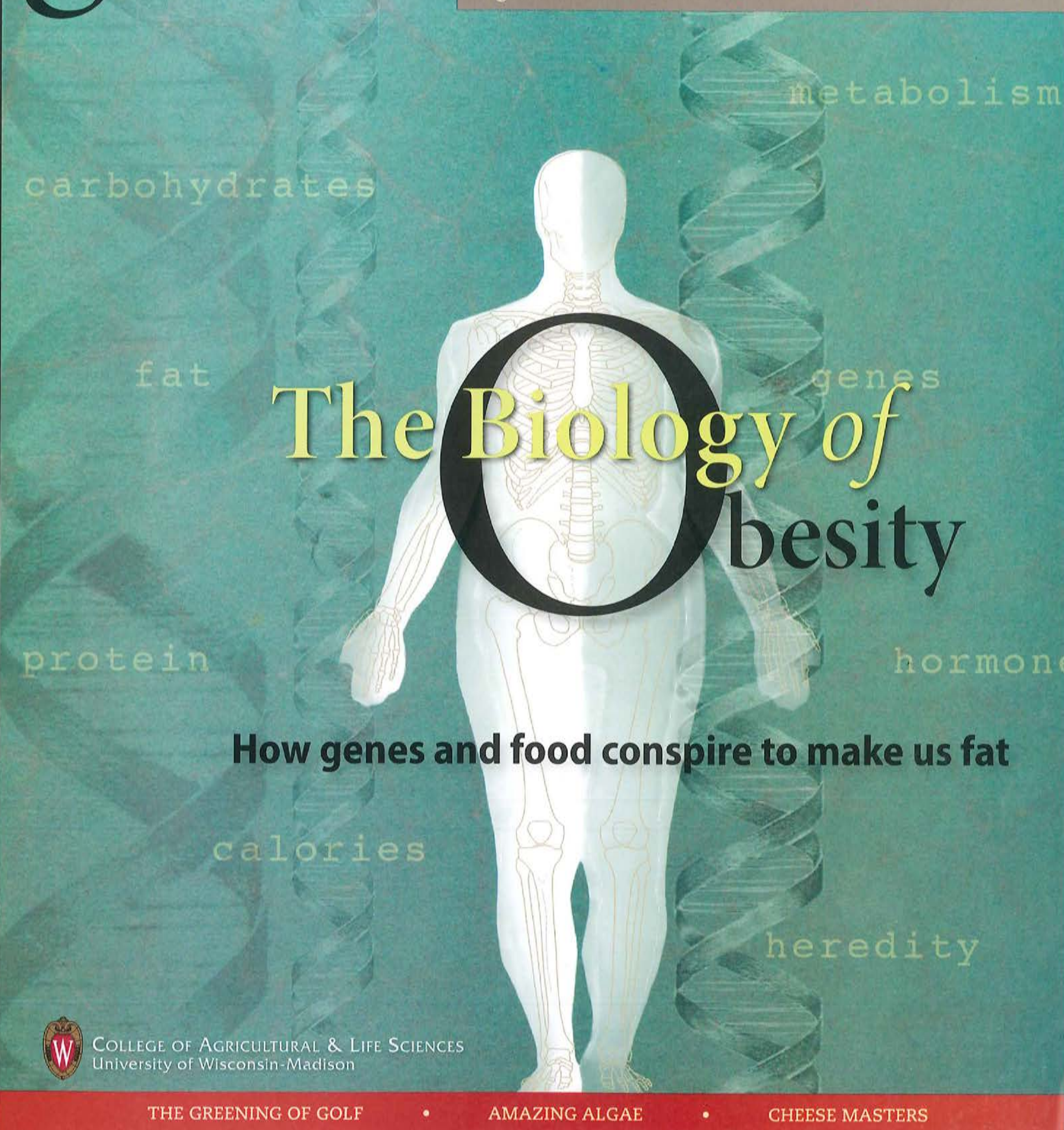
grow

Wisconsin's Magazine for the Life Sciences • Summer 2008

agriculture • food • health • environment



The Biology of Obesity

How genes and food conspire to make us fat

College of Agricultural & Life Sciences
University of Wisconsin-Madison

THE GREENING OF GOLF • AMAZING ALGAE • CHEESE MASTERS

Volume 1, Issue 3 • Summer 2008

THROUGH THE LOOKING GRASS: Blades of perennial rye grass (left) and creeping bentgrass grow in a campus greenhouse, where turf experts are studying lower-input grasses for use on golf courses.

grow

Wisconsin's Magazine for the Life Sciences

Departments

Dean Molly Jahn

Our Talent is Blossoming

FEW DECISIONS ARE MORE IMPORTANT to the long-term vitality of our college than the decision to hire a new professor. Faculty and staff are on the front lines of every aspect of our mission. They do far more than teach or work in labs—they define our capacity to respond to opportunities and make a difference in our community. This is why it's so important to get these hiring decisions right.

We've been making a lot of these decisions lately. By the time we finish this year's recruitment, we will have hired 122 new professors since 2000—an amazing 42 percent of our entire faculty. To some extent, this remarkable turnover reflects a natural, healthy cycle in higher education. Research universities enjoyed a tremendous boom in the 1960s and '70s, and many of the faculty hired then are retiring. Another factor is our ability to marshal resources to support faculty in new areas. Despite budgets that resulted in the loss of 90 faculty positions from 1980 to 2005, we've been able to find other means to begin to grow our faculty base back toward where it once was.

One result of this hiring is that CALS is now a relatively young place. The average age of these 122 professors is 43, which in today's research environment is barely out of the gates. According to data from the National Institutes of Health, professors now don't earn their first NIH grant until 42 years of age, a reflection of how competitive these awards have become. Because of our history of excellence and commitment to our land-grant missions, we've been able to recruit the best and brightest young talent in the world, who can excel even in this rigorous environment.

Because of our history of excellence and commitment to our land-grant missions, we've been able to recruit the brightest young talent in the world.

Now the hard work begins. The key to upholding and enhancing our college's ability to serve our missions will lie in nurturing this generation of leaders. Just as our college provided for those luminaries on whose foundations we build, our job now is to challenge, to support and to inspire this generation as they look toward the horizon.

It has been said that where there is no vision, the people wither. Our college was invented to provide both vision, and, on a very practical level, the means to improve the lives of our citizens. This wave of hiring offers us an opportunity to reload our intellectual cannons—and to aim them at new targets. We are indeed a young and clever college these days. And we are a college that aspires to turn all this knowledge and potential toward something, that, in the fullness of time, may be called wisdom.

grow

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COLLEGE OF AGRICULTURAL & LIFE SCIENCES
University of Wisconsin-Madison

By the Book

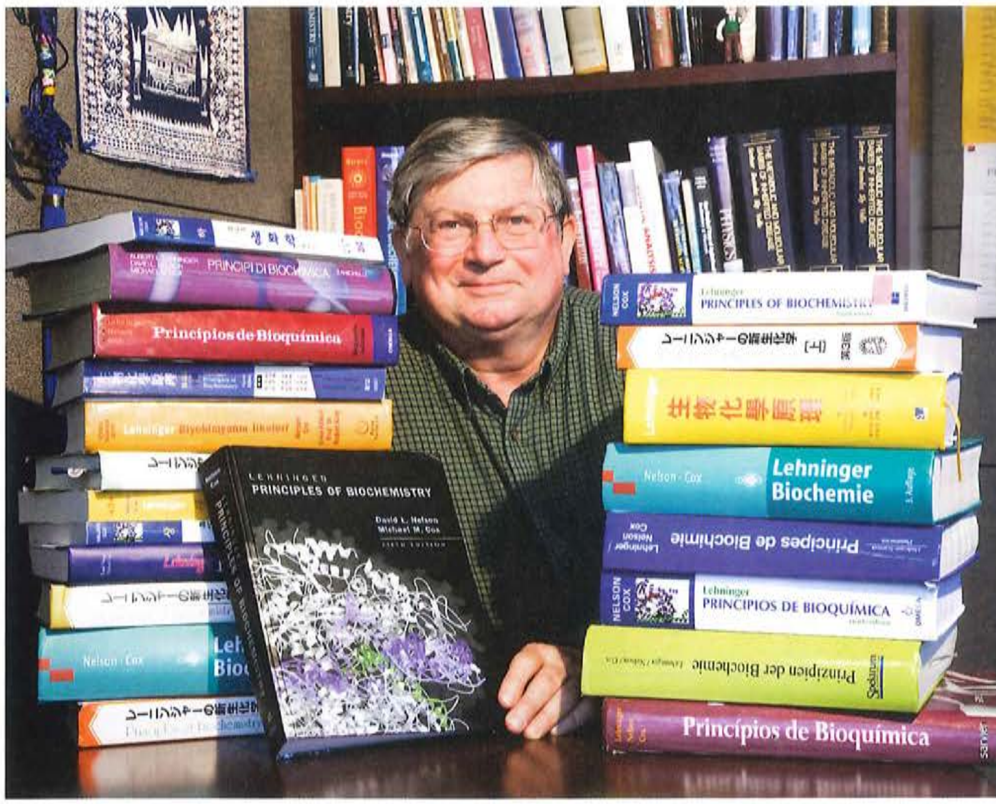
Are textbooks still relevant in a digital age?

Sometimes it is difficult to tell what beginning biochemistry students struggle with more: the weight of their subject or the weight of their textbook. At six pounds and 1,100 pages, *Lehninger Principles of Biochemistry* is a backbreaking lesson that budding life scientists don't soon forget.

"It's a classic," says Dean Molly Jahn. "It was truly the flagship text when I was a student."

It still is—thanks largely to the efforts of biochemistry professors David Nelson and Michael Cox. The pair have edited the textbook since original author Albert Lehninger died in 1986, ushering four new editions to press, the latest of which appeared this spring. The book remains one of the most heavily used introductory texts in the field, and it has been translated into 12 languages.

But when modern students are more likely to hit Google than crack a mammoth text in search of information, even standbys like Lehninger are having to adapt to avoid extinction. Science textbooks are now accompanied by web sites and CDs full of interactive features, designed to build upon the lessons imparted through the flat reality of print. The newest *Lehninger* edition, for example, has an online component with rotating molecule models and "living" line graphs, which allow students to change data and observe the effect.



David Nelson's office is stacked with versions of a biochemistry textbook he co-authored with Michael Cox. The book has been translated into 12 languages.

All of which raises the question: Do students still need the book?

"I think it's getting harder and harder to justify," says Monica Theis BS'79 MS'88, a lecturer in food science who co-authors *Introduction to Foodservice*, a 700-page primer on the food industry. "These books are expensive, and it really makes me wonder if I should be requiring them."

Theis says she uses her textbook less in her classes than she once did. Instead, she posts readings online and brings in current examples to spark discussion. At the same time, she thinks textbooks offer an organizing device that can help students filter and apply fundamental knowledge. If she were to drop the text entirely, she says, her course "might be messy."

Nelson agrees. "The value of writing (the textbook) is that a good book really does help students learn," he says. "If I thought the book wasn't having that effect, I wouldn't touch it."

But after hauling *Lehninger* around all day, some students might not want to touch it, either. And that ultimately may drive change in textbooks. "There's a lot more we can do to make these books more accessible and less intimidating," says Nelson. "I would imagine they're going to look very different in the future."

—Michael Penn

Ice Creamier

Edible antifreeze puts the smooth in Smoothie.

Food scientist Sunny Wang pours liquid nitrogen during an experiment to simulate the temperature changes a typical gallon of ice cream endures.

It's Friday night, and the movie's already spinning in the DVD player. You run to the kitchen to grab a gallon of ice cream and a spoon, but you find the tub nearly empty. What's left is an icy mess that crunches unappetizingly when you poke your spoon into it. Time to make popcorn.

If this has happened to you, then Srinivasan Damodaran has good news. The food science professor has discovered an edible antifreeze that can preserve ice cream's smooth, silky texture. Colorless and tasteless—you'd never know you were eating it—the antifreeze employs a cocktail of small gelatin proteins to slow the growth of ice crystals, which over time form in ice cream and other frozen foods, ruining texture and overall quality.

Ice crystals form when frozen foods are exposed to temperature variations, which usually happens when freezers defrost or are repeatedly opened and closed. In the ice cream business, a $5 billion-a-year industry in the United States, that's hardly a selling point, and several companies have been working to develop substances that can prevent crystal formation. The multinational food company Unilever, for example, sells ice cream in the United States, the Philippines and Mexico that includes an antifreeze protein derived from fish. The additive is pending approval in Europe, but strong consumer sentiment against genetic engineering may prevent it from being widely accepted. Damodaran believes Europeans and other consumers may take more favorably to a gelatin-based antifreeze, which comes from animal collagen, the same protein source tapped for gelatin desserts such as Jell-O.

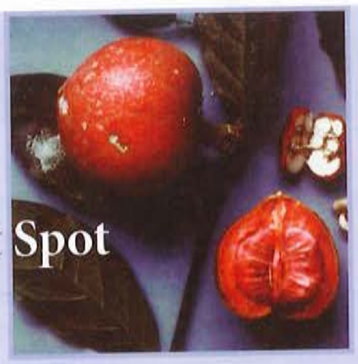
"A lot of people study antifreeze proteins because they have so much technological value," he says, adding that they can be used in a variety of frozen desserts, fruits and vegetables. "They are very appropriate for meat, too. So much texture is lost due to ice crystal damage in meat tissues."

To create the new antifreeze, Damodaran mixed gelatin with papain, a natural enzyme from fruit that cuts proteins into smaller pieces. When blended into ice cream, a group of truncated gelatin proteins worked to keep the frozen treat smooth even after researchers exposed the samples to repeated fluctuations in temperature, designed to mimic the variances of a typical home freezer.

"We used ice cream as the model to show that this antifreeze works," says Damodaran. "Now it's up to the companies, manufacturers and the consumers to decide if they want to have it in their products."

— Nicole Miller MS'06

Sweet Spot



BERRIES of the West African oubli plant are so sweet that, according to legend, they make nursing babies forget their mothers' milk. Now, the protein responsible for that taste—a substance 1,000 times sweeter than cane sugar with virtually no calories—may soon become an ingredient in sugar-free foods. CALS researchers first isolated the protein, known as brazzein, from *oubli* plants in 1994, and they've recently perfected a way to produce the protein outside its berries. Natur Research Ingredients, a California company that makes natural sweeteners, has licensed the technology and plans to market brazzein under the product name Cweet, pending FDA approval. The company sees potential for Cweet to sweeten bitter-tasting pills or to help diabetics stick to low-sugar diets. "It gives a pure, sweet property," says Fariba Assadi-Porter, a CALS biochemist who developed the technology, "and that's hard to come by."

Photo courtesy of John Markley

Growing Season

Earlier planting—not climate—may be boosting corn yields.

How much difference can two weeks make? For corn growers in the northern United States, plenty. New research is finding that a two-week extension of the corn growing season is likely a significant factor driving up U.S. corn yields during the past 30 years.

Chris Kucharik, a scientist with UW-Madison's Nelson Institute for Environmental Studies, set out to explain why Midwest corn growers produce three times more corn today than they did a half-century ago. After modeling the influence of several factors, including planting dates and climate change, he determined that earlier plantings account for 20 to 50 percent of the yield gains seen since 1979.

"What I found was that while climate probably has contributed in a small way to the yield trend, the overwhelming contribution has been from this land management change," says Kucharik, an expert on climate and agriculture with the Nelson Institute's Center for Sustainability and the Global Environment.

It also doesn't appear to be the case that farmers are planting earlier because of warming temperatures. Instead, Kucharik says new corn seeds are engineered to endure the colder and wetter soils of early spring, which has allowed northern corn growers to adopt hybrids with a longer growing season.

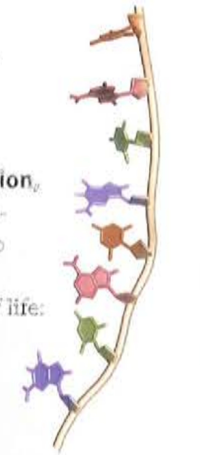
"Before we jump to conclusions about the impacts of climate change on agriculture, we really need to consider subtle management changes that are taking place and will likely take place in the future," says Kucharik. "Anytime you deal with a system that's being managed by people, it makes for a more complicated story."

—Madeline Fisher

Number Crunching

90 PERCENT OF U.S. FACULTY IN THE LIFE SCIENCES HOLD ONLY ONE OR NO PATENTS, according to a survey of 1,800 U.S. professors in biological and agricultural sciences conducted by CALS economists Brad Barham and Jeremy Foltz MA'94 PhD'98. The authors say the statistic shows that despite an explosion in academic patenting in recent years, most life sciences professors still do research the "old-fashioned" way—by winning federal grants, publishing results in scientific journals and graduating Ph.D. students.

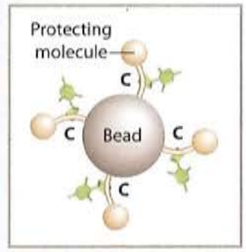
how to make DNA

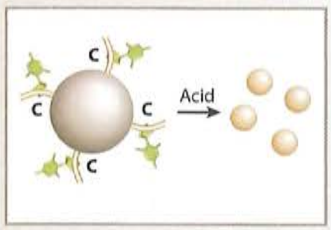


Custom-built DNA may sound like the stuff of science fiction, but it's a common tool for many genetics labs. Tiny and nonfunctional, these pieces of code are useful in experiments to check or sequence other genes. Here's how UW-Madison's Biotechnology Center goes about building the ingredients of life:

Write the code. Every piece of DNA contains a unique combination of bases—the four building-block molecules, abbreviated A, T, C and G. To order a custom-built strand, all a researcher needs is to spell out the desired sequence.

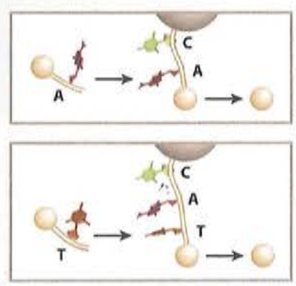
Attach the last letter in the sequence to a polystyrene bead. The Biotechnology Center's DNA synthesis lab stocks boxes full of tiny vials for each base, which contain beads coated with billions of copies of that base. To start a new strand, technicians start at the bottom, inserting a vial containing the last base in the sequence into a $200,000 synthesis machine.

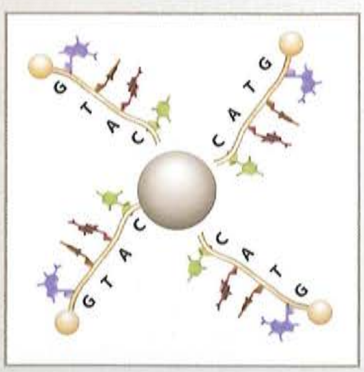




Inject acid into the vial. Acid releases a large molecule that protects the reactive site on the bases, priming them to bond with the next base. This protective molecule keeps the bases from bonding with anything except the next link in the chain.

Add the next base. Subsequent letters are injected into the vial in a solution. Activating molecules help the bases bond to the DNA chain. This process is repeated for each letter in the sequence until the strand is complete. Common lab experiments usually call for strands about 20 bases long, but the lab has created chains with up to 150 letters.





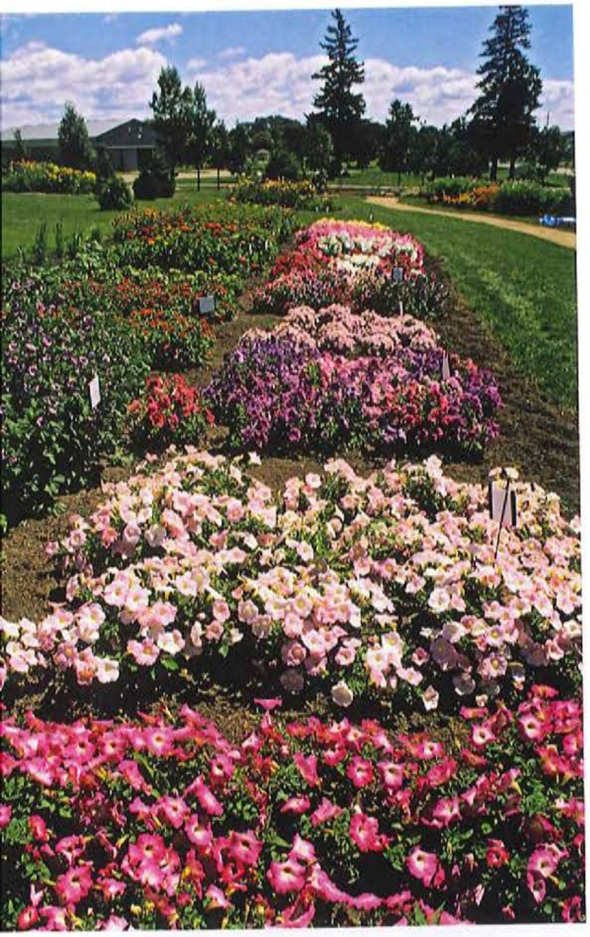
Illustrations by H. Adam Steinberg

When all the bases are in, flush the vial with basic solution. This causes the polystyrene beads to release the completed DNA molecules, which are collected in a tube.

Check for typos. Using mass spectrometry, lab technicians measure the molecular weight of their finished DNA molecule and compare it to a predicted total, calculated from the known weights of each base. Any difference means there's likely an error in the code, and the whole process has to be redone.

Budding Collaboration

West Madison station helps Wisconsin's flower industry bloom.



ON TRIAL: Flower varieties are put to the test in the West Madison research station's gardens.

In late spring, the four-acre demonstration plots behind the West Madison Agricultural Research Station turn into a patchwork quilt of color, as hundreds of varieties of flowers, herbs, vegetables and fruits bloom. The show delights many visitors who roam the gardens. And lately, it's been wowing commercial flower growers, as well.

In 2006, the Wisconsin Commercial Flower Growers, which represents the state's multimillion-dollar flower industry, forged an agreement with the research station to test flower varieties in its trial gardens. The idea was to expose alluring varieties to Wisconsin's elements, something many commercial growers don't have the space or facilities to do.

"We can grow something in the greenhouse and it looks beautiful in the greenhouse. But if it doesn't perform well outside, (customers) are not going to be happy," says John Esser, executive secretary of the growers' group. "And that's where this research station really helps."

Growers pick the plant species and supply the station with seedlings. Research staff and interns then plant, nurture and monitor the flowers throughout the growing season. At the end of the trial, they produce an annual report that ranks the varieties in six key categories—foliage appearance, flower display, weather tolerance, site considerations, comparison to standard varieties and an overall garden rating. They also record anecdotal observations: About a Cloud nine Blue Bacopa flower—one of last year's best performers—the staff raved, "Best Bacopa in the series, nice flowers, good foliage, kept blooming." On the other hand, a Bermuda Sky Bacopa didn't stand up so well. "Delicate plants browning/yellowing, lacking profusion of blooms," staffers noted.

This kind of information offers a great read on how flowers will perform in customers' gardens, explains Esser. He says that growers use the trial gardens' sneak preview to help plan purchase orders.

"So often, the information that we had was from trials performed in California, which doesn't really apply very much in Wisconsin," he says. "From that standpoint [the trial gardens] really helps the commercial greenhouses in the state to determine what varieties they want to grow."

In fact, flower growers have grown so attached to the program that this year members voted to devote a portion of their annual dues to the West Madison facility. They also have secured a state grant to fund two summer interns and a Web site that will share the team's findings.

"The interns are kind of what makes this thing go," says Bruce Sadowski, who owns Groth's Country Gardens, a greenhouse business based in Cedarburg. "What we learned last year when we came down there and looked is that the interns are very knowledgeable; they've got all the knowledge of growing them (the plants) through the season and how they've looked from day to day and they're able to give that information to the growers."

—Kate Tillery-Danzer MS'08

Veggies in the Sky

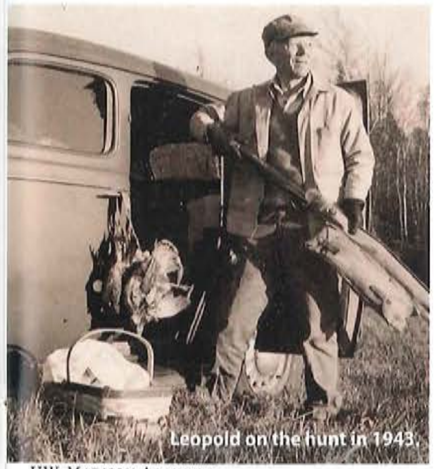
MATT BONACCORSO

Two UW-Madison business students are hoping to get an intriguing food idea off the ground—literally. Keith Agoada and Troy Vosseller have launched Sky Vegetables, a startup company seeking to grow fresh fruits and vegetables in greenhouses on top of existing supermarkets ***(see illustration, left)***. With the average supermarket produce item spending 2,000 miles and as much as two weeks in transit, the students see an opportunity to cut production costs while offering customers a fresher alternative. Their idea took top honors in the School of Business' G. Steven Burrill Business Plan Competition, which earned them $10,000 and a spot in a statewide competition. But will rooftop produce fly? "This really is a new way to tap into consumer interest in foods that are locally produced and healthy to eat," says horticulture professor Brent McCown BS'65 MS'67 PhD'69, who advised the team. "If the greenhouse is on the roof, you can't get much more local than that."

The Life of Riley

Professor preserves a town's Leopold legacy.

When Janet Silbernagel grew up playing along the banks of the Sugar River, near the small Wisconsin town of Riley, she never imagined that she was following the footsteps of a legendary naturalist. Years earlier, Aldo Leopold had paced that same ground to do two things he loved—explore natural landscapes and hunt birds.



Leopold on the hunt in 1943.

UW-Madison Archives

In 1931, while a CALS professor of wildlife ecology, Leopold had forged the Riley Game Cooperative, a unique arrangement in which farmers agreed to maintain the marshy lands along the Sugar River as wildlife habitat and hunting preserve. Eventually including 11 farms and some 1,700 acres, the cooperative came to influence Leopold's ideas about managing private lands to support native populations of wildlife.

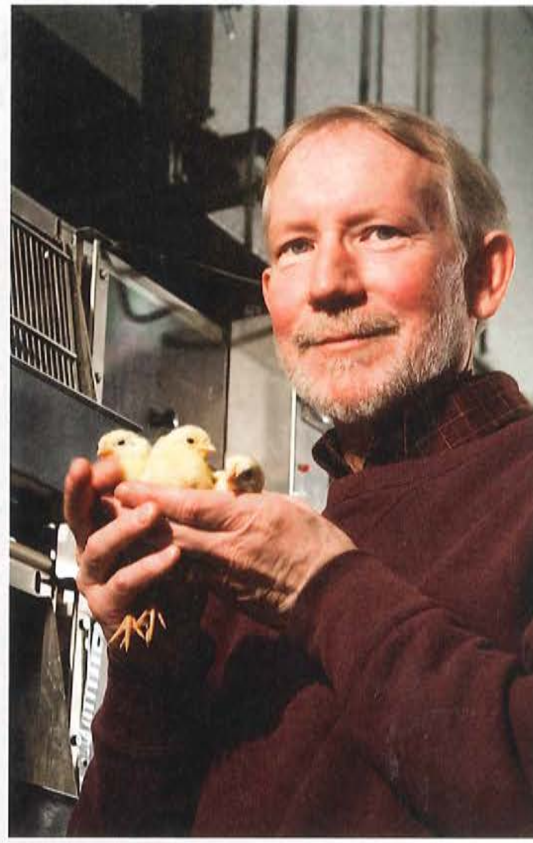
"It represented a unique partnership between town and country to cooperatively manage a landscape," says Silbernagel, now an assistant professor of landscape architecture. "It's an example of a different aspect of Leopold's work, which is what makes it exciting as a place for environmental education."

Silbernagel only discovered Riley's Leopold legacy by chance, while browsing some of his old writings a few years ago. Now she hopes to raise public awareness of the area's history to spark efforts to preserve it. Just 14 miles from Madison, the area faces encroaching sprawl from the city and its fast-growing suburbs, and land prices have risen steeply. Dane County has listed the area as a conservation priority in its most recent parks and open space plan, and the Natural Heritage Land Trust, a Wisconsin-based conservation group, has also done work in the area to encourage landowners to adopt conservation practices.

Silbernagel is aiding those efforts by meeting with landowners to discuss options. So far, there are more ideas than solutions, but the Riley native has plenty of reason to keep pushing. "It's absolutely personal for me," she says. "There are many beautiful, special landscapes around the state. This is one I feel I can contribute to on a personal level. I kind of feel like I owe that."

—Michael Penn

mark cook



• **job** Professor of Animal Sciences • **lab** Tenth floor of the Animal Sciences Building • **team** Four graduate students, four undergrads and one research specialist • **current research** How nutrition regulates immune function in poultry

What's the research question on your mind right now? Why does a chicken grow faster in a germ-free environment?

Is work in the lab 9-to-5 or 24/7? I try to open my door at 8 a.m. and close it by 6 p.m., but I'm all over the place all the time. I do love my early mornings. I would rather rise at 3:30 a.m. than stay until 7 p.m.

What's the view from the window? The sky. I can't seem to get close enough to the window to look south.

What's playing on the lab radio? It changes as the students change. My office rarely has music. I don't think I could play a full song without interruption.

If you had to evacuate your lab, what would you grab first? I have personal bound notes and calendars with critical intellectual-property information on patented research. That could be the most I can carry out.

Where do you get your best work done? Everywhere. Right now, I'm writing this while sitting in the airport in Atlanta.

Eat out or brown bag? When I worked in the cane fields, the workers teased me because I ate cold lunch. Now it is hot lunch, but almost always leftovers and microwaved. I only eat breakfast on Saturday morning or when I'm trying to impress some new faculty hire or something like that.

Any personal items in the lab? Egg yolk separators from Pampered Chef. They are the best for making our antibodies. We could not figure out how to pay for them using a lab account, so I bought a bunch and gave them to the lab to use.

What's your desktop picture? On my old computer, I had a picture of the planets. No one put one on my new computer.

What's your favorite way to recharge the batteries? Give me a new problem and time to think about it. Late Friday afternoons are often the best time—everyone is starting to settle down and there is time to think.

What's the coolest thing you've learned by doing research? How to prevent hairballs in cats.

GUATEMALA

Tomatoes Ripen Students' Training

Barely six months into his graduate studies, Jonathan Jacobs BS'07 has already realized something critical about becoming a plant pathologist. And his epiphany had little to do with science.

Instead, it came as Jacobs stood in a dying tomato field in the central highlands of Guatemala, where he was completing a month-long research trip to gather information on a bacterium known as *Ralstonia solanacearum*. In plants such as potatoes, tobacco, bananas and tomatoes, *Ralstonia* can produce a devastating wilting disease that can leave plants—and farmers—ruined. And that's exactly what Jacobs saw surrounding him—acres of limp, wilted tomato plants and a farmer desperate for answers.

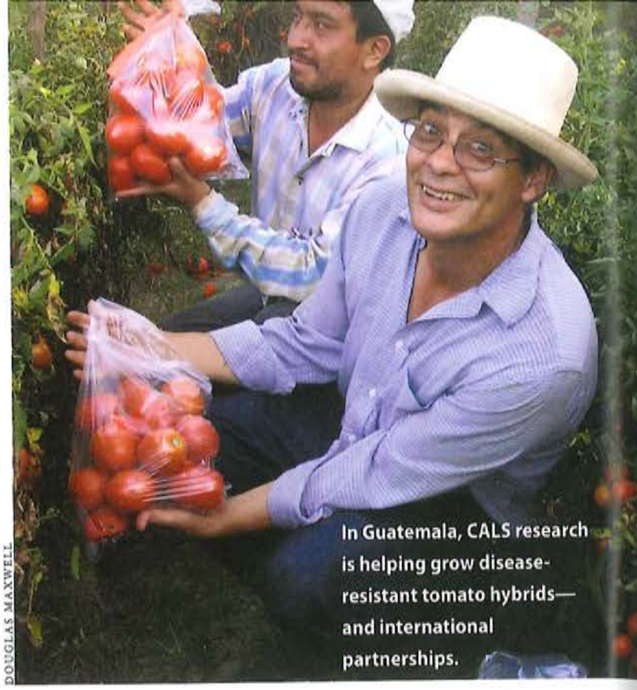
"It changed my whole perspective on plant pathology," says Jacobs, whose trip was funded with a grant from UW-Madison's Latin American and Caribbean studies program. "To see it right in front of me, it made me want to understand this plant-microbe interaction even more, so that hopefully my research can help to reduce this disease in the future."

Jacobs is not the first CALS student to have an eye-opening experience in Guatemala, where plant pathology professors Caitilyn Allen and Douglas Maxwell have maintained an active partnership with scientists studying bacterial wilt and other tropical plant diseases. Allen and Maxwell have sent a half dozen students to the Central American country to participate in research collaborations and see first-hand the effects of the tropical diseases they study.

"Few of our students have experience with the kind of devastating crop loss you see in developing countries," says Maxwell. He notes that geminiviruses—a group of tropical plant viruses that are the focus of his research—have been blamed for destroying up to 20 percent of Guatemala's tomato crop. "I've seen entire fields just abandoned. It's heartbreaking."

Yet also motivating. Since turning his attention to geminiviruses in 1998, Maxwell has led a multinational effort to develop hybrid tomatoes resistant to the viruses, which are spread by whiteflies. A seed company in Guatemala now markets four varieties that stand up to the disease.

Four years ago, the breeding project expanded to take on another scourge for farmers in the subtropics: the bacterial wilt caused by *Ralstonia*. The Guatemala-based team's efforts are aided by the expertise of Allen's lab, which has identified the bacterial genes that are active when *Ralstonia* infects a plant. Trials are still in their early stages, but Maxwell is optimistic.



DOUGLAS MAXWELL

In Guatemala, CALS research is helping grow disease-resistant tomato hybrids—and international partnerships.

"We're growing these tomatoes on two sites, and they look very promising," says Maxwell. "One of the farmers we work with told us he had never seen tomatoes grow in his field before. He wants seeds right now."

—Michael Penn

KAZAKHSTAN

Turning Dirty Bombs into Clean Silage

When the Soviet Union was dissolved in 1991, a group of microbiologists in Kazakhstan lost their jobs. And that's a good thing, because they'd been employed to develop biological weapons.

But if you're interested in world security, it's probably not a bad idea to keep people with this kind of expertise off the job market, which is why the U.S. Department of Agriculture retrains former weapons makers to do agricultural research. Sponsored by the state department, the program teams U.S. researchers with colleagues in former Soviet republics to redirect their microbiological talents on problems that will lift the economies of their home countries.

"The goal is to help them develop production of commodities that could be used commercially, either domestically or for export," says Paul Weimer MS'75 PhD'78, a bacteriologist who participates in the program.

Weimer and Richard Muck, scientists with the USDA's Agricultural Research Service who hold appointments on the CALS faculty, have traveled to Kazakhstan twice and will return this year. Kazakh scientists have also visited the UW-Madison campus, where Weimer and Muck have demonstrated improved techniques for making silage.

Although Kazakhstan is in the middle of an oil boom, it's still largely an agrarian country with extensive grasslands. Thanks to oil, incomes have improved, creating interest in new foods and ways of eating. This has led to a "mini dairy boom," says Weimer. "But they don't have strong dairy production system in terms of feed analysis and the technology to grow high-quality forages. We're helping them develop enzyme preparations that will help them upgrade their grasses to make better silage."

In the course of the Kazakh scientists' former line of work, they had researched countless native bacteria and fungi and discovered some that produce an effective cellulase, an enzyme that breaks down cell walls and release sugars. Weimer and Muck helped them find ways to put these native microbes to work making silage.

"Their results look pretty promising," Weimer reports. In fact, quantities of the Kazakh enzymes may soon be on their way to Wisconsin, where Muck and Weimer will use them to make silage and feed cows.

—Bob Mitchell BS'76

ICELAND

Lake Swarm May Hold Lessons for Wisconsin

From a distance, the surface of Iceland's Lake Myvatn seems to be cloaked in a dense, low-lying fog. A closer view reveals that the fog is alive, and it's thrumming. Billions of tiny, gnat-like midges rise from the lake and drift over its surrounding lands—so many that in Icelandic, Lake Myvatn means "midge lake."

To entomologist Claudio Gratton, these swarms are more than just a natural curiosity. He sees a neat system for transporting food and energy from one habitat to another—one that might have lessons for Wisconsin agriculture.

Árni Einarsson, University of Iceland

As an insect ecologist, Gratton is keen to understand how what insects do in one part of the landscape affects what happens in other parts. Lake Myvatn offers an extreme example of this interaction. Midges hatch in the lake, feeding on tiny organisms in sediment as larvae. As adults, they rise from the lake to mate, gradually drifting *en masse* over nearby lands. And that's where most of them die, creating a mass movement of living organisms from water to land.

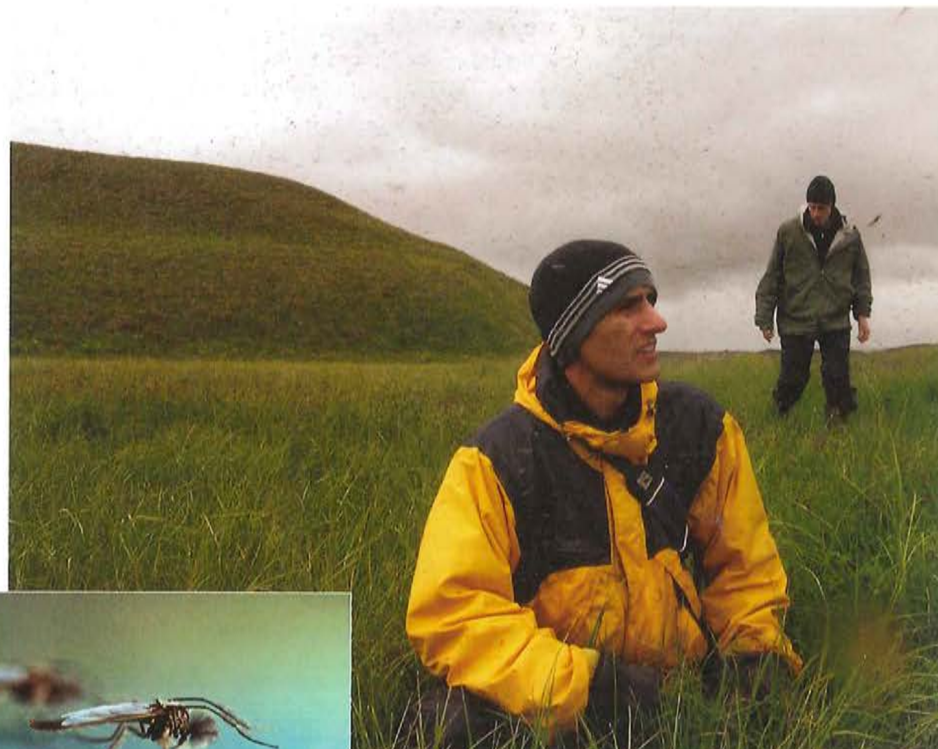
In each of the past two summers, Gratton has taken a team of students and researchers to Lake Myvatn to study this phenomenon. They're particularly interested in what role the midges play in the ecosystem once they die: Do they decompose, providing nutrients for the soil? Do they fall prey to spiders or other insects?

But what the researchers learn will not apply only in Iceland. Gratton sees his research there informing his work with Wisconsin potato and soybean growers, potentially revealing new strategies for controlling agricultural pests.

"I'm interested in how pests and their predators move in the landscape," he explains, noting that what he learns in Iceland can be applied to the natural enemies of crop pests such as aphids and potato beetles. "It's all about understanding ecosystem linkages."

Of course, the stark moors of Iceland are very different from Wisconsin's relatively lush, diverse landscape. And that's why it's a perfect place to study habitat linkages, Gratton says.

Entomologist Claudio Gratton and limnologist Jake Vander Zanden (background) brave a swarm of midges, gnat-like bugs that rise in huge numbers from a remote lake in Iceland.



Jack Donaldson

"It's simple and it's dramatic. You can (follow) the movement of these organisms with your eyes," he says. "This is a neat model for looking at really strong ecosystem linkages—the kind of linkages we're trying to understand in a landscape like Wisconsin, where it's a patchwork of agriculture and non-agriculture."

—Bob Mitchell BS'76

In Search of Spuds

David Spooner hunts the globe for wild potatoes that just might save our nation's crop from disaster.

The quest for the perfect potato has kept David Spooner on the move for most of two decades.

TO COLLECT WILD potatoes from around the planet, David Spooner has touched down on mountain peak landing strips, scaled potato-coddling trees in old-growth rainforests and endured double vision while hiking over a 17,000-foot mountain pass between Bolivia and Peru. A CALS horticulture professor and researcher with the U.S. Department of Agriculture, Spooner made these trips to give plant breeders the raw materials they need to better protect cultivated potatoes from disease. But a few years ago, he abruptly stopped. *Grow* recently sat down with Spooner to ask why.

Grow: How different are wild potatoes from our cultivated varieties?
Spooner: Very different. Wild tubers, for instance, are often tiny and mildly poisonous. Most of them have long stolons—their underground stems. And actually, the tuber that we eat is just a swollen stolon. So with wild potatoes, it's often an Easter egg hunt to try to find the tubers. One thing people breed for with potatoes is short stolon. Obviously, you don't want to put a potato plant in the ground and then have to harvest the potatoes 20 feet away.

Grow: How about good traits? Why is it important to preserve the biological diversity of this species?
Spooner: So that plant breeders have access to the genetic diversity needed to improve our cultivated potato. Wild potatoes are an enormous reservoir of beneficial traits, including disease resistance, nutritional qualities and a whole range of agronomic traits. By agronomic traits, I just mean how (a potato) grows, how it processes, what it looks like and those types of things.

Grow: With all of the agricultural tools available to farmers in America today, are our potatoes really at risk for disease?
Spooner: Many diseases can be avoided through chemical control, and in the United States, we can afford the pesticides, insecticides and fungicides needed for that. However, there are certain diseases that can't be controlled very well. So yes, disease is still a big problem here, and people are constantly trying to better the potato's resistance to those particular diseases.

Grow: Is there any chance that we could face another devastating crop failure on the scale of the Irish Potato Famine?
Spooner: During the Irish Potato Famine, a major disease almost completely wiped out the potato crop (in Europe) because potatoes didn't have resistance to that disease. It was a classic case of an emerging disease, an example of something we are constantly concerned about. In fact, disease resistance is one of many reasons why we collect and preserve (wild potato) germplasm —in order to try to breed crops that have resistance to diseases that we think might be a problem.

Grow: So really, collecting and storing this germplasm is about preserving biodiversity.
Spooner: Yes—but I wouldn't say I've always thought of it that way. As a formally trained botanist, I knew about biodiversity, but I only thought about it in the sense of preserving plants and animals in their natural environment, like in the rainforest. I didn't think about it in the context of plant breeding, because that wasn't my training. This idea wasn't obvious to me until I joined a community that uses biodiversity in an applied sense, instead of in the usual "green" sense. Now it's clear to me that biodiversity can be viewed in an ecological context, as well as in more of an applied agricultural context.

Grow: When you come across a new kind of potato, what do you do with it?
Spooner: Typically, we send some of its seeds to the U.S. Potato Gene Bank in Sturgeon Bay, Wis., where they catalogue and store the species.

Grow: And the gene bank receives samples from all over the world?
Spooner: Yes. However, that has changed tremendously in the last 10 years. The whole system of collection, storage and distribution of germplasm

may have been brought up from the south. In short, the United States is relatively germplasm-poor. Fortunately, we have one of the richest collections of crop germplasm in the world. And we share it widely, because all nations depend at least to some extent on germplasm from elsewhere in the world.

Grow: How do you continue your work under the new restrictions?

Spooner: Now I study potatoes abroad a few months out of every year. The Peruvians don't mind you studying their potatoes in their country. It's to their benefit. In fact, two of my graduate students recently did a big project looking at Peruvian germplasm. To do this study, we imported germplasm from the United States to Peru.

And luckily, the world seems to be reconsidering the current system. People are starting to realize that when they put a wall around their own country, not only do they keep stuff in, but they're keeping good stuff out as well. The policy is so restrictive that some of the good exchanges have been stopped.

"Wild potatoes are an enormous reservoir of beneficial traits, including disease resistance, nutritional qualities and a whole range of agronomic traits."

started in the 1970s, when the paradigm was "common heritage of mankind." This means that, at the time, everybody saw germplasm as common property. But then, through a number of developments—including changing intellectual-property rights practices, national legislation on access to genetic resources and sharing the benefits from their use, and the Convention on Biological Diversity—some nations began to restrict access to their genetic resources.

I collected 14 years in a row, from 1987 up until 2000. My last expedition was to Panama in 2000. Since then I haven't been given permission to collect. It's very frustrating.

Grow: What potential problems do these restrictions pose for U.S. breeders?

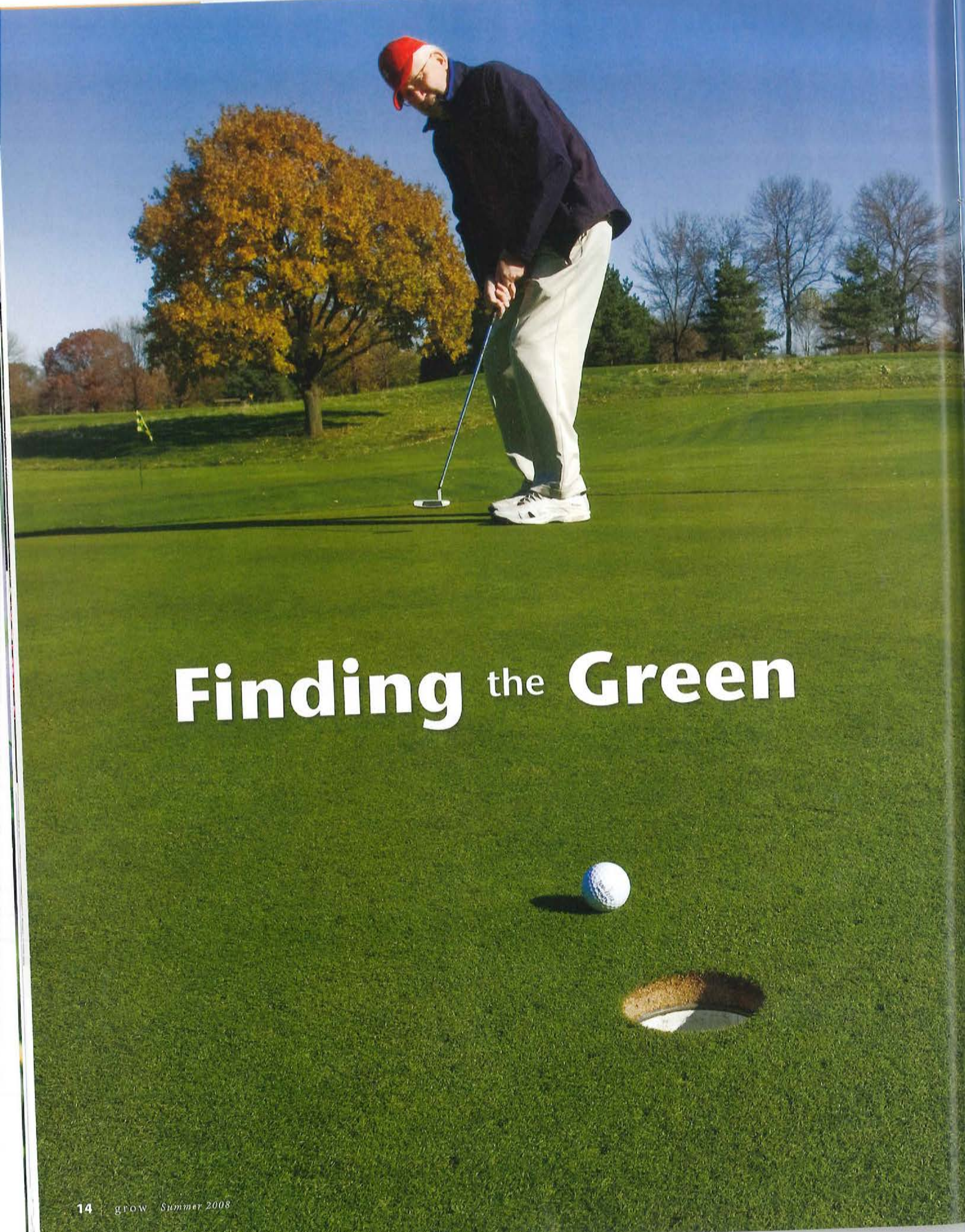
Spooner: When you look at the major native crops that originated in the United States, we've got blueberries, sunflowers and strawberries. It would be hard to feed a family on that. We also have what the Native Americans ate, such as corn and beans. But even those items

Grow: If the restrictions loosen, would you return to collecting samples?

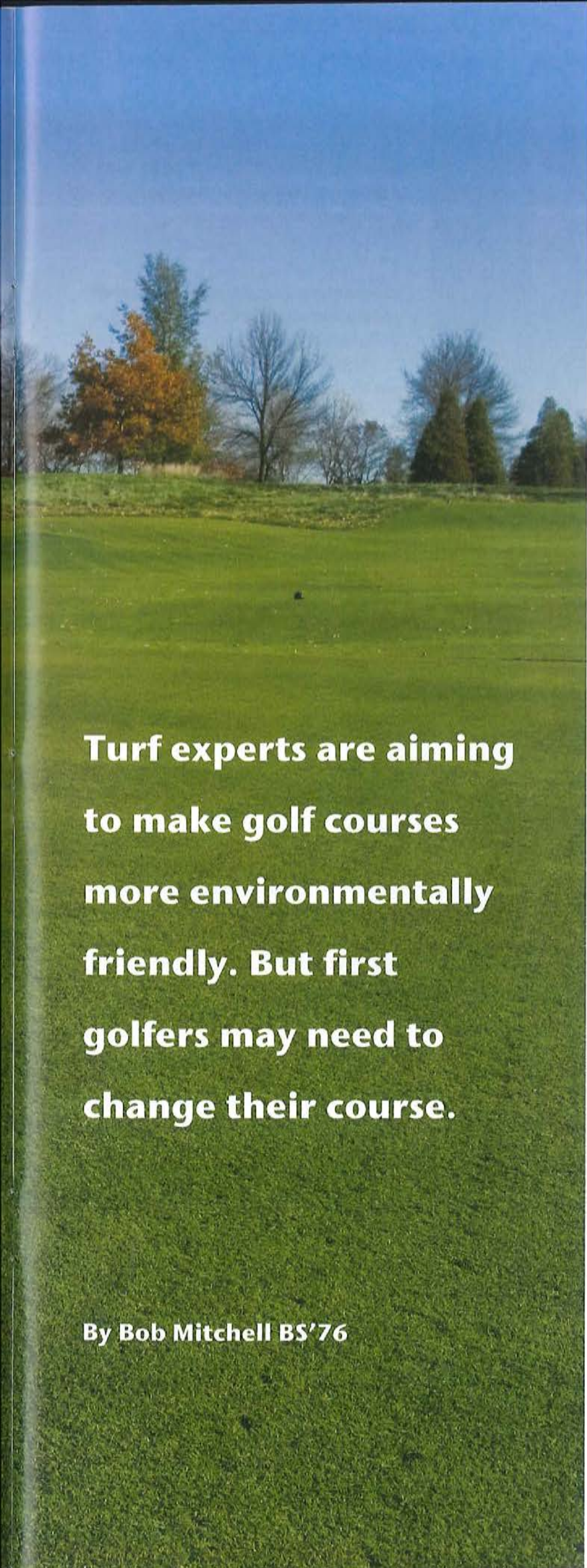
Spooner: I hope I can in the future. One of the things that I'm doing to create a better climate is training graduate students from Latin America. In fact, almost all of my students in the last 10 years have been from Latin America. In this way, I'm also helping to address the desire for reciprocity.

Grow: You must have some great stories from the years you spent collecting specimens.

Spooner: For 14 years, I collected from every country from Mexico to Chile. It was a great opportunity to develop as a scientist, meet people and establish collaborations. One time, I spent six weeks on a boat in Chile just going from island to island collecting potatoes. That was fun. Also, I love Peru because it's just so full of biodiversity and I've made many friends there. These aren't really stories, just fond memories of something I dearly miss doing. I would love to get back into the field again.



Finding the Green



Turf experts are aiming to make golf courses more environmentally friendly. But first golfers may need to change their course.

By Bob Mitchell BS'76

Monroe Miller leans back in the seat of his cart and gazes across the railroad tracks that separate his maintenance yard from the greens and fairways of Blackhawk Country Club. In the distance, the early afternoon sun glints off the windows of the hilltop clubhouse. A pair of red-tailed hawks circles overhead, but Miller's eyes are on the grass.

He points out a spot in the rough by the closest green, where dinner-plate-sized white circles pock the dark green Kentucky bluegrass—signs of a fungal disease called snow mold.

"There are two or three things that if I don't treat for, it will be devastating," he says. "If you don't treat for snow mold, you won't have any greens. We had snow mold on our greens this year, even though we did treat. It was scary."

A golfer gets a clean roll on a green at Westmoor Country Club in Waukesha, where the course will shut down in August to replace grasses on greens with more drought-resistant varieties.

"In golf you're **under a jeweler's eye.** We're very aware of our visibility."

Miller BS'68 has been fighting snow mold and dollar spot at Blackhawk for 36 years, since he took over as superintendent of the course in the village of Shorewood Hills, on Madison's west side. The view of Lake Mendota hasn't changed much in that time. Nor have Miller's worst enemies, a handful of soil-borne fungi that can devastate a green if left unattended. But just about everything else has. For much of Miller's tenure, golf has been the fastest-growing sport in the United States, booming from 11 million players and some 10,000 golf facilities in 1970 to more than 28 million golfers playing at 16,000 sites today. In 2005, those facilities generated $28 billion in revenue, more than all professional and semi-pro spectator sports combined. Throw in equipment and golf-related products and golf these days is a $76 billion-a-year industry.

But golf has also generated a different kind of interest. The sport's boom began around the same time as the environmental movement, and activists have found plenty not to like about the growth of the golf industry. U.S. golf courses occupy as much acreage as Delaware and Rhode Island combined, and two-thirds of that land is turfgrass that receives significant volumes of chemical fertilizers and herbicides. Particularly as golf has expanded into water-scarce places such as Arizona and Nevada, environmental groups have called for limits on water and chemical use on existing golf courses and fought construction of new ones.

Miller got his first inkling of the scrutiny to come in 1975, when he was called to testify before the State Assembly natural resources committee about a proposal to ban phenoxy herbicides, which at the time were claimed to cause cancer and other ailments. Miller and other turf managers told legislators that they had no alternatives for controlling broadleaf weeds. The proposal failed, but the experience taught Miller that more than golfers were following golf.

"In golf, you're under a jeweler's eye," he says. "We're very aware of our visibility. And that's a pretty good catalyst for getting involved in these environmental efforts."

Varieties of grass grow in a campus greenhouse, where researchers test their ability to get by with less water and fertilizer.

Opinions about the environmental impact of golf courses vary. While 91 percent of U.S. golfers say golf is an environmentally friendly sport, only 66 percent of all U.S. adults feel that way, according to a 2008 survey by *Golf Digest*. Among all respondents, 44 percent believe that golf courses use too much water, and 41 percent believe they use too many chemicals.

Another survey taken in England in 2002 shows the ambivalence over golf in a different way. Asked to name an environmental benefit of golf courses, players most often cited that they provide natural habitat. Among non-golfers, the most commonly cited problem was that golf courses destroy natural habitat.

There will probably never be consensus on the environmental impacts of golf courses, but there's no question that the combination of environmental awareness and economic necessity are driving a green revolution on America's greens. The old days, when groundskeepers laid on fungicides containing heavy metals, have yielded to an eco-friendly era. At professional conferences, the talk is about irrigating with wastewater and making roughs bird-friendly, and sustainability fills the pages of turf magazines.

Environmental issues were part of the turf management culture at least by 1989, when the U.S. Golf Association began sponsoring research on the topic, focusing on issues such as the effects of fertilizers and pesticides in surface water and groundwater. In 1996, the organization convened representatives from 16 groups—including the Golf Course Superintendents Association of America, the U.S. Environmental Protection Agency, the National Wildlife Federation and the Sierra Club—to hammer out a set of principles for environmental responsibility in course design, construction and maintenance. Among other things, those principles call for planting drought-resistant grasses to decrease water use and adopting pest management strategies that reduce the need for chemicals.

Around 2,400 U.S. golf courses now participate in a program run by Audubon International, a nonprofit group that certifies courses for their environmental stewardship. Nearly 4 percent of U.S. courses have already

Emeritus soil scientist Wayne Kussow uses a plot at CALS' O.J. Noer Turfgrass Research and Education Facility to investigate how nutrients and pesticides move through turf.

been certified, and more are on their way. The resort chain Marriott recently announced plans to earn certification for 34 of its North American golf resorts by the end of the year.

Any trend that shakes the golf world reverberates in Wisconsin. With more than 730,000 golfers playing 12 million rounds annually, the state ranks second nationally in the number of golfers per capita. About $100 million is spent in the state each year to manage 43,500 acres of turf on roughly 500 golf courses. If you add in lawns, parks, sports fields and roadsides, turfgrass is Wisconsin's fourth-largest crop.

Addressing environmental concerns was a prime motivator when in 1991 the Wisconsin Turfgrass Association built CALS' O.J. Noer Turfgrass Research and Education Facility. The 23-acre center, located southwest of Madison next door to the University Ridge golf course, evaluates hundreds of new products, including many from natural sources. Among them are fertilizers such as compost teas and seaweed, a herbicide derived from the bottlebrush plant and turf fungicides derived from wood-decaying mushrooms.

Noer also gives scientists such as Chris Williamson, a CALS associate professor of entomology, a place to explore integrated pest management strategies, which involve combining cultural, mechanical and chemical practices to help control pests with the least environmental impact. Researching the black cutworm, a common predator on golf greens, Williamson has learned that mowing greens an hour before sunrise can kill cutworm larvae and that bagging and removing clippings can rid greens of their eggs. He has also found ways to take advantage of genetic resistance in some grass species. "If you establish Kentucky bluegrass in the periphery of the green, you create a situation that's unsuitable for cutworm development, and cutworms don't lay eggs on the green," he says.

Noer's research plots are also home to rigorous testing of lower-input grass varieties that haven't been used much on Wisconsin greens and fairways, most of which are planted with creeping bentgrass, Kentucky bluegrass and annual bluegrass. Horticulture professor John Stier is looking at alternatives such as velvet bentgrasses for putting greens and fine fescues for fairways, which appear to require far less water and chemicals than traditional choices.

"Some of these don't have the water requirement that creeping bent does, and they are more resistant to disease," he says. "They also seem to do well without nitrogen. I have plots of fine fescue that have never had fertilizer and seem to be doing fine."

Creeping fescue, a grass native to New Zealand, covers the roughs and fairways at Whistling Straits, a world-class course on the Lake Michigan shore north of Sheboygan. The grass needs one-third to one-half of the water, nitrogen and pesticide required by typical Wisconsin fairway grasses, says Michael Lee BS'87, golf course superintendent for Whistling Straits. While most Wisconsin golf courses might get watered three times a week in season, Lee says Whistling Straits received a complete soaking only three times during all of 2007. What helps the fescue survive drought—its ability to go dormant—also helps create the distinctive character of the course, which opened in 1998 and hosted the 2004 PGA Championships. "When things start to turn a little brown, and there's still a little green in the fairway, it's just stunning," says Lee.

But fescues thrive on sandy soils and cool air, conditions not found on most Wisconsin courses. Other superintendents are looking for improved varieties of standards such as creeping bentgrass that can get by with fewer inputs. Jerry Kershasky has chosen one such grass to replant on the greens and fairways at Westmoor Country Club near Waukesha when the course undergoes a major renovation this August. The chance to completely replace the grass on an established course is very rare, and Kershasky did his homework. After poring over trial results from Noer and elsewhere, he is going with a deeper-rooted variety that should get by with less water, as well as stand up better to disease.

You wouldn't think a Wisconsin turf manager would have to worry about water. It's the kind of concern you associate with courses in the Southwest, where the average golf course water bill is 20 times that of a course in the North Central region. Scarcity of water has led some western states to require golf courses to irrigate with recycled wastewater when it is available. A Nevada water authority even paid one Las Vegas-area course to convert 70 acres to native plantings, netting the club $3 mil-

"A lot of people think golf courses make water worse. We're a great filter."

lion and potentially shaving $200,000 off its annual water bill.

But in Waukesha, Kershasky has reason to think about water. Most of the county lies just west of the subcontinental divide, where water flows to the Mississippi River rather than to the Great Lakes. By rule, places such as Westmoor aren't allowed to draw water from Lake Michigan, a dozen miles away. Instead, they must pump from a deep aquifer, which, under pressure from relentless development, is shrinking rapidly.

"I'm in the recreation business," says Kershasky. "If it comes down to needing water for drinking, and for industry, recreation is not going to get any water."

But Westmoor is welcome to one source of water: runoff from roadways, rooftops and other impervious surfaces in surrounding neighborhoods, including six lanes of Interstate 94 that border the course. When it rains an inch, Westmoor receives more than a million gallons from the freeway alone. That water is laden with road salt and contaminants, but Westmoor isn't picky. Recently, the club expanded a marsh and deepened storage ponds to triple its capacity to catch and filter runoff water, which is then treated and used for irrigation before draining into a nearby creek. Kershasky is quick to point out that the water that leaves the course is cleaner than it arrived.

"A lot of people think golf courses make the water worse. In fact, it's in great shape when it goes off of our property," he says. "We're a giant filter."

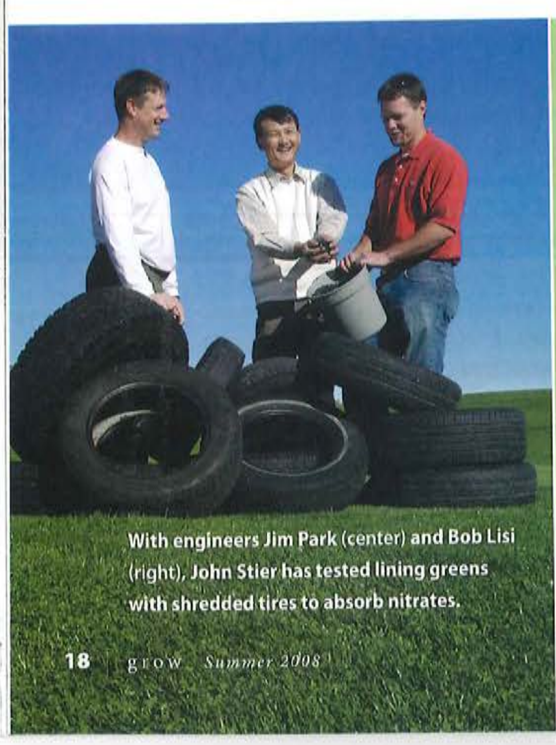
The example illustrates why it's so difficult to pin down golf's environmental impact, good and bad. Some research at Noer shows that efforts aimed at reducing environmental impacts on golf courses can actually have the reverse effect. For example, most organic fertilizers are high in phosphorus, an element that's already overloading Wisconsin waters, meaning that their widespread use could potentially exacerbate runoff problems. Reducing fertilizer use, too, can be a double-edged sword, says Stier.

"Not fertilizing causes more sediment loss into surface waters than proper fertilizing does," he says. "There's not enough turf there to hold the sediment. With proper fertilization, you can reduce sediment loss to about zero."

Sustainability becomes even more complex when it's factored against the chief objective of all golf courses: to offer a good round of golf. Thin, weedy fairways and patchy greens don't just look bad; they frustrate golfers by making a ball take unpredictable turns or settle in bad lies.

An ongoing experiment at Beth Page State Park on New York's Long Island shows why these goals may never be attainable without some chemical assistance. Jennifer Grant, of New York State's Integrated Pest Management Program, and Frank Rossi, a turfgrass specialist at Cornell University, divided the greens on a heavily used public course into three groups with different levels of pesticide use, ranging from conventional to chemical-free. They quickly concluded that eliminating chemicals entirely rendered the greens unplayable, and so they modified that treatment to "reduced risk," using only pesticides that have very low toxicity.

With that change made, Grant says golfers are happy, even with the parts of the course that get minimal treatment. "Basically, over the years, they haven't picked up any differences," she says. "They have always rated all of our treatments between 'good' and 'very good.' "



With engineers Jim Park (center) and Bob Lisi (right), John Stier has tested lining greens with shredded tires to absorb nitrates.

MICHAEL FORSTER ROTHBART

TIRES ON THE GREEN: *How Golf Recycles*

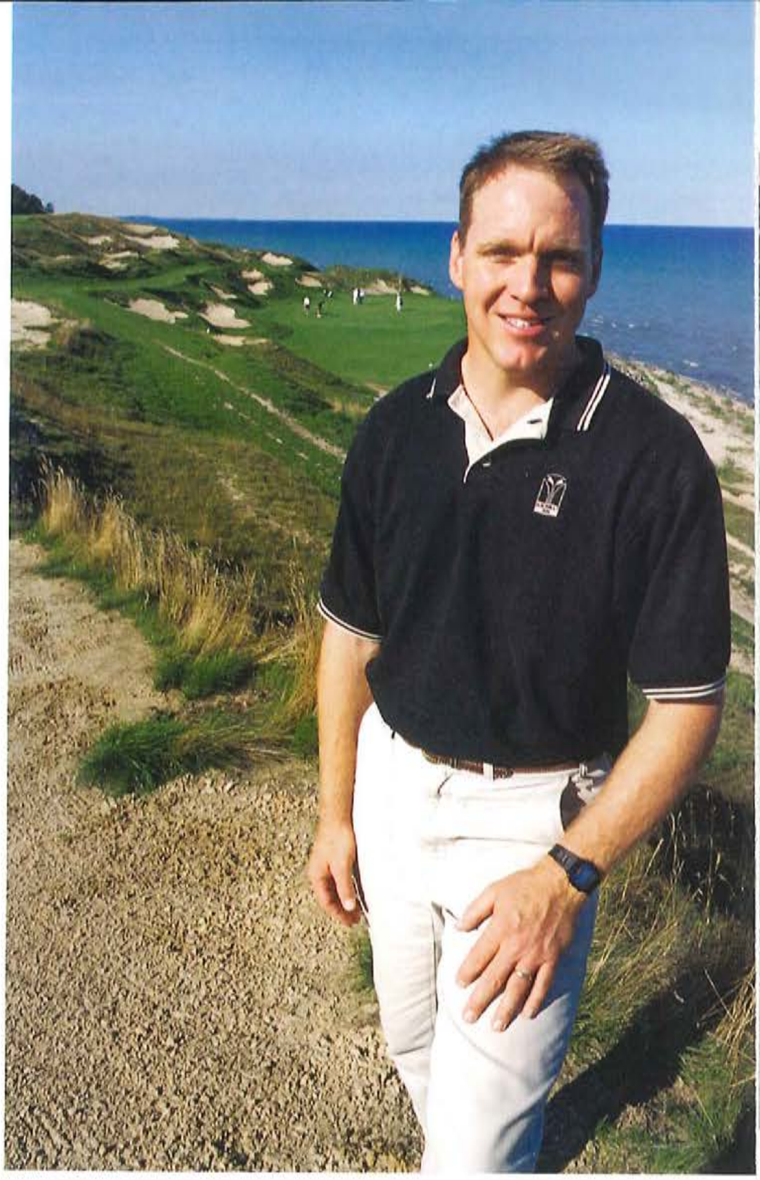
A manicured golf course may be the last place you'd expect to find old tires, let alone the end products of sewage treatment. But in fact, greens and fairways are a great place to recycle a variety of castoffs.

Researchers at UW-Madison's O.J. Noer turfgrass facility have shown that putting a layer of shredded tires under a golf green can help keep fertilizers out of groundwater.

Golf courses can recycle effluent, too. Some golf courses in the Southwest are using effluent wastewater to irrigate turf, which has benefits for both turf and groundwater. "Right now, nutrients in effluent are discharged into surface water," says CALS soil scientist Doug Soldat, who has been testing wastewater irrigation to see how suitable it is for Wisconsin's conditions. "Plants have the opportunity to take out the nitrogen and phosphorus, and they're very efficient at cleaning that up." In fact, CALS was involved in this work as early as the 1920s, when Oyvind Juul Noer, the namesake of CALS' modern turfgrass facility, pioneered technology to manufacture fertilizer from sewage sludge. The product of that research, marketed under the name Milorganite, has been used on U.S. golf courses since 1925.

Even course sites can be recycled. Several new golf developments have sprouted in land that can't be used for much else, including former industrial sites, abandoned strip mines and gravel pits.

Most turf managers flinch at the sight of brown grass, but Michael Lee welcomes it at Wisconsin's celebrated Whistling Straits. It's not just good for the environment, he says—it's good golf.



But a survey of Beth Page golfers also shows that most golfers will go only so far in accepting reduced quality. Only 2 percent of respondents said they wanted no pesticides used, and 4 percent wanted minimal use regardless of turf quality. Just over half preferred that greens be kept at reasonable quality using pesticides only as needed. But one third said they wanted the best turf possible, using pesticides whenever they might help.

In fact, golfers' expectations have never been higher, which industry insiders attribute to what they call the "Augusta syndrome," the net effect of watching blanket coverage of tournament golf — especially the Masters, professional golf's signature event. Held each April at Augusta National Golf Club in Augusta, Ga., the tournament is seen on television by nearly 100 million people around the world, some of whom inevitably conclude that the verdant perfection of Augusta's course is how golf is supposed to look everywhere.

But much of what viewers see is strictly made for television, explains Greg Lyman, environmental director of the Golf Course Superintendents Association of America. "The course isn't played for months before the tournament. They bring in an army of people to work on it. They have it in spring, when their turf there is in great shape," he says. "Golfers watch it and have unrealistic expectations."

Those expectations have made life harder for superintendents such as Monroe Miller. Thinking back to when he took charge of the turf at Blackhawk in 1973—when only the final seven holes of the Masters were televised—he says, "We didn't spray as much back then as you might think, because the (green) cuts were higher. Plants were healthier. Demands weren't as great as they are now because people weren't watching the Masters. Golfers forget that at Augusta, they do it for a week. They want those conditions every day. It's biologically impossible."

But tastes in golf change. One trend in course design that favors sustainability is the emergence of links courses, which emulate the sandy, wild and windswept courses in Scotland where golf was born six centuries ago. Whistling Straits is one example. Michael Lee says that what makes Whistling Straits environmentally friendly—grasses that do well in dry conditions—also makes it a good place to play golf.

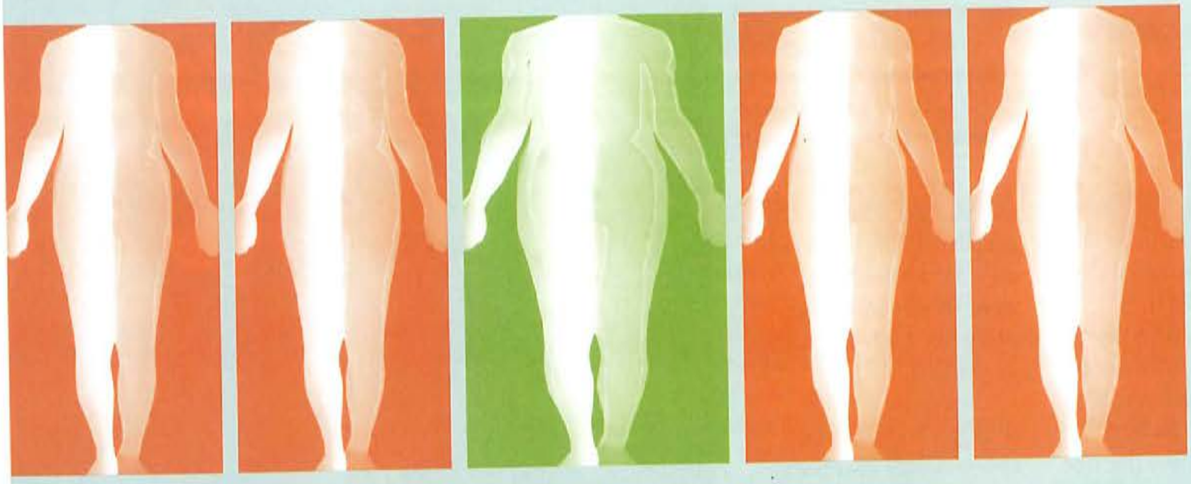
"Less water is desirable both from the links experience—playing a dry golf course is great—as well as from a water conservation standpoint," he says. "Golfers love it. They like a firm, tight lie. They love the ball roll. Who wouldn't like an extra thirty yards?"

"People really embrace that links idea," agrees Jay Blasi BS'00, a golf course architect with Robert Trent Jones in San Francisco. "If you look at any list of the most highly thought-of courses, it's dominated by courses that are built on sand and have this windswept look about them." Blasi went with that look for his first major project—Chambers Bay, a municipal course on Puget Sound in Washington, which is built on a former gravel pit. After opening last year to rave reviews, the course was selected to host the 2015 U.S. Open, one of the prime dates on the PGA Tour.

Blasi says that environmental concerns—above all, the need to save water—are a driving force in today's golf course design. "It used to be that you would create a golf course so that you would have grass all the way from tee to green," he says. "(Now) in the desert, they build little pods of tees, then you hit over the desert to the fairway, and then hit over the desert again to get to the green."

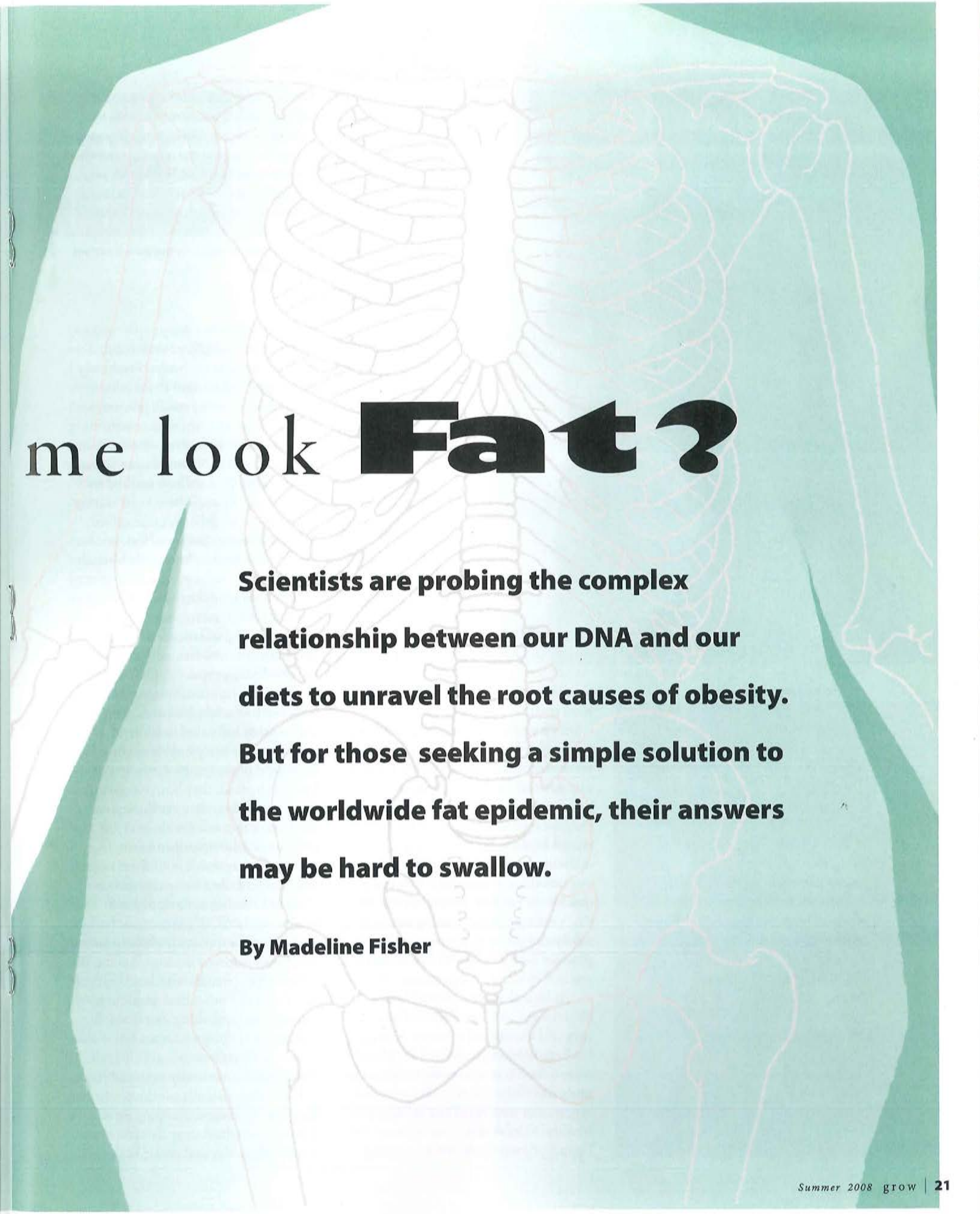
The fact that golfers are embracing a natural look to the golf course landscape is a big step toward truly sustainable golf, says John Stier. Now he hopes they'll go one step further, toward a truly natural turf.

"Golfers expect a perfect disease- and weed-free golf course with stands of grass that all look the same," says Stier. "To have a truly organic or sustainable golf course, we have to let nature have its way. That means there will be different grasses growing next to each other. Things won't be as uniform. It may mean the putting is not as true as it has been. It means that there is a little more chance to the game."



Do these genes make

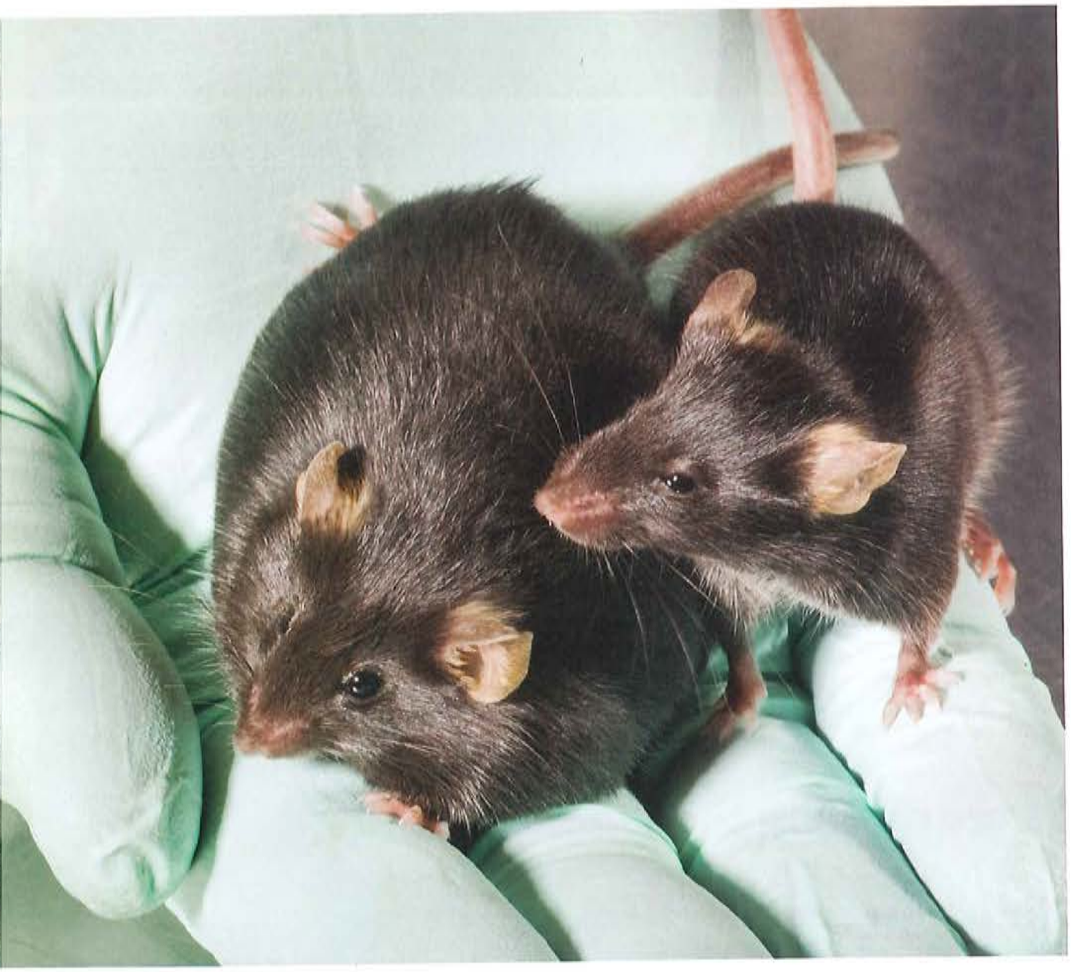
It's hardly a secret that America is fat. Take a look around any bar, mall or fast-food joint, and you'll quickly find evidence of our collective corpulence. Spilling out of our seats and our relaxed-fit jeans, we cram together at tables to down mountainous plates of food and bucket-sized drinks. Doors have been widened to accommodate us, and chairs reinforced. Even our pets have grown plump, and, more tragically, our children.



me look Fat?

Scientists are probing the complex relationship between our DNA and our diets to unravel the root causes of obesity. But for those seeking a simple solution to the worldwide fat epidemic, their answers may be hard to swallow.

By Madeline Fisher



Two mice in James Ntambi's lab illustrate the power of genes in controlling fat. While both mice eat the same fat-laden diets, the mouse on the right lacks a gene that is critical to how the body stores fat from food. Without this gene, this mouse can eat what amounts to a cheese-burger and fries every day and gain no fat. Ntambi (facing page) has found that substances in some foods change how this gene functions in our bodies.

According to the Centers for Disease Control and Prevention, one-third of Americans have progressed to that dangerous state of flabbiness known as obesity. Another third are overweight. This means that, all told, hundreds of millions of us now carry too many pounds, and with them, a greater risk for obesity-related illnesses, including diabetes, heart disease and some cancers, just to name a few.

On one level, there's an obvious reason for our growing weight problems—and an obvious solution. We're eating too much, and we need to eat less. But less of what, exactly? Should we cut out fats or cut back on carbs? Are we eating too much red meat or not enough? For every diet that works for one person, an opposing diet seems to work for someone else. And then there are those rare individuals who appear able to eat anything and never gain a pound. It seems like something else must be going on that explains our complex response to food, something beyond the matter of food itself.

As it turns out, there is. Though we tend to see food as the cause of our flab, it's the way food interacts with our intricate network of genes that ultimately dictates whether we pack on pounds. In the past several years, scientists have discovered dozens of obesity-related genes, including ones that control the size of our fat cells, our metabolic rate and how quickly we feel full. And while the story that's emerging from these genes is wildly complicated, it may also finally produce solid answers to a crisis that has reached epidemic proportions.

At least that's the hope of James Ntambi. A CALS professor of biochemistry and nutritional sciences, Ntambi has been working to unlock the secrets of how food interacts with our genes for more than 20 years. It's a curiosity that began as an undergraduate student at Makerere University in his native Uganda. Ntambi can recall lingering outside the biochemistry department to pore over wall charts that detailed the body's metabolic pathways. Eventually he turned his attention to fat cells—specifically, how the small, precursor fat cells we're all born with transform over time into fat-storing adipose tissue. In the late1980s, Ntambi began to study a gene called SCD, which seemed to dramatically increase its activity during this conversion process, making him wonder about its potential link to obesity. He has been following that hunch ever since.

We now know that SCD encodes an enzyme that converts certain saturated fatty acids into unsaturated forms. These unsaturated fats are the building blocks of many types of lipids, including triglyceride, the main component of body fat. In the lab, Ntambi's team showed that mice that lack the SCD gene are completely unable to store fat from food or make new fat from carbohydrate. Instead, they burn calories like crazy. Even when they eat the equivalent of a hamburger and fries at every meal, these mice gain virtually no fat.

Ntambi's research with these miracle mice has sent drug companies scrambling to find chemicals capable of inhibiting the SCD genes in our bodies, which would supposedly allow us to eat fatty foods without storing extra fat. But intriguingly, Ntambi has found that certain foods and other biological molecules do the same thing. For example, omega-3 and omega-6 fatty acids—also known as fish oils because of their abundance in fish—naturally suppress SCD. In lab studies, fish oils cut the activity of the gene significantly, helping tip the body's metabolism away from fat synthesis and storage and toward calorie

"We've always had nutritional experts who tell us about diets, but now we're telling them how the diets work."

burning. This is likely one reason fish are so highly touted in diets. (The American Heart Association recommends that people eat foods high in fish oils at least twice a week.) They actually alter a key gene's operation.

"We've always had nutritional experts who tell us about diets," says Ntambi, "but now we're telling them how the diets work."

Growing up on a Ugandan coffee and cotton plantation, Ntambi never imagined that he would study fat. When he entered graduate school at Johns Hopkins University, he put his interest in metabolism aside and pledged to study "an African disease." He began investigating the parasites that cause African sleeping sickness, as well as a related scourge of cattle called ngana, all the while making plans to continue the research back home in Uganda. He laughs heartily now at the memory, because of course things didn't turn out that way.

Instead, after earning his doctorate in 1985, Ntambi was invited to do what turned out to be his fateful research on human fat cells. His new post charged him to identify and clone the genes in mice that switch on as fat cells grow, which led him to SCD. In 1988, he became the first person to clone SCD, and soon afterward, he began examining the foods and other factors that affect the gene's activity.

What Ntambi has discovered since is that, while molecules such as fish oils inhibit SCD and promote energy expenditure, many others do the opposite. For example, the hormones insulin and estrogen, the vitamins A and D, and the simple sugars glucose and fructose all boost SCD's activity dramatically, suggesting that when they're present, they encourage the body to make fat. And two of these substances—glucose and fructose—are more present within us now than ever before.

One of the chief reasons is the emergence of high fructose corn syrup, a sweetener made from corn. Low corn prices in the 1980s made the sweetener a low-cost alternative to cane sugar, leading soft-drink giants Coca-Cola and Pepsi to begin using it. At the same time, Americans were growing wary of fat in their diets, and the food industry responded with an array of reduced-fat products, many of them stoked with corn syrup to boost their flavor. Now, corn-based sweeteners are in everything from fruit drinks to baked goods to supposedly healthy items such as yogurt.

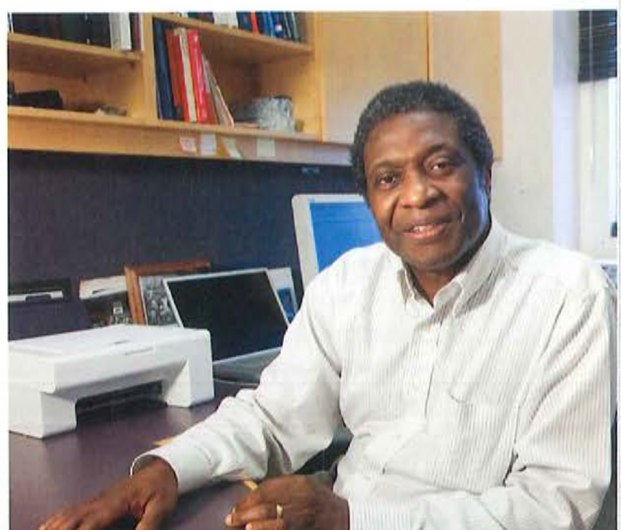
Based on everything he knows about SCD, Ntambi doesn't think this bodes well for our waistlines. Some of his latest results in mice show that an excess of sugary and starchy foods acts directly on the SCD gene in the liver to boost the making of fat. Indeed, swigging Big Gulp soft drinks and gobbling king-size candy bars may ramp up SCD so much that the body's natural energy balance is lost, swinging instead toward ever-increasing levels of fat storage.

"A lot of processed carbohydrate is not good," says Ntambi. "That's basically what we are saying."

Why then, when being obese takes such a toll on our health, does the body seem bent on tucking away every last calorie as fat? To answer that question, we may need to look back millions of years to our ancestral roots, to times when people were never quite sure where their next meal was coming from.

"Actually, the particular challenge we are having now—too much food—is quite new," says Eric Yen, an assistant professor of nutritional sciences who joined the CALS faculty last fall. "Throughout evolution, selection was usually the other way around: Individuals were selected who could store energy when food was around so that they could survive when it wasn't."

Those lucky people didn't just survive; they also passed their fat-storing capabilities onto their children through their genes. SCD may have been one of those genes. Yen believes the gene and enzyme he studies, called MGAT, could be another.



"Lots of times we give out dietary guidelines that don't really make sense for certain people."

"It looks like the main job of this enzyme is to preserve the energy we get from dietary fat so that we don't waste it," he says. He explains that the body normally absorbs around 92 percent of the fat we eat; any amount less than that signals disease. In contrast, we take up only 15 to 85 percent of the cholesterol in our food, depending on body needs. "Fat is a very precious nutrient," he says.

Dietary fat consists mainly of triglyceride, which also happens to be the major component of the fat we store. But triglyceride is too large a molecule to make the transition from food item to body fat directly. Instead, digestive enzymes must first break it down into fatty acids and glycerol molecules for passage across the intestinal wall. Once these building blocks have shuttled inside special cells lining the small intestine, they are assembled once more into triglyceride for packaging and shipping to the rest of the body.

Within these cells, MGAT carries out a step in the reassembly of triglyceride, but its role is also turning out to be more complex than this simple action implies. Similar to Ntambi's experiments with mice missing the SCD gene, Yen and his colleagues engineered mice to lack MGAT in all tissues, and then placed them on a high-fat diet to see what would happen. Much to their surprise, mice without MGAT took up the same amount of fat as control mice, although they did so more slowly. What they didn't do was store the extra calories they absorbed. Instead, their energy expenditure rose, along with their body temperatures. A mere delay in absorption, in other words, led them to waste the energy from fat as body heat.

"It's just fascinating to me: Why would slowing down fat absorption change our energy metabolism?" says Yen. "That's very counterintuitive because we used to think that one calorie equals one calorie. Fat is fat, and once it gets in (the body), it should behave the same as any other calorie. But it doesn't

Sizing up Fat

Our bodies store fat in adipose cells, a connective tissue that stockpiles fats from the foods we eat and makes them available later when we need energy. Found under the skin and around internal organs, these cells keep the body warm and provide soft tissue between the body's inner machinery—but you can have too much of a good thing. Although the number of adipose cells in our bodies doesn't change much, their size can. Immature adipose cells contain hardly any fat at all, but adult ones can become swollen with glistening oil droplets, making them some of the largest cells in the body. When we consume more energy than we burn off—especially when the energy comes from foods rich in saturated fats and carbohydrates—it causes adipose cells to soak up more fat and grow in size. On the other hand, exercise or diet restrictions can have the opposite effect, shrinking adipose cells, and thus, our waistlines.

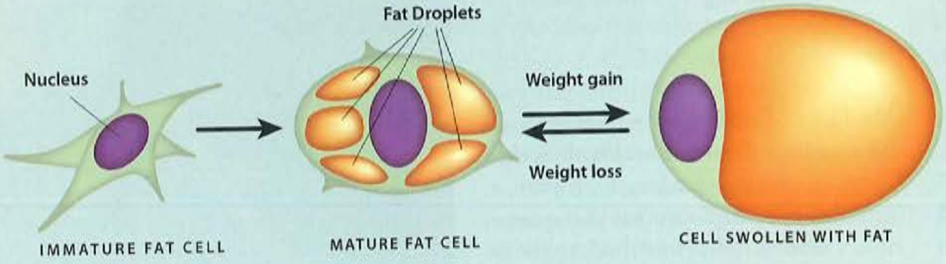
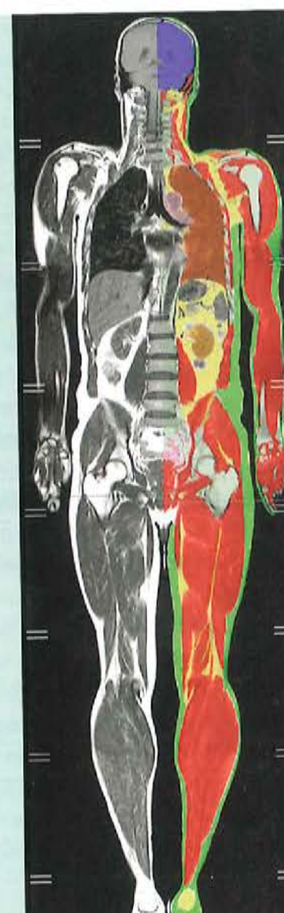


ILLUSTRATION BY H. ADAM STEINBERG



AN MRI HIGHLIGHTS BODY FAT IN GREEN AND YELLOW.

MEDICAL RESEARCH COUNCIL

Nutritional sciences professor Eric Yen and graduate student Stephanie Lamb examine liver cells, which the lab studies to understand how our bodies assemble and store fat from food. Yen is exploring how variations in a gene involved in metabolism may explain why people can eat the same foods but put on different amounts of weight.

seem like that's the end of the story. I think there may be many layers of complexity that we're just figuring out."

At the same time, Yen is also hoping to uncover how MGAT functions in different individuals. He suspects the gene may contain subtle mutations that cause the MGAT enzyme to work less efficiently in certain people than in others, possibly helping to explain why some individuals never grow plump even when they eat lots of fatty foods.

"A lot of the emphasis of our work may be to look at variations in this gene," Yen says. "Can those variations account for the differences we see in how obese people get on similar diets?"

Teasing out those differences may not only help us to better understand obesity as a disease, he adds, but could also lead to improved dietary guidelines for preventing the problem in the first place. "In the past, the main challenge of any public health field has been to create a simple message that people can remember, such as, 'Don't eat fat and you'll be lean,'" he says. "But people are not simple. So lots of times we give out dietary guidelines that don't really make sense for certain people."

Here lies one of the difficulties in explaining the relationship between genes and obesity. While people are largely similar on a genetic level—we have more than 99 percent of our DNA in common—the structure and deployment of those genes is wildly variable. Even with the same blueprint, our bodies make unique modifications that can trivialize blanket assessments of how we function. Take, for example, the case of type 2 diabetes, a disease that is often closely associated with obesity. There is good reason for that: Of the 20 million Americans who suffer from type 2 diabetes, roughly 80 percent are also obese. And yet, the vast majority of obese people don't go on to develop the disease.

This paradox plays out strikingly when you compare diabetes risks among people of different cultures or geographic regions. Among the Pima Indians of Arizona, for instance, one-half of all adults have diabetes, one of the highest rates of diabetes in the world. While obesity is epidemic among the Pima community, another factor seems to be at play, says Alan Attie, a biochemistry professor who studies diabetes. Attie points out that while white Americans are considered to be at risk for diabetes when they have a body mass index (BMI) of 30 or above, the figure is much lower for the Pima Indians. A much lower level of obesity puts them at risk for developing the disease.

The same is true of people who live in southern India: Scientists estimate that southern Indians need only hit a BMI of 23 to be in the same danger as a white American with a BMI of 30. So while a six-foot-tall, 175-pound Caucasian male would need to gain about 50 pounds to be considered at high risk for diabetes, a southern Indian man of the same weight and height would already be there.

"So that tells you something about genetics," says Attie. "There clearly are some genetic factors that are normally silent when you're lean, but that interact with obesity to bring on diabetes. And they're much worse in certain groups of people."

Much like Ntambi and Yen, Attie has been probing this idea in experiments with genetically engineered mice. His lab houses two groups of mice, both of which are morbidly obese. But only one is susceptible to type 2 diabetes. He is now searching for the genes that account for the disparity.

But even as we're uncovering genetic differences in how we process foods, the foods themselves are growing more

Research specialist Natalie Racine encloses student volunteer Jamie Cooper into the Bod Pod, a machine that calculates the percentage of a person's body that is fat. According to the American Council on Exercise, an acceptable amount of body fat ranges from 25 to 31 percent of body mass for women and 18 to 25 percent for men.

homogenous, a trend that could greatly complicate efforts to prevent obesity-related diseases such as diabetes. On the street in Taipei, Taiwan, where Yen grew up, for example, six American fast food outlets have sprung up since he graduated from high school. And Taipei is not alone: As Western staples and processed foods spread around the globe, we're only beginning to learn what effect those diets will have on populations that have historically not consumed them. Already, obesity rates have been climbing in Asia and other parts of the world, and this has Attie worried about the implications for diabetes. "Although we talk a lot about the diabetes epidemic in the United States and Europe, the diabetes epidemic that is anticipated in Asia is going to be much worse," he says.

This global transformation is proving significant for Africa, as well. When Ntambi left behind his studies of African sleeping sickness to investigate obesity, he never imagined that someday he'd again be working on an African disease. Sadly, though, that's exactly what obesity and diabetes have become.

"When I was growing up in Africa, I never saw many obese people. Now I do," says Ntambi, who travels back every year to Uganda to teach and do research. "So something must be changing, and I think it's lifestyle and diet."

Ntambi believes Ugandans, like many Westerners, have grown fatter as they've become more affluent, which brings access to more food and time-saving technologies that encourage a sedentary lifestyle.

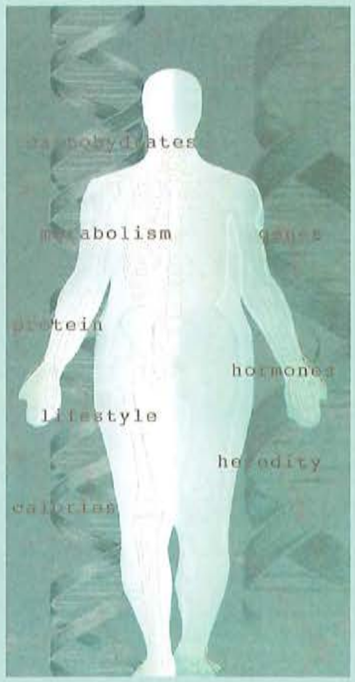
"It's a paradox," he says. "In Africa, when you buy a car or when you have a TV, it's a sign of prosperity and you would be proud. But if you misuse that technology, it's going to turn around and affect your health."

To be sure, recent years have seen a massive investment in research to address this global epidemic. Ntambi's work with SCD, as well as Yen's research on MGAT, have pointed two possible routes toward intervention. Based on the knowledge that inhibiting genes such as these change how our bodies store fat and burn energy, several drug companies are now trying to develop a pill that would tilt our metabolic balance away from cherishing fat.

While a weight-loss pill is a tantalizing idea, however, things aren't quite that simple. For one thing, while mice don't naturally express MGAT in the liver, people do, and Yen imagines that a drug targeted at MGAT could cause liver side effects not evident from mouse studies. Chemically inhibiting SCD also has potential downsides. Mice lacking the gene suffer from dry eyes and severe skin problems, and their levels of saturated fatty acids rise—with unknown consequences. What's more, deleting

The simplest advice we don't take

New program studies why we can't seem to eat less and exercise more.



Once people get the proper advice on how to lose weight, shedding pounds should be a snap, right? Like many scientists and nutritionists, Dale Schoeller used to think so. But 30 years in obesity research has taught him differently.

"When I started out, I thought you just needed to tell people to exercise more and control their diet, things that for me—although I'm not perfect at them—weren't that difficult," says Schoeller, who is a CALS professor of nutritional sciences. "But they are very difficult for well over half of our population, two-thirds probably."

Just as with smoking, there are a host of reasons why people who know they should be eating less simply can't. Some overindulge for emotional reasons or because they lack knowledge about nutrition, and others simply can't resist the smorgasbord of processed foods that are available today. Such a complex and multi-pronged problem requires a multi-pronged solution, which is why Schoeller now heads up a university-wide initiative called Wisconsin Prevention of Obesity and Diabetes, or WiPOD. A joint effort of CALS and the UW School of Medicine and Public Health, WiPOD is composed of UW-Madison faculty, staff and students who want to reverse the trend toward increasing flab in the Badger State and beyond. Many WiPOD participants already study obesity, including Schoeller, who uses tools such as the Bod Pod—a machine shaped like an oversized egg that measures a person's body fat—to understand the effects of exercise on metabolism.

But WiPOD also aims to involve researchers from fields as diverse as psychology, engineering, education and land use. "We want to tackle the issue of obesity not just from our viewpoints as individuals, but as teams that can take a wider view," says Schoeller.

Schoeller hopes the program will lure more scientists and medical practitioners into obesity research and offer them better training. But the ultimate goal is to bring new knowledge about obesity to the public, both by collaborating with community programs and by educating governments about actions they can take to promote healthy lifestyles. "We want to accentuate the positive," says Schoeller, noting that the growing number of bike lanes and farmers' markets around cities are steps in the right direction. But as with exercising to lose weight, the key will be keeping up the momentum.

SCD causes the metabolic rates of mice to skyrocket, suggesting that drugs aimed at the gene could possibly affect longevity.

"So, it's tricky," says Attie, who has collaborated with Ntambi on several studies of the gene. "But we'll know. There are a lot of drug companies working on SCD."

Side effects aside, there is perhaps a bigger reason not to pin all of our hopes on a miracle drug for obesity. Such drugs are bound to be expensive—and therefore out of reach for much of the world's population, says Ntambi. He has seen it before with diabetes in Uganda.

"Diabetes can be managed by diet, exercise and, of course, by insulin. But insulin is very expensive in developing countries," he says. "So someone may be diabetic, but not really have access to insulin, or individuals can become diabetic and they don't know it."

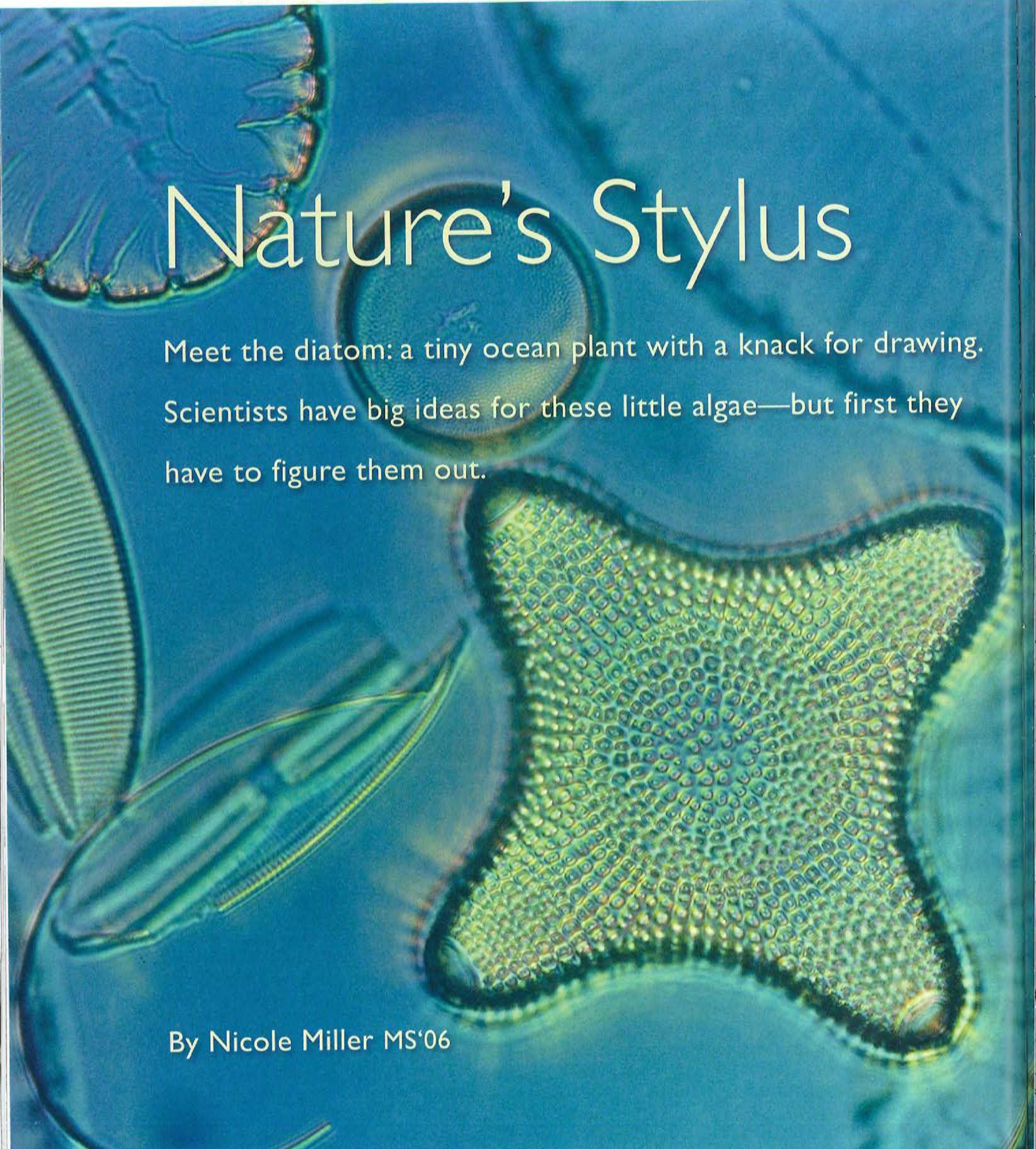
That's why, when Ntambi was packing last December for a six-month sabbatical in Uganda, he packed some 3,000 donated kits for monitoring blood glucose levels. During his visit, he handed them out for free so that people could check their blood sugar and get appropriate medical attention. He also hoped, along the way, to educate as many people as possible on ways to prevent obesity and diabetes, since for many Ugandans, changes in lifestyle and diet are likely the best—and possibly only—solutions for good health.

"We're not saying that you shouldn't eat a high-carbohydrate or a high-fat diet," says Ntambi. "You can eat what you like, if you enjoy it, as long as you're able to have energy balance in the body. The energy coming in has to be counteracted by the energy that is going out." And in nutrition, that's as simple as it gets: Expend more energy than you take in, and you'll shed pounds. We've heard it before, but the science of genetics is reinforcing its essential truth by showing us exactly why it works this way. The only question is: Will we listen?

Nature's Stylus

Meet the diatom: a tiny ocean plant with a knack for drawing. Scientists have big ideas for these little algae—but first they have to figure them out.

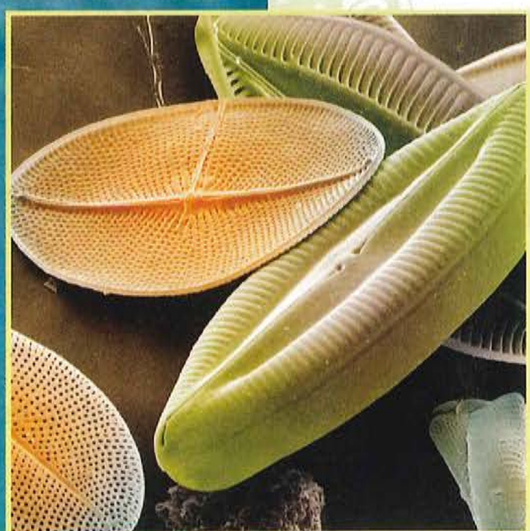
By Nicole Miller MS'06



Darlyne A. Murawski/National Geographic Image Collection/Getty Images

To the beachcombing tourists of Seaside, Oregon, the dark, brownish foam that washed up on the peaceful resort town's shores one day in February looked like an oil slick. Up and down the beach, swaths of coffee-colored froth bubbled in with the surf, settling in unsightly clumps on the sand. Worried visitors poured into boardwalk shops, asking if there had been a ship wreck off shore. The tourism office got so many calls that it issued a press release. No need to panic, the release soothed. It's just diatoms.

Billions and billions of diatoms.



Found in virtually every body of water on the planet, microscopic diatoms create glass-like shells called frustules (shown above), which are intricately designed with lines of silica.

Diatoms—microscopic, single-celled algae that grow in virtually every body of water on the planet—have been likened to the grass of the ocean because they are so plentiful and so humble a part of the ocean food chain. They bloom in huge numbers near the ocean surface, where they take in energy from the sun, along with nutrients in the water, and convert them into carbohydrates. Fish feast on them—the nutritionally valuable omega-3 fatty acids in seafood come from the diatoms they eat.

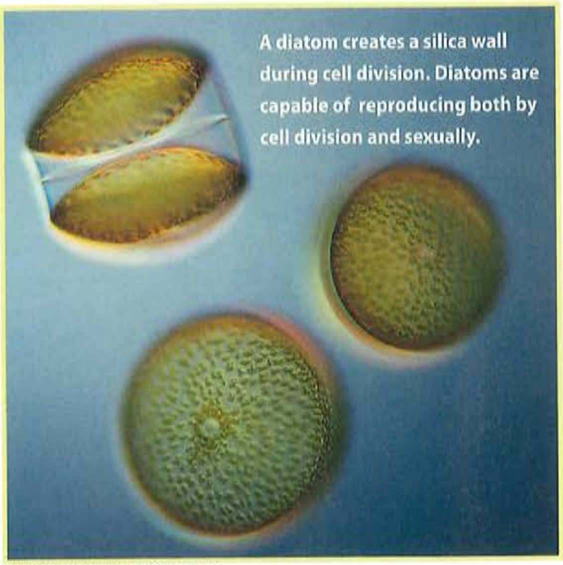
Diatoms are also unheralded players in the Earth's carbon cycle: They remove the same amount of carbon dioxide from the atmosphere each year as all the world's rainforests combined. Yet they do all this with very little fanfare. In fact, most people never hear of them, except on the rare occasion when winds push blooms of diatoms onto a seashore, as happened in Seaside. And even then, they appear *en masse*, as an oily muck that conceals their amazing beauty.

Up close, diatoms are actually quite stunning. They are encased in cell walls made of silica, a kind of glass, and each of the thousands of species of diatom features a unique pattern of intricate grooves, lines and notches. When they were first discovered shortly after the invention of the microscope, parties were convened just to marvel at their filigreed, jewel-like shapes.

But with that beauty also comes intriguing possibilities. Using the high-tech tools of biotechnology, scientists are starting to learn how diatoms do the things they do, including their remarkable ability to create their intricate cell walls using tiny lines of silica. The answers could help advance a field of human endeavor that is critical to modern life as we know it.

"Diatoms are beautiful organisms that are able to lay down nanometer-sized lines of silica," says CALS molecular biologist Michael Sussman. "If we could genetically control that process, we would have it nailed. We would have a whole new way to make computer chips."

These kinds of intuitive leaps are entirely in character for Sussman, whose interest in diatoms was sparked by a single, one-hour talk he attended at a genomics conference organized by the J. Craig Venter Institute. Born and raised in New York City, Sussman brings a free-associating spirit to his laboratory, which is filled with equal parts laughter and inspiration. "Things are usually pretty mirthful [around the lab]," says Matthew Robison, one of Sussman's graduate students who worked with him researching diatom genetics. "Sometimes it can be difficult to keep him on topic, but we try our best."



A diatom creates a silica wall during cell division. Diatoms are capable of reproducing both by cell division and sexually.

Visuals Unlimited/Corbis

Sussman spent much of his early career studying *Arabidopsis*, a model plant that scientists like because it has a rapid life cycle and can be grown in Petri dishes. He joined CALS as a horticulture professor in 1982, before switching to biochemistry in 2002. But the most significant turn in his work came in 1997, when he agreed to direct UW-Madison's Biotechnology Center, a core facility that assists scientists with high-end research tasks such as gene sequencing and DNA analysis. The position allowed him to turn his creative energy toward dreaming up and perfecting new research tools, such as a DNA chip he developed with UW-Madison electrical engineer Franco Cerrina and geneticist Fred Blattner. The technology led to the 1999 launch of NimbleGen Systems, which last year was acquired by the pharmaceutical giant Roche for $272 million.

But for all his technological skill, Sussman has the heart of a naturalist. He lives on a quiet hog farm 12 miles from Madison, about which he enthuses, "We eat breakfast with Bambi and Thumper every morning." He also shows a near-fanatical obsession with *The Life Aquatic with Steve Zissou*, a quirky movie that chronicles the adventures of an aging oceanographer in search of a mythical "jaguar shark." In interviews, he references the film repeatedly, and he occasionally blasts songs from its soundtrack on his office computer.

"He's got this fantasy that he could move his lab onto a boat and cruise around the world doing research on it," says Robison.

Even before he learned about diatoms, Sussman was exercising his inner Zissou by exploring the unique

"For the longest time, we've tended to study organisms where you could see the direct impact on humans. It's a bigger leap for many to understand the importance of the microorganisms in the ocean."

Virginia Armbrust
Professor of Oceanography, University of Washington

"I do believe quite strongly that the true strength of biology will be its odd organisms: the electric eels, the silicate sponges and the diatoms."

Michael Sussman
Professor of Biochemistry, UW-Madison

capacities of some of the planet's strangest aquatic creatures. For a number of years, he's been fascinated by electric eels, and he recently wrote an article for the *Journal of Fish Biology* calling on the scientific community to sequence the genome of *Electrophorus electricus*, which he thinks could open the door to new ways to produce and store energy.

But Sussman is quick to point out that a little eel curiosity hardly makes one a naturalist. "Actually, I think about myself as an un-naturalist," he says. "I like to do unnatural things with biology." In other words, his interest in eels and diatoms is driven by a desire to deconstruct nature and apply the lessons elsewhere.

This, essentially, is what led Sussman to diatoms—and by extension, to Virginia Armbrust. In 2004, the University of Washington oceanographer led a team that sequenced the 13,000 genes of a diatom species known as *Thalassasora pseudonana*, or *Thaps* for short. "Once we (had a diatom sequence), then things moved into a realm where people like Mike could imagine working on them," says Armbrust. "It gave people tools to ask additional questions beyond the basic ecology of the organisms."

Shortly after hearing the talk on diatoms, Sussman contacted Armbrust, and a collaboration began to coalesce. Using the Thaps genome and NimbleGen technology, Sussman's team created DNA chips containing all of a diatom's genetic information. Using these chips, Sussman and Robison then began searching for genes of interest. "This [technology] is like a new type of microscope," says Sussman. "But instead of looking at things that reflect visible light—that's what a regular microscope does—it lets us peer into the nucleus and directly tells us which genes are involved in any process."

With diatoms, Sussman and Armbrust are interested in the genes at play when the organisms create their ornate cell walls. Before a mature diatom divides, it must build enough new cell wall material to protect its two "daughter cells." It does so by laying down lines of silica that are only a few hundred nanometers wide, far thinner than the smallest lines drawn on computer chips using today's best photolithographic techniques. Conveniently, a diatom's chief building material, silica, is closely related to silicon, a material often used in the manufacture of semiconductors and other industrial materials, including window glass, cement and certain car parts. Recently, researchers at the Georgia Institute of Technology were able to chemically alter diatom shells, turning them into silicon. They then used these nanoscale structures to create sensors capable of detecting minute amounts of certain toxic gases.

But Sussman is most intrigued by the potential for semiconductors. "The semiconductor industry has been able to double the density of transistors on computer chips every few years. They've been doing that using photolithographic techniques for the past 30 years," he explains. "But they are actually hitting a wall now." The limits of photolithography to pack in smaller and smaller lines of silicon onto a single chip may soon be reached.

Enter diatoms. By observing diatoms in action, Sussman expects to discover genes that give the organisms the ability to draw silica lines in such fine detail. Those genes—and more likely, the proteins that they encode to do the work—could become the basis for a new industrial process that would allow the semiconductor industry to go smaller still, adding more density, and thus speed, to future generations of computer chips.

Already, Sussman and Armbrust have reported finding a set of 75 genes specifically involved in silica bioprocessing in *Thaps*. Now it's just a matter of figuring out what these genes and their corresponding proteins do inside the diatom, no small task. *Thaps* was the first silica-requiring organism ever to be sequenced, and as a result, more than half of the 75 genes the researchers found are novel, meaning they bear no resemblance to the 32 million genes currently found in the national GenBank database. In many ways, they are still at square one.

At the University of Washington in Seattle, Virginia Armbrust occupies what might be Michael Sussman's dream office. From her desk in a new research tower, she enjoys a sweeping view of downtown Seattle, punctuated prominently by the Space Needle. In the foreground, Lake Union shines in the morning sun, and if Armbrust leans over, she can check out the university's two research vessels, the very ships that regularly carry her out to sea.

Sussman makes no bones about his admiration for Armbrust's work. "She's a real oceanographer," he says. "She's (studied life) at the bottom of thermal vents, and that's her world."

NOAA

Marine plants such as diatoms may be microscopic, but their multitudes can be unmistakable. At left, billions of surf diatoms tinge ocean waves yellow. Above, a bloom of green and blue algae off the coast of Argentina was recently captured by a NASA satellite camera.

"He calls me Captain Zissou all the time," says Armbrust of Sussman. "It's hard for people that don't go out to sea to know what it's really like out there. It becomes very romantic. So Mike would ask me, 'Is it really like it was in *The Life Aquatic*?' Of course I would tell him, 'Yes, it's exactly like that.' We were just joking around."

From the start of their collaboration, Armbrust and Sussman set out to create a casual atmosphere that encouraged free-wheeling brainstorming. The two arranged a joint meeting of their lab teams at an eco-resort in the U.S. Virgin Islands, where they took in PowerPoint presentations in an open-air cabana and went snorkeling amidst the ocean life they had come to discuss.

While Sussman is the biotechnologist, Armbrust fits the mold of a classical ecologist. She got hooked on oceanography while working a summer job on a research boat, and then started studying diatoms in graduate school. Her interests now lie in how changes in the oceans, such as increasing temperatures and acidity, are affecting diatom populations—and what implications will follow for the planet's carbon cycle.

"For the longest time, we've tended to study organisms where you could see the direct impact on humans," she says. "It's a bigger leap for many to understand the importance of the microorganisms in the ocean, and the role they play in global biogeochemical cycles that make our planet function, that make it a place we can inhabit."

However, put the right way, their importance is astonishingly direct: Diatoms make 20 percent of the oxygen we breathe. "As one of my colleagues always says," says Armbrust, "every fifth breath, thank a diatom."

While you're at it, you may want to thank diatoms for the fact that global warming is not worse than it is. When diatoms die—which they do after a six-day lifespan—their heavy shells drag them to the bottom of the ocean, effectively trapping the carbon inside of them underwater. It can take a geological epoch for these sunken diatoms to resurface and release that carbon. (Ancient ocean beds are often caked with fossilized diatom shells, which are sometimes harvested and sold as diatomaceous earth, a natural insecticide favored by organic gardeners.)

Seeing this potential to trap and store carbon in diatoms, some scientists and government officials have suggested that they might offer a quick fix to offset the release of greenhouse gases from fossil fuels. Entrepreneurs even launched a company, called Planktos, which planned to seed swaths of the ocean with iron, which induces diatom blooms, to increase the amount of carbon dioxide absorbed from the air. That plan never got off the ground, however, in part because environmentalists objected to the idea of fertilizing the ocean with iron. Earlier this year, Planktos declared bankruptcy and folded.

Armbrust's and Sussman's research shows one reason why environmental groups may be right to worry. "Our study adds another concern about the efficiency of iron fertilization," says Thomas Mock, a postdoctoral researcher in Armbrust's lab. When grown at low iron concentrations, diatoms tend to produce thicker cell walls. This means that iron-fertilized diatoms have thinner cell walls, making them lighter and less likely to sink to the ocean floor.

To Sussman, iron fertilization sounds like a "dangerous experiment, because we'd be messing with the flask in which we live." And that represents the wrong kind of biotechnology—the large-scale toying with biological systems that could lead to unforeseen, irreversible circumstances.

On the other hand, Sussman believes firmly in a different kind of biotechnology, one in which we observe, study and mimic natural systems to help overcome specific engineering problems. This model of innovation has already led to some stunningly creative developments. In 2007, for example, an international team of researchers reported the creation of a "bio-inspired" adhesive tape that mimics the way that flies and other insects hang on walls and ceilings. Another group is studying octopuses to improve designs for flexible robotic arms.

"I've always had this notion that during those 3 billion years of evolution that have been cranking away, nature has come up with some solutions to physical constraints that maybe the engineers haven't found yet, and should use," says Sussman. And that's where the un-naturalist meets the naturalist: In some of the planet's most peculiar critters—the ones that have thrived under challenging conditions or invented ingenious strategies to flourish—Sussman sees the potential for enormous scientific innovation.

"I do believe quite strongly that the true strength of biology will be its odd organisms," he says. "The electric eels, the silicate sponges and the diatoms."

Working Life | *food*

Making a Masterpiece

CALS program keeps Wisconsin cheeses a cut above.

Above: a sample of Sid Cook's award-winning handiwork with Carr Valley Cheese.

If you visit Sid Cook at Carr Valley Cheese in La Valle, Wis., he'll carve you a hunk of his beautifully complex chipotle cranberry Cheddar. And if you're lucky, he'll tell you how to eat it.

For Cook, every bite of cheese is a symphony waiting to happen. "If you think of the profile in terms of music," he says of the award-winning Cheddar, "it's cheesy, and then you get the sweetness of the cranberry. Then you get the smokiness of the pepper, and then the heat comes in. Then you take a sip of beer and start all over again. And that's three or four measures of music."

Cook, the fourth-generation owner of the family business, has more than 60 cheese-championship awards to attest to his virtuosity. But in 2002, he earned something else: the title of Master Cheesemaker, which he gained by completing CALS' three-year Master Cheesemaker program, which is funded by the Wisconsin Milk Marketing Board. The only of its kind in the nation, the program trains experienced cheesemakers in the scientific and technical aspects of their craft, including eight courses, exams and on-site inspections. Since 1994, 50 Wisconsin cheesemakers have graduated from the program, which certifies them as masters in up to two cheeses.

"It's like graduate school for cheesemakers," says food science professor Bill Wendorff BS'64 MS'66 PhD'69. "You have the same kind of relationship with faculty and staff with the cheesemakers that you would have with a graduate student."

Initially, Cook was unsure about devoting time to the program. Like many cheesemakers, his introduction to the craft was through the family business, which has made cheese for more than 100 years. But increasingly, even veteran dairies are finding that continuing education can pay off. Wendorff notes, for example, that graduates of CALS dairy short courses comprised 38 percent of the winners at this year's World Championship Cheese Contest in Madison. Short-course grads also won 65 percent of the prizes at last year's U.S. cheese championships.

Now Cook is sold. "All of those classes that I took with both cheesemakers academics from (all around the world)—that's invaluable because you can see how they do it and why they do it in a certain way," he says. In fact, he's signed up again to add two new cheeses to his master symphony.

—Kate Tillery-Danzer MS'08

The Grow Dozen | 12 Alumni who are making a difference in the food industry

About the Dozen

These 12 alumni represent the stunning depth and breadth of CALS graduates' accomplishments. Selections for the list are made by the Grow staff and are intended to reflect a sample of alumni stories. It is not a ranking nor a comprehensive list. To read more about CALS alumni, go to www.cals.wisc.edu/alumni/

Next issue: **Biotechnology**

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

Kevin Bacon

BS'84 MS'86, Animal Sciences

Often confused with the famous actor, this Kevin Bacon wouldn't trade places. "Where else would a guy with the last name of Bacon work but Oscar Mayer," he jokes. In 22 years with the company, he's done everything but drive the Wienermobile. Now plant manager, his job is to ensure employee safety, high quality food products and customer service. Recently, he helped develop processes and recipes for Oscar Mayer's new all-beef hot dogs, released in April.

Juelene Sorensen Beck

MS'78, Food Science

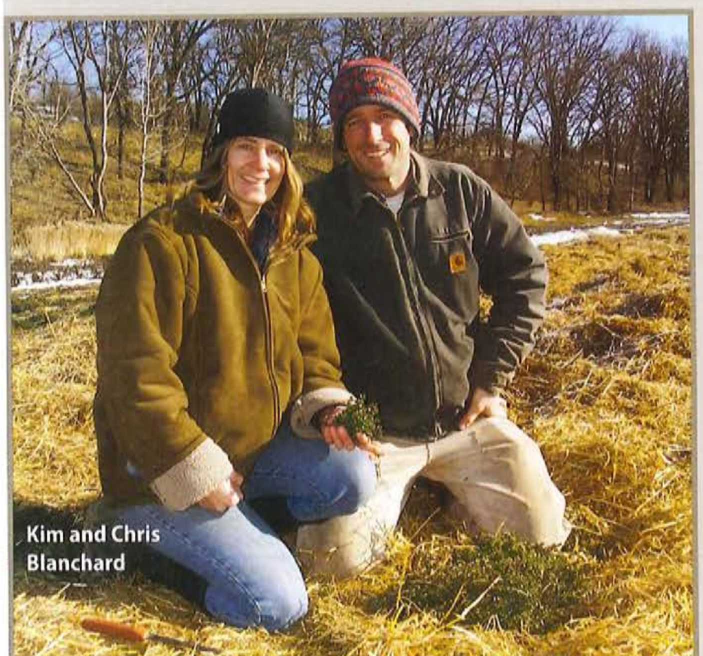
Beck knows her way around the food industry. As president of Julene Beck and Associates, she's a full-time consultant to operators and suppliers in the chain restaurant business. That's certainly a market she knows well, having held leadership positions in such popular names as Dunkin' Donuts, Burger King, Subway and Sara Lee. She is also a worthy steward of higher education. She has created an internship through the CALS horticulture department in honor of her father, emeritus professor Gail Edwin Beck, and she chairs the college's Board of Visitors.

Juelene Sorensen Beck

Kim and Chris Blanchard

BS'93, Horticulture

If you've ever wondered what to do with broccoli raab, Chris and Kim Blanchard are the people to talk to. Of course, you'll have to catch up with them first. The two run the 80-acre Rock Spring Farm in Decorah Iowa, while also dispensing advice on organic farming, cooking and eating through magazine articles, online forums and community outreach. Chris currently serves on the board of directors for the Midwest Organic and Sustainable Education Service, a nonprofit organization committed to advancing organic agriculture, and since 2000, he's coordinated presentations for the annual Organic Farming Conference in La Crosse, the largest organic meeting in North America. When Kim isn't running circles around her farm, she's doing it around cities—she's completed two Twin Cities marathons.



Kim and Chris Blanchard

Robert Brackett

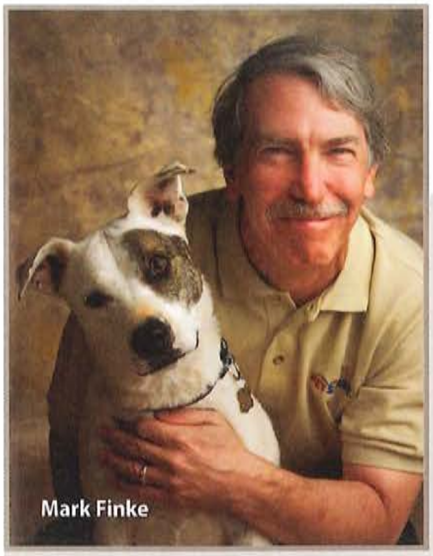
BS'76, Bacteriology; MS'79 PhD'81, Food Science

A former high-ranking official with the U.S. Food and Drug Administration, Brackett is now senior vice president for the Grocery Manufacturers Association, a powerful trade association that represents some of the heaviest hitters in the food industry. As the GMA's chief officer for science and regulatory affairs, Brackett advises food companies on safety issues and runs the GMA's in-house food safety lab. He focused on the same issues with the FDA, directing the government's Center for Food Safety and Applied Nutrition from 2004 to 2007.

Mark Finke

PhD'84, Entomology and Nutritional Sciences

What's an entomologist doing in a food list? Insects are savored as protein-rich delicacies around the world by humans and animals alike and Finke has been researching their role in animal diets since graduate school. As a sideline to his day job as director of technical services for the national chain PetSmart, Finke has created detailed nutritional analyses of insects used to feed various pets, including reptiles,


Mark Finke

amphibians, birds and some small mammals. Finke has helped zoos and wildlife rescue organizations plan menus for orphaned and injured insect-eating animals. He's even designed diets for the bugs to boost their nutritional value when they become food for other animals.

Brian Flood
MS'72 PhD'75, Entomology

Flood is in charge of integrated pest management for Del Monte Foods, where he has worked for more than three decades. As part of his task to keep Del Monte's produce fields free from predators, he's helped lead a collaborative research effort that has yielded benefits for both industry and farmers. In 2005, the group developed an Internet tool called Insect Migration Risk Forecast, which combines climate and insect migration patterns to help growers know when, and if, pesticide application is necessary on their fields.

Jonathan Frey
BS'80, Bacteriology; MS'83 PhD'85, Food Science

Frey has one of the most interesting sounding jobs in the food business. His official title—director of sensory and knowledge discovery at Taco Bell—means that he's in charge of ensuring that new products satisfy the hordes of consumers looking for a quick Tex-Mex fix. Through data mining—the careful sifting of reams of consumer and product reviews and demographics—Frey can help his company turn a market opportunity into a chalupa.

James Lochner
BS'74 MS'76, Animal Sciences

Everyone knows that Tyson Foods is a brand leader for chicken, but the food giant has a thriving beef and pork operation, too—and Lochner is in charge. As senior group vice president for Tyson, he heads Tyson Fresh Meats, where he oversees 41,000 employees at 17 locations. He also manages Tyson's commodity trading and risk management operations.

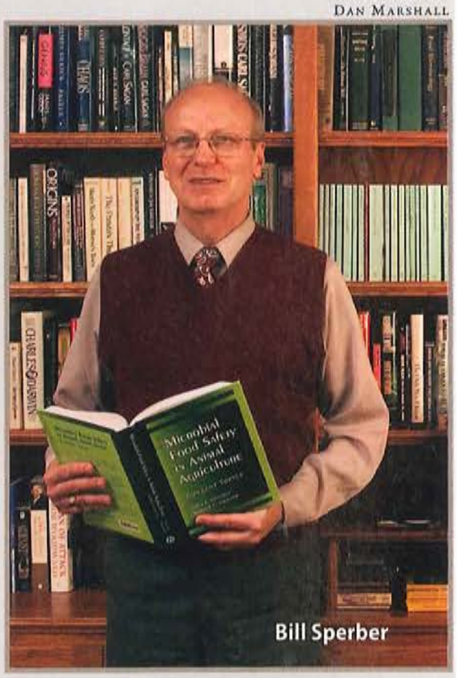
Cassandra Miller
BS'06, Food Science

Miller is working to improve nutrition for low-income families around the world as part of Sustain, a Washington, D.C.-based organization that connects food industry specialists and technologists with governments and international groups working to improve the quality of food staples. After earning her degree, Miller joined a project in Mexico to fortify corn masa flour and tortillas with iron to help combat iron deficiencies in the region. She's also involved with the Food Aid Quality Enhancement Project, which seeks to improve the nutritional value of food distributed through government aid programs.

Bill Sperber
MS'67 PhD'69, Bacteriology

If you care about food safety—and who wouldn't?—you should know about Sperber's work. After spending four decades safeguarding food for industry giants such as Pillsbury and Cargill, as well as serving as an international advisor for the USDA and the World Health Organization, he's now semi-retired—but certainly not merely semi-productive. These days, he develops textbooks on food pathogens and food safety risks and has recently taken on a role as secretariat of Safe Supply of Affordable Food Everywhere, a unique partnership among global food companies such as Cargill and McDonald's, non-governmental organizations and academia to study and address threats to the global food chain.

Dan Marshall


Bill Sperber

Paul Stitt
MS'69, Biochemistry

In 1976, Stitt left a career in corporate food-product development to launch Natural Ovens Bakery, a small bread shop in Manitowoc, Wis. Buoyed by the popularity of his fresh, wholesome breads, he's been out to change American diets ever since. Dismayed by the ubiquity of junk foods in children's diets, Stitt

The Grow Dozen

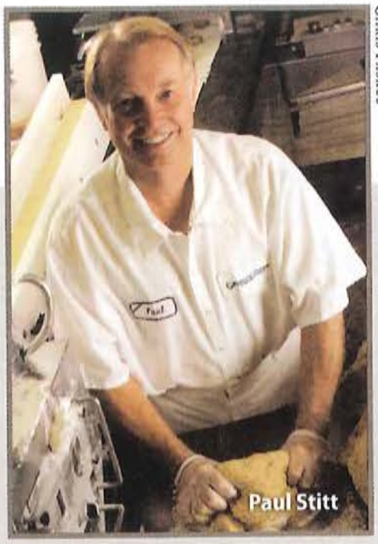
teamed up with schools in Appleton, Wis., to devise a five-year pilot project to remake school lunches. His efforts to replace soda and French fries with fruits and whole grain "brain food" was featured in Morgan Spurlock's documentary, SuperSize Me. Now retired from Natural Ovens, Stitt lives in Virginia and is working on a project to fortify foods with nutritional supplements.


M. Aman Wirakartakusumah

M. Aman Wirakartakusumah

MS'77 PhD'81, Food Science

Widely recognized as one of the leading authorities on food in Indonesia, Wirakartakusumah is a professor of food science and technology and the former rector of Bogor Agricultural University. But these days, his most prominent role is as his country's ambassador to the United Nations Educational, Scientific and Cultural Organization (UNESCO). In that capacity, Wirakartakusumah has advanced educational programs to address malnutrition and promote food safety and championed enhanced fitness and health education in schools. A fellow of the International Academy of Food Science and Technology, he has been a strong advocate for the development of standards for research on biodiversity and biotechnology in Indonesia, where issues such as genetically engineered crops and conservation of natural resources are pressing. He also finds time to stay connected with UW-Madison, serving on a global advisory panel for the dean of international studies.


CHRIS PASKUS

Paul Stitt

next Steps

Three things you can do to stay connected with CALS

1 Eat a potato. CALS is one of the players behind Wisconsin Healthy Grown potatoes, a brand that promotes environmentally friendly agriculture. Launched in 1996, the brand represents a collaboration among CALS, the Wisconsin Potato and Vegetable Growers Association, the World Wildlife Fund and other conservation groups. Growers have to meet strict standards for reducing pesticides and other chemicals to earn the brand label, which has won awards from the U.S. Department of Agriculture and the International Crane Foundation. Check the Healthy Grown web site for a list of retailers. Go to ***www.healthygrown.com***

2 Hire an intern. You know that business project that you never quite get to? A CALS student might be just the answer to get it done. The vast majority of CALS undergraduates seek out internship opportunities to build professional skills and enhance their education. And businesses benefit, too. Students offer knowledge that can help reinvigorate a company's marketing efforts or bring a fresh eye to research projects, which is why some of the nation's top companies return every year to hire interns. And setting up an internship is easier than you might think: just come up with a project that offers a positive, substantial learning experience, and the college will do the rest. *Contact **Christina Klawitter**, CALS Career Services Director, cklawitter@cals.wisc.edu, (608) 262-5780.*

3 Ready for some football? Badger football season will be here soon, and that means it's time to start thinking about CALS' annual Fire Up. Hosted by the college and the Wisconsin Agricultural and Life Sciences Alumni Association (WALSAA), the Fire Up is a pre-game tailgate party for the entire CALS community. It's a great way to reconnect with old friends and meet new ones. Proceeds benefit student scholarships and the newly created Wisconsin Rural Youth Scholarship Fund. This year's event will take place in the UW Field House before the Badgers' Sept. 6 home game against Marshall. *For more information, contact **Bonnie Jaedike** in CALS' alumni affairs office at (608) 262-1445 or bjaedike@cals.wisc.edu.*

Peter Potter BS'07, Food Science

It's only been a year since Peter Potter earned his CALS degree, but talk about busy. Before he even finished his studies, Potter launched an organic cracker company with his mother, Nancy, who ran a bakery in New Glarus, Wis. Together, they run Potter's Fine Foods, which sells flavored crackers in markets throughout Wisconsin. In his free moments, Potter is pursuing a graduate degree in systems engineering—and dreaming up new cracker flavors.

• You got an earlier start than most on owning a business.
Yes, I started it up in between my junior and senior year of college. After my freshman year, I had an internship in a food company, and after my sophomore year, I worked in a lab. Then, when the next year came around, I knew I didn't want to work in a lab again because I had spent the previous summer doing that, and I had already had a pretty good internship, so I decided to start up my own company.

• How were you prepared to do that at such a young age?
Well, my degree was in food science, and that is what we study—we learn how to develop products and how to develop processes to go along with those products. I took the business option in the program, so I was able to take four or five business classes before I started my company. And so through the program I kind of learned how to do the whole thing—how to make it, process it and sell it.

• Why crackers?
Basically, I saw a marketing opportunity. There was nobody in Wisconsin producing crackers, and we are the cheese state and so I thought we needed a good cracker to go with that.

• How did that opportunity come knocking at your door?
I was actually out to eat at Lombardino's, and I was having their cheese plate. It was absolutely gorgeous. They had these great cheeses from Italy and some from Wisconsin, and they were serving them with horrible crackers. They were these overly processed ones from California. And it posed a question to me: Why are they doing this? And I realized that they have to do it because they don't have any other crackers, like local ones or high-quality ones. So I kind of translated that into a business idea.

• How many cracker varieties do you have?
We have about 100 varieties. We kind of specialize in the product development stages, and we rotate them seasonally since we use so much local produce.

• And you do all this while in graduate school?
Yes—I'm doing a master's degree in systems engineering. I'm still studying food and food manufacturing and food processing, just from a slightly different perspective.

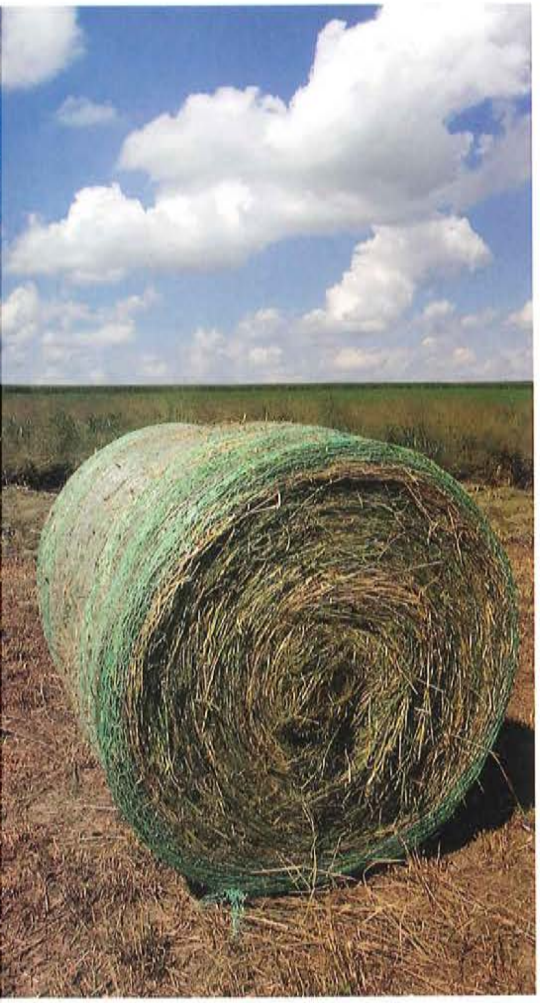
• You seem like someone who enjoys a challenge.
Yeah, I do, definitely. And hopefully, I can continue to challenge myself through Potter's Crackers and other things. I do really like the entrepreneurial thing, and so hopefully I can get some other companies started up.

• What do most people not know about crackers?
Well, for one thing, it's pretty difficult because crackers are pretty thin and they do rise quite substantially, so you really have to put a lot of work into getting them nice and flat. And for people who don't eat Potter's Crackers, I guess they don't know how delicious crackers can be.

Five things everyone should know about . . .

Carbon Offsets

By Chris Kucharik



Prairie grasses such as switchgrass are valued for their ability to trap carbon in the soil.

1 | Carbon offsets are economic arrangements where businesses or individuals pay someone else to counterbalance their CO_2 emissions. To comply with regulations on greenhouse gas emissions, or to make themselves more environmentally friendly, some businesses and individuals now pay others to trap and store carbon in plants, soils or below-ground reservoirs. The idea is that these actions, which remove carbon from the atmosphere, can help cancel out their own emissions, bringing them closer to being "carbon neutral."

2 | For farmers and landowners, carbon offsets can provide some income. In the United States, formal carbon credits are sold on the Chicago Climate Exchange as part of an arrangement with the National Farmers' Union. These credits pay a market rate for carbon that farmers and landowners sequester by taking steps such as planting trees, restoring grasslands or adopting no-till farming practices. As of May, the going rate was about $7 per metric ton of carbon stored. This means that a typical Midwestern farmer with 200 acres could earn around $700 per year just by not tilling.

3 | Buyers beware: The offsets you pay for may not actually exist in nature. Verification of actual carbon sequestration is difficult and expensive. It requires collecting and processing numerous plant and soil samples and complex computer modeling. Instead, the quantity of carbon offsets assigned to any given land is based on generalizations. For example, all permanent grasslands across the eastern two-thirds of the United States are allocated the same offset value—one metric ton per acre—even though the rate of carbon storage varies significantly with climate, soil type and vegetation planted. So when you buy a carbon offset, there's usually no way of knowing if it's really removing that much carbon from the atmosphere. Sometimes you might be getting more than you pay for, sometimes less.

4 | Carbon offsets are not a silver bullet to stop global warming. Scientists believe that we may be able to offset only 10 to 20 percent of annual carbon dioxide emissions with sequestration. And carbon dioxide isn't the only greenhouse gas accumulating in the atmosphere. Molecule per molecule, nitrous oxide and methane have even greater potential for creating warming. In any case, we will need a wider approach to stabilizing our climate.

5 | There are still good reasons to do the things carbon offsets encourage. Practices such as no-till agriculture and prairie restorations have many other important environmental benefits. Increases in soil carbon are connected to improved crop productivity, increased water-holding capacity (which reduces the potential for floods), and better water and air quality. Turning land over to prairie can also promote biodiversity and provide wildlife habitat while reducing fertilizer runoff that can contaminate rivers and well water. There is also enormous potential for grasses and trees grown on conservation reserve lands to be used as feedstocks for future biofuel production, which may cut greenhouse gas emissions by reducing our need for fossil fuels.

Chris Kucharik is an associate scientist in UW-Madison's Center for Sustainability and the Global Environment, part of the Gaylord Nelson Institute for Environmental Studies. He researches the role that different natural and managed ecosystems play in the planet's carbon cycle. He has recently studied the soil carbon-storing potential of prairie restorations across southern Wisconsin.

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Questions from actual exams given to CALS students

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Forestry: What is the best predictor of the timber volume of a tree:

a. tree species
b. tree diameter
c. tree height

From Forest Ecology 300: Forest Biometry, taught by Volker Radeloff

Bacteriology: One of the most important benefits that the human gastrointestinal flora provide for their host is:

a. digestion of dietary cellulose
b. a low grade toxemia
c. production of dietary protein
d. antagonism against colonization by potential pathogens
e. production of antibodies

From Bacteriology 303: Procaryotic Microbiology, taught by Kenneth Todar

Food Science: Special interest groups often have a great deal of influence on food law and regulations. Which of the following is currently petitioning the FDA to restrict health claims on labels?

a. Consumer Freedom
b. Center for Science in the Public Interest
c. Safe Tables Our Priority
d. Institute of Food Technologists

From Food Science 321: Food Laws and Regulatoins, taught by Monica Theis, Steven Ingham and John Norback

Agronomy: During flower development, pollen is formed in the developing anthers. This process is called:

a. Megasporogenesis
b. Double Fertilization
c. Microsporegenesis
d. Cytokinesis
e. None of the above

From Agronomy 338: Plant Breeding and Biotechnology, taught by Shawn Kaeppler

Urban Planning: A "green" or *sustainable* approach to site planning seeks to minimize the environmental impacts from development by which of the following techniques:

a. preventing the development or disturbance of existing riparian areas, wetlands, steep slopes and native woodlands
b. limiting site clearing and soil disturbances to the areas required for construction access, building footprints, circulation systems and utility infrastructure
c. dispersing storm water runoff from roofs and other large impervious surfaces over vegetated, pervious surfaces
d. all of the above

From Urban and Regional Planning 601: Site Planning, taught by James LaGro

LAST ISSUE: Answers were 1: c, 2: a, 3: d, 4: b, 5: c. Congratulations to Paul Cramer, who was the only person to answer all questions correctly and is last issue's winner of a box of Babcock Hall cheese.

STAND TALL

SHOOTS OF WILLOW AND FIREWEED sprout on the floor of a Canadian boreal forest, where CALS professor Tom Gower is researching the health of this critical biome. ▮ WANT TO SEE OTHER WORK GOING ON AT CALS? ▮ VISIT: www.cals.wisc.edu/grow/

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