously unimaginable power to the equation. "The reason for doing genetics is we can't imagine the complexity of these processes," Attie explains. "We really do need the serendipity of genetics to find our way."

Attie sent Sam Nadler, a new M.D./Ph.D. candidate, off to Maryland and California for training. It was an ambitious project, and the old analytical tools broke under the mountain of new data. Enlisting the help of Brian Yandell, a CALS professor of horticulture with a joint appointment in statistics, they were

Photo by Sevie Kenyon BS'80 MS'06

Postdoctoral scholar Melkam Kebede: Her observations at a microscope were key to understanding the function of Sorcs1-deficient cells.

able to interpret their data.

In late 2000 the team published the first paper on genome expression changes in diabetes using gene chip technology. It was premature to get too excited—they were, in effect, translating a book of unknown length, and had only finished the first of many chapters.

But it was an important demonstration of the power of their new tools. And Attie and his lab were now a known quantity in the world of diabetes research, and part of the conversation.

Attie's team could now assess any DNA they got their hands on, but there was still too much static hiding the working genes. Only by basing his experiments on other, more tangible clues could Attie find anything useful.

He decided to tackle the obesity link. "Most people who have diabetes are obese, but most people who are obese don't have diabetes," he notes. To get at the problem, Attie's team took two strains of lab mice: a standard control strain known as "black 6" (B6) and a diabetic strain (BTBR) that, when the mice became obese, were diabetic. The team intercrossed the two strains for two generations, testing the second generation of mice for diabetes. Offspring were strategically bred to enable the lab to pinpoint the genes responsible for diabetes susceptibility.

The collaboration that had begun with Brian Yandell now expanded to include Christina Kendziorski, a professor of biostatistics with the School of Medicine and Public Health. Teasing conclusions from large data sets was an exciting new field, and the team saw real potential for developing new techniques—and they had the statistics grad students to do it. Some even took up residence in Attie's lab to be closer to the puzzles cascading from each successive experiment. It was like game after game of Clue, only with a half million possible rooms, a half million possible murder weapons, and a half million possible suspects. And as many homicides as you wanted to look for. Some computations took days.

Ultimately they were looking for genes, but what they found at first were just general target zones, located on chromosomes 16 and 19. That was a big first step, but chromosomes are constructed of many millions of base pairs—the building blocks of DNA. Considered relatively small, chromosome 19 still runs to about 61 million base pairs. The first round of sifting reduced the search zone to a neighborhood with only 7 million base pairs, an almost 90 percent narrowing of the field.

Pinpointing the gene required a constant shuffling of the genetic deck, counting on the random nature of sexual reproduction to winnow away the chaff, revealing the kernel of the gene. It's a process that can take years, measured in mouse generations. Finally, in 2006, they were able to pinpoint the precise location of Sorcs1. It was a triumph, but it also set the stage for heartbreak.

Meanwhile, other projects kept rolling. Sushant Bhatnagar, a postdoctoral scholar in biochemistry, was working on the other target zone—chromosome 16. In 2011 he zeroed in on Tomosyn. "It was crazy," he says of the work needed to sift through so many mouse generations.

But in the end they discovered that Tomosyn-2 played a critical role in diabetes. Tomosyn was also more willing to give up its secrets. Most of the myriad proteins in a beta cell are positive regulators, which means they facilitate flipping the insulin switch to "on." Tomosyn is an off switch—one of very few known to exist.

Though mouse and human diabetes are different, the lab confirmed that the human version of Tomosyn plays a similar role. Now the challenge is using the clue to develop a targeted therapy.

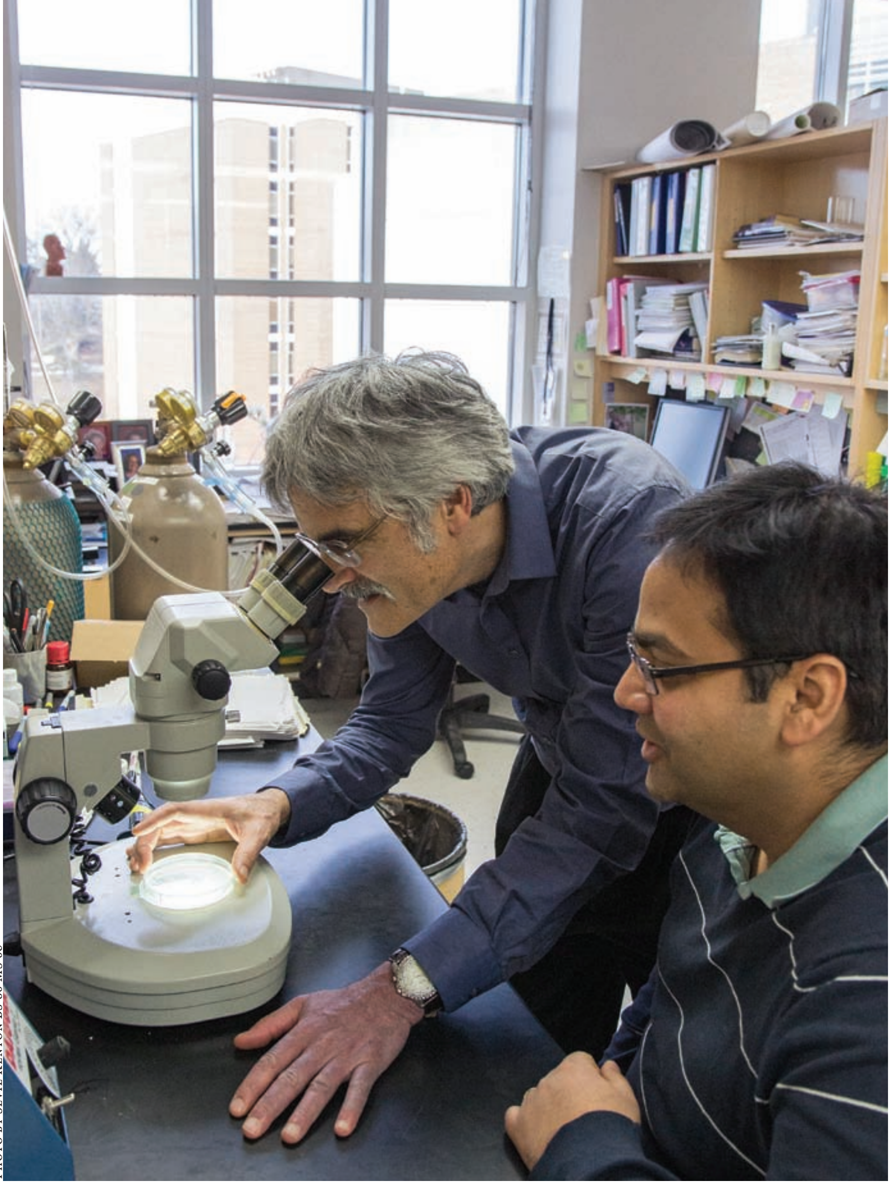


Photo by Sevie Kenyon BS'80 MS'06

Attie with postdoctoral scholar Sushant Bhatnagar, who focused on Tomosyn.

"Loss of insulin secretion leads directly to diabetes," Bhatnagar explains. "If you can fix insulin secretion you can fix the majority of diabetes."

Finding Sorcs1 had been difficult enough, but unlocking how it worked would prove devilishly complex. Two students tried and failed, and eventually left research altogether, demoralized by the dead ends. Attie felt terrible. "I always feel responsible for everything that goes on in the lab," he says.

Then, in 2012, Attie welcomed a new postdoctoral scholar. The only problem was that Sorcs1 was a beta cell problem, and Melkam Kebede did not come to Madison to work on beta cells.

A child prodigy from Ethiopia by way of Australia, Kebede was through college by age 18 and had her Ph.D. at 23. After spending most of her career on beta cells, she was looking for something different in her second postdoctoral position. Able to go almost anywhere, she chose Madison, and Attie.

"Of all the places I interviewed, Alan was the most passionate about teaching," Kebede says. And she liked the way he encouraged people. She'd always been told that she was exceeding expectations, and nobody challenged her during interviews. Except for Attie. "I wanted someone to push me more, so I can do more than what I've been doing," she says.

Pushing people, of course, is a delicate process, and easily fumbled. Attie instead seems to pull with a magnanimous curiosity. And with Kebede he was patient but persistent. Attie would keep asking: Why were the Sorcs mice diabetic? "You still have the parents of these mice waiting in the hallway at the hospital," he would say. "They are buying so many coffees. You've got to come up with a reason why they are diabetic."

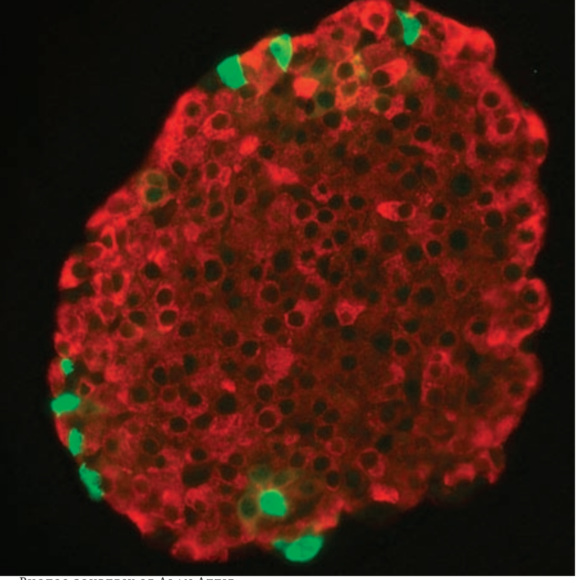
Finally, Kebede couldn't resist the puzzle—the opportunity to find the link between obesity and diabetes. While the lab hadn't cracked Sorcs, they had narrowed the focus. And Angie Oler, an invaluable technician with 20 years of experience, would help her get the end game rolling.

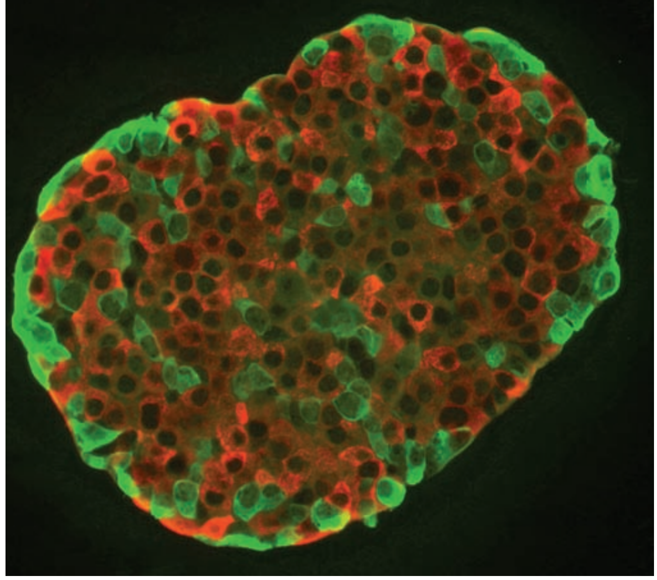
In an obese person, cells do not respond completely to normal insulin levels—this is called insulin resistance. To compensate, the body typically produces more insulin. Type 2 diabetes develops when the insulin resistance outpaces the body's attempt to make more. Sorcs seemed to play a role, but how?

"There are so many things in the body that contribute to controlling glucose levels in the blood," Kebede explains. A beta cell has to sense an increase in glucose and secrete insulin, which then triggers other reactions that lead, ultimately, to glucose being removed from the blood and absorbed by the cells that need it. Sorcs1 could work anywhere in this great game of cellular call and response.

Despite all of the genetic and biochemical tools at Kebede's disposal, it was ultimately a simple observation in a microscope that yielded the key. Insulin is manufactured in advance and stored by beta cells in the pancreas, then released as needed. Typically only 1 to 4 percent of the insulin is released at any one time, and a healthy beta cell would simply reload and release more insulin as needed. Examining hundreds upon thousands of cells, Kebede realized that the diabetic beta cells were partly emptied of insulin—but not enough to reveal an insulin secretory dysfunction.

The problem was that a standard lab testing for insulin production was a one-shot deal. The Sorcs1-deficient cells could handle that first test, but not a second test. Finally she understood: The diabetes was caused not by a lack of insulin, but by a failure to reload in a timely way.





Pancreatic islets tell the story. The islet on the left is composed of healthy beta cells (stained red for insulin), while the one on the right has a high number of cells producing glucagon (stained green), which raises the concentration of glucose in the bloodstream—indicating diabetes.

PHOTOS COURTESY OF ALAN ATTIE

The team had the answer—but after their first submission to the prestigious *Journal of Clinical Investigations*, they were asked to do 22 more experiments.

Kebede had been thinking along the same lines and had already begun the additional work. "We wanted to make sure we got the story right," she says.

It took an extra eight months, but in August 2014 the paper was finally released. It was an exciting and novel find. In type 2 diabetes, it often seems as if the insulin-producing pancreatic beta cells are wearing down. The Sorcs1 discovery suggests a possible explanation for that, and also provides an important change in how to work with beta cells.

Around the same time, a related discovery came from, of all things, a single-celled organism called *Tetrahymena thermophila* being studied at the University of Chicago. Attie and Kebede went down to brainstorm with Aaron Turkewitz, a professor of molecular genetics and cell biology. It was an inside-baseball connection, the kind that might take pages to explain and doesn't show up in grants or co-authored papers. But it personifies the role of a researcher like Attie in an endeavor as complex as decoding diabetes.

"His interests at the most basic scientific level have immense medical implications, and in that way, he connects to a large swath of investigators," explains Peter Arvan, M.D., Ph.D., director of the University of Michigan Comprehensive Diabetes Center. "There are few like him, but he is a model investigator for the 21st century. As the science gets more complex, the field needs investigators like Alan to connect us."

Once upon a time, Alan Attie had a bumper sticker that said, "Don't believe everything you think."

And Attie thinks about so many things. He makes very good wine and is an accomplished amateur photographer. As much as he loves research, he's passionate about teaching. Conversations glide from the unification of Germany and money in politics, to Ebola and science funding, to income inequality and student debt.

Attie's not the happiest of scientists right now. As the United States has reduced its lead in science funding, he's become acutely aware that the kind of midcareer leap he made into diabetes would be impossible in today's funding environment. He's got fewer mice in inventory than at any time in recent memory—and to him that means discovery is languishing.

"We can't pursue all of our good ideas. We can't pursue all of our bad ideas, either. But we don't know which ideas are good or bad until we try. The thing is, we're not trying as much," he concludes, frustrated. He worries that we're losing our edge.

For example, he has a lead on a protein that appears to be involved in both Alzheimer's and diabetes—perhaps the two greatest challenges to health care financing. "I won't write the grant because it has zero chance of receiving funding," Attie says.

In an age where science seems so often a political pawn, it's refreshing to hear it talked about as a human ideal.

In Attie's vision, scientific thinking isn't just running the numbers and picking the ones you like. It's about "being self-critical, being introspective about how you think and what algorithm you're using to arrive at a conclusion about anything in the world," says Attie. "If that were a widespread value, I think our society would be different, better. We would have less hatred, less racism. We would be more nuanced in the way we judge other people."

Meanwhile, there are mice to study and students to train. Attie's been involved in the Collaborative Cross, a massive multi-institutional effort to refine mouse genetics to better allow the study of human disease. Using new mice strains, his team is beginning a major fishing expedition, a multiyear project focusing on insulin secretion and beta cell biology in general—utilizing brand new genetic techniques that already are being hailed as game-changing.

Attie knows there will likely be moments of eureka as well as dead-end heartbreak. The team that he loves so much will grow and change as members adapt to the shifting landscape of discovery. He'll miss the old students and technicians as they move on, but he'll gain new students and collaborators as he keeps asking the questions that come so naturally to him.

"Being in science is very humbling because I've been wrong about a lot of things over time," says Attie. "That's part of learning to be a scientist—and yet I think it's also part of learning to become a better human being." g

in the Field


Nikita Brabbit


Jeffrey Davis


Mike Dockry


Dean Jefferson


Emilie Justen

Nikita Brabbit BS'08 Forest Science (Recreation Resource Management) Paraguay '08–'10 • Brabbit served as a Peace Corps volunteer specializing in agro-forestry in rural southeastern Paraguay, an area she found quite similar to where she'd grown up in Wisconsin's Driftless region. In partnership with a local nonprofit and other agricultural organizations, Brabbit assisted in establishing a community tree nursery, planting trees for firewood and restoring endangered tree species—but some of her most meaningful intercultural experiences were spent gardening and baking with her neighbors. Brabbit now works in Winona, Minn., at a nursery specializing in native grasses, wildflowers and trees that are sold to gardeners and organizations restoring prairies throughout the country. Her passion for nature extends beyond her career. When she is not training for her first marathon, Brabbit enjoys foraging and making natural products out of what she finds.

Jeffrey Davis BS'96 Agronomy Senegal '97–'99 • "Growing more for less" was the goal of Jeffrey Davis and the farmers of Senegal whom he served as a Peace Corps volunteer. During his service Davis applied his CALS education in agronomy to production practices and played a role in the development of improved varieties of maize, sorghum, rice and other crops. Davis had wanted to join the Peace Corps since high school and remains grateful for the preparation that CALS gave him, especially in strengthening his technical expertise. In particular, a course called "Cropping Systems of the Tropics" sparked his interest in learning how to produce food in varying climates, knowledge that proved invaluable while in the Peace Corps. Davis now works at the Louisiana State University AgCenter, where he works to develop and implement soybean varieties, especially those that are resistant to insect pests.

Mike Dockry BS'94 PhD'12 Forest Science / Bolivia '97–'00 • As a Peace Corps volunteer in Bolivia, Dockry helped local university agriculture students with their field trials and studies. He found his work there so gratifying that he extended his service, spending his third year coordinating resource management plans for communities surrounding central Bolivia's Amboró National Park, a nature reserve with more than 800 species of birds and 125 species of mammals, including puma, ocelot and the rare spectacled bear. Now based in Saint Paul, Minn., as a research natural resource specialist with the USDA Forest Service, Dockry regards both his CALS education and his Peace Corps service as instrumental to his career. In particular, his Peace Corps service instilled in him the ability to work with a range of diverse perspectives in a common effort to address environmental challenges.

Dean Jefferson BS'74 Rural Sociology El Salvador '74–'76, Costa Rica '77 • Dean Jefferson recalls how the civil rights movement and the Vietnam War greatly influenced the thinking of many students on campus during his undergraduate years—and he was no exception. The Peace Corps provided Jefferson the means not only to apply his agricultural skills, which he had developed growing up on a small farm, but also to serve international peace. While in the Peace Corps Jefferson completed a study of farmers involved in an irrigation and land reform project, served as an agricultural extension agent to a local farm, and worked with the Salvadoran Department of Natural Resources. Jefferson left his service in Costa Rica with a wife, proficiency in Spanish, and a deepened appreciation for an international perspective on politics, the economy and the environment. His career has encompassed a variety of jobs within and outside of agriculture—he recently retired from Madison College—but he remains rooted in his farming upbringing.

Emilie Justen BS'00 MS'08 Horticulture / Guatemala '00–'02 • Emilie Justen was raised on a dairy farm and continued to pursue her interest in agriculture as a horticulture student at CALS. Through the guidance of an adviser who was a former Peace Corps volunteer, Justen recognized the Peace Corps as an effective means to pursue and apply her agricultural skills and education. In Guatemala she served as an agricultural

Alumni who have made a difference via the Peace Corps

—By Claudia Roen

Mariah Leeseberg

Aaron McKean

Caroline Reddy

Marian Weidner

extension agent and assisted in the development of a flower nursery for a local women's group. In her current position with the Minnesota Department of Agriculture, Justen works to eradicate noxious weeds and help landowners become better land stewards. Her time as a volunteer instilled in her the confidence to take risks and the realization that serving her community must always be at the core of her career, she says.

Mariah Leeseberg BS'05 Wildlife Ecology / Madagascar '06–'08 • Mariah Leeseberg was first introduced to the Peace Corps at a CALS Career Day event and was intrigued by the opportunity to explore a foreign country's environment, animals and culture. She was sent to the exotic island of Madagascar, where she had the not-so-exotic task of overseeing the construction of 10 pit latrines and three wells. She also helped organize a youth camp that promoted discussion of HIV/AIDS, environmental concerns and career goals. Her work thereafter has included surveying fish, plants and animals in Alaska and elsewhere. Today she works for the Alaska Department of Fish and Game, where she is involved in efforts to survey sport fishing boats.

Aaron McKean BS'08 Agricultural and Applied Economics / Azerbaijan '09–'11 • Drawing on his degree in agricultural and applied economics, as a Peace Corps volunteer Aaron McKean worked alongside a microfinance bank that served primarily small businesses and farmers in Lankaran, a city on the Caspian Sea near the Azerbaijan–Iranian border. He also helped establish a soccer camp for girls and assisted students in applying for study abroad programs. His time in the Peace Corps solidified his desire to pursue a law degree, which he is currently doing at the University of Wisconsin Law School. As a reflection of his agricultural and legal interests, McKean hopes in his final year of law school to explore rural and urban land use. Having grown up on a farm, McKean is especially interested in how law can be applied to helping preserve natural resources.

Caroline Reddy BS'12 Agricultural and Applied Economics / Cameroon '13–present • As a Peace Corps agribusiness adviser in the village of Besongabang in Cameroon, Caroline Reddy is working with an agricultural cooperative to renew its fair trade certification for the production and sale of coffee and cocoa. Reddy is also surveying, mapping and testing wells in a water supply and use project. Recently she taught a group of high school students a course in entrepreneurship that had them researching and developing business plans. Alongside her work, Reddy enjoys learning to cook traditional Cameroonian dishes as well as swimming in and exploring the country's beautiful rivers and waterfalls.

Marian Weidner BS'06 Rural Sociology / Morocco '09–'11 • Organizing a women's leadership camp, establishing a library for students and planning a science curriculum workshop for local teachers and principals were some of the activities Marian Weidner engaged in during her Peace Corps service. Weidner was inspired to join the Peace Corps after taking courses from Jack Kloppenburg, now an emeritus professor of community and environmental sociology, who had served as a volunteer himself. Her Peace Corps experiences continue to shape her career. She works in San Francisco for an open-access publisher of science and medicine articles, reflecting her interest in increasing public access to knowledge and information.

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 …

Kartik Chandran PhD'01 Biochemistry

Kartik Chandran has spent years studying an organism that most of us hope never to experience: the Ebola virus. Last year the infectious agent not only spread within West Africa but also for the first time reached the United States. The ensuing panic prompted a number of national broadcast news media outlets to turn to Chandran for answers.

Ebola is a major focus of Chandran's research as a professor of microbiology and immunology at the Albert Einstein College of Medicine in New York. His contributions include helping to identify both the chemical pathway Ebola uses to invade host cells and a specific mechanism inside of cells that acts as an Ebola receptor.

• What fascinates you about viruses?

So many things! They are just these incredible nanomachines, and are often so beautiful to look at. This is what got me into virology in the first place. My Ph.D. adviser at UW–Madison, Max Nibert, showed me some gorgeous image reconstructions of reovirus particles and I was hooked.

Viruses form such a crucial part of life on earth. Indeed, life as we know it wouldn't exist without viruses. I'm fascinated by the perpetual war, ancient yet modern, that viruses and hosts wage against each other, and by how much that has shaped biology on this planet.

• In light of the recent Ebola outbreaks, do you have any words of comfort or hope?

It has been horrifying to watch the Ebola epidemic take hold in West Africa. I am hopeful that the resources needed to control it are finally being brought to bear, with the U.S. leading the way. But it's happening so slowly! We need to multiply our efforts by an order of magnitude and do it quickly—it still feels like the world is in denial about what is happening. I am optimistic also that we will be able to throw vaccines and therapeutics into the fight in the next few months.

But in the meantime, we need to find ways to short-circuit the delays involved in creating infrastructure like treatment centers and the challenge that staffing such centers entails. We have to do more to reduce the spread of the virus at the local level. This seems desperate, but I think we need to help people care for their own family members "in place" by providing the resources and information they need—personal protective gear, chlorine, food. And we have to do this in communities on a regular schedule, not just once by handing out a kit.

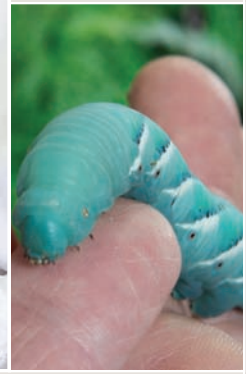
• What else would you like to tell the public about Ebola?

We need a different approach to develop vaccines and therapeutics against emerging agents like Ebola that are not considered major public health threats (or were not, until a few months ago). This and other episodes illustrate the failure of our planet-spanning civilization to act with foresight and plan for the future. The model of letting the marketplace dictate which therapeutics get developed is clearly inadequate to this purpose, since it rewards only short-term thinking. Unfortunately, the government-driven model is not really optimal either—it takes too long to act and disburses funding too anemically.

I don't pretend to know what the right models are, but I hope we will actively work on coming up with them in the coming months and years. Because this is definitely going to happen again—if not with Ebola, then with some other infectious agent.

—Joan Fischer

Photo courtesy of the Albert Einstein College of Medicine



Insect pets: *Entomology professors Walter Goodman (left) and David Hogg have students raise a tobacco hornworm from egg to moth (moths and caterpillar shown here).*

"Science for Citizens"

CALS IS ACCLAIMED AS ONE OF THE BEST schools in the nation for training top-notch researchers and practitioners. Less known is the fact that CALS offers challenging, creative courses to undergraduates from outside of the natural sciences as well—in keeping with the college's mission to cultivate science literacy as a vital component of good citizenship. For many students, these classes may be their only exposure to college-level science.

Two classes exemplifying that mission are Entomology 201—"Insects and Human Culture"—and Plant Pathology 123, "Plants, Parasites and People." Both are highly popular classes that use insects and plants as ways to connect students with essential information about the natural world.

"It offers a window to science as it relates to their everyday lives," says plant pathology professor Mehdi Kabbage.

"This is really biology with insects on top of it," says entomology professor Walter Goodman, who's been teaching Ent 201 for more than 20 years. "We use insects as a vehicle for describing biology and looking at the practical aspects of biology, like agricultural entomology as well as medical entomology."

Both classes engage students in a range of hands-on activities. In Entmology 201, students take home the tiny eggs of a tobacco hornworm, or *Manduca sexta*, and over a period of two months raise it to maturation, keeping a daily logbook in which they describe its metamorphosis from fat turquoise caterpillar to large brown moth. In Plant Pathology 123, each student is given a "mystery microbe" in a petri dish—a *Pseudomonas aureofaciens* bacterium, for example, or a *Fusarium oxysporum* fungus—and devise various experiments to determine which microbe they have.

The students are having fun—but they're also sharpening their observational skills and learning about the scientific process as well as how to make and critique a scientific argument. Their engagement with science often has deep and far-reaching consequences.

Education major Tess Bashaw signed up for Entomology 201 simply to fulfill her science requirement—and instead, "It opened up so many roads to me," she says. In addition to gaining new skills and information—"learning how to catch and pin insects, how to collect leeches in floods, how camouflage really works"—the course made her grow as a writer, she says.

The lessons stuck. And as a teacher of low-income children, she's been sharing those lessons in her classroom for the past decade. "I love teaching writing, and science is a favorite of mine," Bashaw says.

Given the important mission and high student demand for this signature style of science education, CALS would like to expand offerings to more departments and more students.

To learn more about supporting those efforts, please contact Sarah Pfatteicher, CALS' associate dean for academic affairs, at sarah.pfatteicher@wisc.edu, tel. (608) 262-3003.

To make a gift, please visit **supportuw.org/giveto/calssignature**.

—Joan Fischer

nextSteps

EXPLORE SCIENCE ON CAMPUS at **Science Expeditions**, **March 20–22**. Learners of all ages are welcome to this cost-free event. CALS faculty offer hands-on "Exploration Stations" at the Wisconsin Institutes for Discovery and participate in activities at other campus venues. More info at **www.science.wisc.edu**.

MEET BUDDING RESEARCHERS at the **Undergraduate Symposium** on **Thursday, April 16**, noon to 5 p.m. (reception at 5:30) at Union South. The symposium showcases undergraduate research from across campus, including CALS. More information at **ugradsymposium.wisc.edu**.

And for a CALS-only experience, come to the **CALS Undergraduate Research Symposium** on **Tuesday, April 21**, in the Microbial Sciences Building. Visit **chars.cals.wisc.edu** for more info.

ENJOY A SCRUMPTIOUS BREAKFAST at **Breakfast on the Farm** on **Sunday, May 3**, 8 a.m.–12 p.m., at the Stock Pavilion. The event is an annual benefit for the Association of Women in Agriculture. More info at **http://awamadison.org/breakfast_on_the_farm.php**.

UP YOUR COOKING GAME with CALS/UW–Extension forest and wildlife ecology professor emeritus **Scott Craven**, who shared his cooking tips for venison, pheasant and other hunted delights on *The Larry Meiller Show*, Wisconsin Public Radio. You can hear him at **wpr.org/cooking-game-makes-hearty-winter-meals**. Photo Courtesy of Katherine Lynch/CC

RUN FOR A CAUSE at the **Dairy Dash** on **Sunday, May 3**, held in memory of **John Klossner**, a member of the Alpha Gamma Rho fraternity who died of a brain injury. The 4K run benefits the Brain Injury Association of America. More info at **www.wisconsinagr.com/run**.

BIKE FOR A CAUSE at the 12th Annual **Ride to Farm**, a 50-mile bike ride to benefit the Wisconsin School for Beginning Dairy and Livestock Farmers. The ride takes place on **Saturday, June 6**. It will start and end at Botham Vineyards, just south of Barneveld. Even if you don't bike, you can pledge a rider. More info at **ridetofarm.dojiggy.com**

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

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Animal Sciences

1. After vaccination it is common for animals to:

a. Have decreased feed intake and reduced weight gain
b. Have increased feed intake and reduced weight gain
c. Have reduced weight gain and increased feed intake
d. Have increased intake and increased weight gain
e. None of the above

Agronomy

2. The group of plants directly involved in symbiotic nitrogen fixation are the:

a. grasses
b. legumes
c. rhizobia
d. root crops

Ag and Applied Economics

3. You estimate that you will have $31,870 in student loans by the time you graduate. The interest rate is 5.45 percent. If you want to have this debt paid in full within four years, how much must you pay each month?

a. $740.46
b. $788.82
c. $761.09
d. $663.99

Entomology

4. Name an insect that is found in WI and is on the federal endangered species list.

a. spring azure butterfly
b. Karner blue butterfly
c. festive tiger beetle
d. Eastern red damsel dragonfly

Soil Science

5. A water contaminant for which boiling would not be an effective treatment is … (select one):

a. *E. coli*
b. cholera
c. bacteria
d. parasites
e. arsenic

LAST ISSUE: Answers were 1: C; 2: E, 3: B; 4: C; 5: D. Congratulations to Max Shenkenberg, who plans to graduate in 2017 with a degree in dairy science. He was randomly selected from the 38 people who aced our Final Exam and wins a gift certificate to Babcock Hall.

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THINK SPRING

This image of budding grapevines at the West Madison Agricultural Research Station reminds us of warmer days to come. You can see this and many other beautiful nature photos from the CALS community on our Flickr site, which recently surpassed 1 million views. www.flickr.com/photos/uwmadisoncals/

Photo by Sevie Kenyon BS'80 MS'06