SUMMER 2022

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College of Agricultural & Life Sciences
University of Wisconsin–Madison

Join **Betül Kaçar** on a dauntless journey through time, back to the

Origins of Life in the Universe

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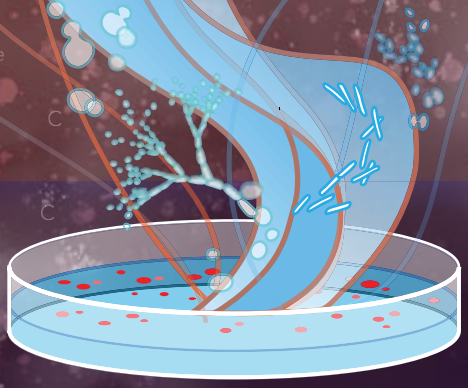

+ SOLUTIONS FOR DAIRY CHALLENGES
BIRD BIODIVERSITY MAPS
THE LIMITS OF VERTICAL FARMING
LESSONS IN THE GARDEN

CALS graduate students stand for conferral of their degrees during the spring 2022 commencement ceremony. The celebration was back fully in person at Camp Randall Stadium after a virtual ceremony in 2020 and limited attendance in 2021.

Photo by MICHAEL P. KING

Wisconsin's Magazine for the Agricultural and Life Sciences

grow

VOLUME 15, ISSUE 3 | SUMMER 2022

FEATURES

DEPARTMENTS

ON THE COVER Betül Kaçar devised a molecular time machine to better study the origins and evolution of early life on Earth, a radical idea that launched her career in astrobiology. Read her story on page 20. Illustration by JACKI WHISENANT

Photos, from top, by ROMULO UEDA, JEFF MILLER and MICHAEL P. KING

Photo by MICHAEL P. KING

DEAN KATE VANDENBOSCH

Stepping Down, Staying On

As I mentioned in the fall 2021 issue, I am stepping down as dean of CALS this summer. This will be my last column for *Grow* magazine. Although it's bittersweet to write those words, I am happy to report that I leave the deanship in highly capable hands.

Our new dean, **Glenda Gillaspy**, begins her tenure in August. Glenda comes to us from Virginia Tech, where she has been a professor of biochemistry since 1998 and head of the department since 2015. She brings a track record of success in enhancing graduate education, attracting and retaining new faculty, and securing resources for teaching and research. I have been enjoyed getting to know Glenda while sharing information about CALS. You'll hear more from her in our fall issue.

This leadership transition comes at a time when CALS is well-positioned for success. We just completed a fruitful comprehensive fundraising campaign. We are also making great progress in developing new academic programs, and the early indications are that the surge in first-year enrollment at UW—Madison is translating into growth for CALS. Our research and outreach programs are strong and have been bolstered by new federal funding for initiatives that are tied to our strengths and priorities. Here are three examples:

The latest federal spending package includes $39.7 million for the USDA Agricultural Research Service (USDA ARS) to build a new plant germplasm facility at our West Madison Agricultural Research Station. The facility will be used by plant scientists from UW and the USDA ARS Vegetable Crop Research Unit. It will bolster our Plant Breeding and Plant Genetics Program, which has been going strong for nearly 55 years.

Another example: CALS received $10 million from the Centers for Disease Control and Prevention for the Midwest Center of Excellence for Vector-Borne Disease (see "Vector Vigilance" in *Grow*, Summer 2018). This center is already making terrific progress on research into illnesses transmitted by ticks and mosquitoes. The influx of new funds will help CALS integrate vector-borne disease into instruction and training associated with the college's new global health major.

Yet another major project receiving a significant federal investment is the Dairy Business Innovation Alliance, a partnership between the Center for Dairy Research and the Wisconsin Cheesemakers Association that supports research and technical assistance for the dairy industry. The additional $20 million will expand the program's reach from five Midwestern states to ten.

I could go on with many more stories about the terrific momentum in CALS. It's clear that our new dean will have exciting projects to champion, changes to guide, and newly recruited faculty, staff, and students to welcome.

With the stage set for a prosperous future for CALS, I am pleased to say I will be remaining with the college to pursue some special projects before retirement. For example, I'll be contributing to curriculum planning in the departments of agronomy and horticulture and also scoping out possibilities for the college's non-credit instruction portfolio. I also hope to learn more about how to communicate effectively with the public about the plant sciences. I expect there will be more, but not enough to impinge on volunteering in Allen Centennial Garden and time with friends and family.

At the time that I am writing this, with just three weeks to go before I pass the baton, I am feeling extraordinarily grateful for the experiences of the past decade. I am proud of all that CALS and its community have accomplished. And I am most appreciative of the many relationships formed with colleagues, alumni, and friends over the years. I am looking forward to even more opportunities to cross paths.

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Six Hard Truths about Vertical Farming

The promise of vertical farming — grow crops anytime, anywhere — is fantastic. Promoters speak of a world where wheat cultivated in a repurposed warehouse is milled for flour and baked into cupcakes, all on the same city block.

Vertical farms are artificial, indoor environments where layers of electrically lighted crops that would otherwise spread out over acres of farmland are stacked on top of each other. They have been built in old warehouses, factories, shipping containers, and abandoned mines. The benefits of vertical farming are real, but so are the costs.

By JOHANNA OOSTERWYK

1. Vertical farms aren't a new concept.

Maximizing growing space by growing *up* is as old as the terraced farms of Asia and the Andes or the fabled Hanging Gardens of Babylon. Many of these feats of engineering still mark the landscapes where they fed civilizations on otherwise unfarmable land, and many are still in use today.

2. Water conservation is part of the good news about vertical farming.

Like their ancient terraced counterparts, vertical farms use far less water per pound of produce than conventional field cultivation. Indoor hydroponic systems that recirculate water use as little as 10% of the water needed to irrigate a field while growing more produce in the same amount of space.

3. The biggest difference between terraced fields and modern vertical farms is our relatively recent ability to grow crops without any natural light.

Artificial light technology now enables entire crops to be cultivated completely indoors with no natural light. This means that multiple crops can be raised in the same space at the same time by stacking them on top of one another *in addition to* growing year-round, regardless of outdoor weather.

4. Vertical farming may reduce land use, but it leaves a huge carbon footprint.

Every layer of plants in a vertical farm needs energy for light, which has to be generated using (mostly) fossil fuels rather than the free sunlight available outdoors. Reckoned in food miles, each pound of field-grown lettuce trucked for 1,000 miles produces a quarter pound of carbon dioxide. Fossil fuels burned to grow a pound of lettuce in a vertical farm produce 8 pounds of CO_2. Even with renewable energy sources, the cost is still high. Solar conversion to electricity isn't very efficient, so it takes more than nine acres of solar panels to light one acre of crops in a vertical farm.

5. There are limits to the crops we can and should grow indoors.

Because of the high cost to build, light, and manage vertical farms, they only make sense for high-value crops that don't need much light. Leafy greens, herbs, and microgreens have proven to be cost-effective, but the rest of your salad ingredients (cucumbers, tomatoes, peppers) need so much light to flower and fruit that it's not feasible to grow without the sun. Vertical farms in inner cities won't solve food shortages or provide the calories that stave off hunger.

6. Local vertical farm produce isn't appreciably better for people or the environment.

The swift transport of field crops to markets means produce retains most of its freshness and nutrients. This makes it difficult to justify the high environmental cost of lighting a vertical farm. A better buy-local option would be to look for produce from nearby greenhouses. Heating a greenhouse is still cheaper and produces less CO_2 than lighting an equivalent vertical farm, and there are more options for what can be grown.

Vertical farms make sense in areas where land and water are scarce, especially if renewable energy is available. They can also create jobs and give new purpose to vacant buildings. So, despite their drawbacks, vertical farms are still worthy of consideration in certain scenarios.

Johanna Oosterwyk, an expert on growing in controlled environments, is a lecturer in horticulture and manager of the D.C. Smith Greenhouse.

Illustration by JACKI WHISENANT

Photo by MICHAEL P. KING

NATALIA BETANCOURT RODRIGUEZ

Community, Humanity, and Openness

This CALS undergraduate embodies the "Ubuntu" spirit as she pursues equality in global health care.

By ASPEN OBLEWSKI

For much of her life, **Natalia Betancourt Rodriguez** BSx'24 never imagined leaving Colombia. She felt that the change she could bring to the beautiful, sunny streets of her hometown of Cali had only just begun. But after a series of experiences in high school showed her the large equality gap in access to health care around the world, especially among women of color, she decided she needed to do something about it.

Betancourt's interest in public health began when she read Harold P. Freeman's *Why Black Women Die of Cancer*. Following that, for a project during her senior year of high school, she studied the conflict between traditional and modern medicine among women in the city of Buenaventura.

"What we found was that there were two barriers," says Betancourt, who is double majoring in biochemistry and global health at CALS. "There isn't easy access to medical facilities in Buenaventura; women must travel long distances in boats or buses to get to my city, Cali. On top of this, they are also treated differently, which brings attention to the racism in the medical field."

Based on her experience with the study, Betancourt feels that a better understanding of discrimination in the medical field is fundamental to addressing it. "We found that even if [these women] had the opportunity to reach out to a physician and go to hospitals or official medicine facilities . . . [they encountered] a problem with racism," she says. "There's been a lot of attention here in the U.S. towards limiting these health inequities. But in Colombia, there hasn't been enough."

As she was wrestling with these issues, one of Betancourt's high school teachers told her about UW–Madison's King-Morgridge Scholarship Program. The program was created as an opportunity for students with a passion for poverty alleviation from Africa, the Caribbean, Latin America, and South and Southeast Asia to receive four-year scholarships to study at UW. It drew her to Wisconsin.

Filling out the application felt like second nature, she says. It gave her a chance to express her desire for reform in Colombia's health care system and talk about the work she had already done in the field. "I just spoke from my heart; and, turns out, it worked!" she says.

Betancourt's quest for health care equality has inspired many, but especially AI4Afrika project lead and chief engineer **Sheriff Issaka**. AI4Afrika aims to bring artificial intelligence (AI) technology to communities where it's lacking. The group's first project is a chatbot, run through an organization called Care International, that is designed to educate girls in various Ethiopian communities about sexual and menstrual health, topics that can be considered taboo in these areas. Betancourt leads the AI4Afrika team that curates and verifies the data used to train the AI on how to better answer the girls' questions.

"We have a term we use, which we call the 'Ubuntu' spirit, which is the guiding principle for this organization, and it's about the whole idea of community and humanity and openness to others and putting others before you," says Issaka, a UW senior majoring in computer science. "Natalia is an embodiment of that spirit, for me. She just reminds me of the whole Ubuntu concept."

And this spirit is guiding Betancourt as she plans her future career. "I thought I was going to stay in Colombia and go to a university and study medicine, because my passion is saving lives and keeping people healthy," says Betancourt. "But I've noticed with the passing of time that, although it's a wonderful career, there's a ton of doctors out there already. If I worked to be a doctor, I could only treat patient by patient. If I go into public health, or a similar career, I could impact thousands of people."

SCHOLARS AGAINST POVERTY

King-Morgridge Scholars are selected for their drive, academic success, and commitment to addressing issues of poverty in their home countries. They receive a full-time, four-year scholarship to UW–Madison funded by gifts. More at **admissions.wisc.edu/international-scholarships**.

Just Like a Trip to Japan

A virtual study abroad course, adapted for the pandemic, emulated the in-person experience of studying food and agriculture in the Land of the Rising Sun.

By NICOLE MILLER MS'06

In a span of 20 minutes, a dozen UW students visited a Japanese pastry shop and a high-tech sushi restaurant, and then they got ice cream — twice. But they all left a little hungrier.

They were the virtual guests of their counterparts at Obihiro University of Agriculture and Veterinary Medicine (OUAVM), taking a food tour of the Japanese city. It was one of several immersive video field trips the students would attend and just a taste of many welcoming and engaging experiences to come. For 10 days last summer, the virtual study abroad program UW Food Systems and the Environment in Northern Japan was in session.

"The [food tour] was one of the highlights for me," says **Maggie Li**, a neurobiology major pursuing a certificate in global health. "The pastries looked so puffy and pretty, and I really enjoyed seeing the sushi conveyor belt."

The short summer program transcended time zones without the jet lag. It introduced UW students to the agricultural and food systems of Hokkaido — the top agricultural producing region in Japan — and compared them with Wisconsin's systems. The program also featured live lectures and discussions led by OUAVM faculty; one-on-one conversations with Japanese undergraduate students; and virtual field trips to an active volcano, a sake brewery, and crop and dairy farms.

The virtual version of the study abroad program — developed in response to the coronavirus pandemic and offered for the first time in summer 2021 — was carefully designed to feel like the in-person experience as much as possible. It served as an effective bridge; instructors anticipate returning to the in-person version of the program in summer 2023.

"One of my goals for this program was to bring UW students as close as possible to the country, its culture, and its people," says course instructor **Aurelie Rakotondrafara**, an associate professor of plant pathology. "And there are lessons here for every UW student: Every time we eat, we participate in agriculture."

The original program was established in 2018 by **Jiwan Palta**, now a professor emeritus of horticulture, after he was inspired by the numerous links between Madison and Obihiro. The two municipalities are sister cities, and their universities have an official research collaboration to improve potato quality

[Above] An aerial drone view of the lands surrounding Yuichi Sato's farm in the town of Shimizu, west of Obihiro, Japan, from an interview and virtual tour recorded in summer 2021.

Obihiro University student Yuka Nakamura receives her order by conveyor belt in a sushi restaurant during a recorded food tour of Obihiro, Japan.

All photos are computer screen captures by MICHAEL P. KING

and production. Obihiro, on the island of Hokkaido, shares a common latitude with Wisconsin of 43 degrees north, so the two areas experience similar climates and seasonal changes. There are notable differences, too, such as Hokkaido's volcanic ash soils.

Hokkaido's farmers produce some of the same products as Wisconsin's farmers — potatoes, soybeans, and dairy, for example — and they grapple with some of the same challenges, such as soil conservation.

"[My farm's] volcanic ash soil is very easy to till but has … poor drainage. For soil management, I am trying to avoid excessive tillage because the soils are very fragile," crop farmer **Yuichi Sato** explained during a virtual field trip to his farm, where he grows a five-year rotation: potato, wheat, wheat, sugar beet, beans.

Students in the program learned about the two countries' different approaches, based on cultural, geographic, and agricultural factors.

"I liked being able to converse with the professors regarding dairy farming in Japan and how different and similar it is to farming here in Wisconsin," says **Rachel Schumann**, a Farm and Industry Short Course student focused on agricultural business. Her family owns Blue Prairie Holstein in Blue Mounds, Wisconsin. "As a member of a dairy farming family, it was interesting to hear how low the fertility rate is on Japanese farms and how small their farms are compared to those in Wisconsin. Big dairy farms in Japan are 80 to 100 cows, whereas my family has a 1,000-cow dairy here."

The course also introduced students to Japanese culture. Ahead of their first meeting with OUAVM faculty and students, UW students learned Japanese etiquette. They could also earn extra credit through lessons about the traditional Japanese tea ceremony, gift wrapping, manga (graphic novels), and more.

In their course evaluations, students reported enjoying the live interactions with professors, farmers, and other undergraduates. And on the other side of the globe, the course provided meaningful experiences for the Japanese students who volunteered to help produce the field trip videos and participate in classroom discussions. Some had their own study abroad plans derailed by the coronavirus pandemic.

"I enjoyed it a lot! We had the opportunity to interact with UW students, discussing Japanese culture and [having] chitchat sessions, asking questions to each other," says **Ai Yamazaki**, a senior studying animal production at OUAVM. "It was a great chance to learn new [English] vocabulary related to agriculture and get to know students from the States."

The warm feelings were mutual.

"Although being in Japan would have been more immersive, being able to interact with the students of Obihiro was fun," says Schumann. "They were so interested in us American students, just like we were interested in them."

FOLLOW-UP

CITIZEN SCIENCE 'APP'-ROACH HAS SUCCESSFUL YEAR

In "Bee-Spying Mission Seeks Operatives" (*Grow*, Fall 2021), **Jocelyn Cao** BS'21 introduced readers to WiBee: The Wisconsin Wild Bee App. It's part of a citizen science effort to observe and collect high-quality data on the abundance, diversity, and activity of wild bees in the state. The scientists behind the app have revealed that 334 users submitted surveys in 2021. These users, including vegetable and fruit growers, gardeners, researchers, and others from Wisconsin and worldwide, supplied 2,250 total surveys and counted 71,168 pollinator visits throughout the year. All of this data helps the WiBee team provide better pollination management recommendations. Get involved at **pollinators.wisc.edu/wibee**.

Photo by JEREMY HEMBERGER BS'12, PhD'20

FINDINGS

Illustration by ISTOCKPHOTO.COM/DR_MICROBE

A MOLECULAR UNDERSTANDING OF ANTIBIOTICS

Antibiotics are good at killing pathogens, but they also eliminate beneficial gut bacteria. This makes patients more prone to reinfection and sets the stage for drug-resistant strains to emerge. With this problem in mind, a group of researchers from the CALS biochemistry department took a close look at an antibiotic that kills only one or a few species of bacteria. Called fidaxomicin, it's used to treat the common healthcare-associated infections caused by *Clostridium difficile*. **The researchers demonstrated at a molecular level how fidaxomicin selectively targets *C. diff* while sparing innocent bacterial bystanders.** The findings, detailed in *Nature*, might help scientists develop new narrow-spectrum antibiotics against other pathogens.

Clostridium difficile bacterium.

Lessons in the Garden

The CALS horticulture department is teaming up with schools and communities to cultivate a hybrid of plants and pedagogy.

By JORI SKALITZKY BS'22

Plants and humans have always been connected. They evolved together. Yet many people fail to realize how fundamental plants are to their daily lives — from food to fiber. Fortunately, two teams from CALS are offering highly visible and immersive reminders of this connection in the form of gardens.

A School Garden for 'Our World'

Claudia Irene Calderón MS'09, PhD'10 has always loved both education and science, and she views gardens as a bridge between the two realms. And now she and a dedicated team are growing such a bridge for the students and teachers at Nuestro Mundo Community School, a Spanish-English dual-language immersion charter school in Monona, Wisconsin. ("Nuestro mundo" means "our world" in Spanish.)

"A dream for me would be to see the teachers feel comfortable to go outside to the garden and do the teaching of whatever lesson they're doing, fulfilling whatever learning goals they have — but outside, using science as their classroom," says Calderón, a researcher and a member of the teaching faculty in the horticulture department.

Calderón is part of Nuestro Mundo's Green Team, a group of parents and volunteers interested in the outdoors and gardens and how they can be incorporated into the school's curriculum. A few years ago, before Calderón was involved with the Green Team, the group established a rain garden full of native and perennial plants that capture runoff and provide habitat for pollinators. With help from Calderón and others at CALS, Nuestro Mundo's outdoor gardens are expanding.

Calderón teamed up with **Johanna Oosterwyk**, manager of UW's D.C. Smith Greenhouse, and her own Horticulture 355 Greenhouse Cultivation Lab class to grow plants for Nuestro Mundo. Following a parent suggestion for salsa gardens, Oosterwyk and Calderón arranged for students to cultivate cilantro, onions, peppers, tomatoes, and tomatillos. They also added corn, pumpkins, and beans (known as the "Three Sisters") to create a traditional milpa garden. This Mesoamerican, pre-Hispanic system offered another cultural angle and more diversity and longevity throughout the growing season.

"It's a great opportunity to get hands-on experience," says **Samantha Tepp** BSx'23, who worked on the Nuestro Mundo garden project with fellow horticulture majors **Lucia Wellso** BSx'24 and **Alan Fox** BSx'22.

"[Helping out Nuestro Mundo] just makes me happy," says Wellso. "Getting a younger generation to start thinking about [gardening] is really vital." Research about school gardens shows that when children begin to experience the process of growing and maintaining plants, they're introduced to an entirely new world — including the movement of produce from farm to table — that is essential to sparking their interest in agriculture.

On May 19, with the threat of frosts long gone, the Green Team transported the greenhouse plants to the Nuestro Mundo garden beds, where teachers and students alike can learn and enjoy while getting their hands dirty.

"The gardens provide so much well-being, so many benefits," says Calderón, who says she loses track of time and forgets her worries while gardening. "And the benefits extend beyond academics."

[Left] In May 2022, students from Nuestro Mundo Community School work with Claudia Calderón (center, red shirt), a member of the teaching faculty in the horticulture department, and recent UW graduate Jackie Olson (far right) to place plants in the school's garden. When Olson was an undergraduate, she and Calderón secured a Wisconsin Idea Fellowship grant to help initiate the Nuestro Mundo garden project. Photo by PAGE GONZALEZ

[Above] Alan Fox, right, a senior horticulture major, waters and fertilizes plants in D.C. Smith Greenhouse with Lucia Wellso, a sophomore horticulture major. The two were helping prepare plants destined for a garden at Nuestro Mundo Community School. Photo by MICHAEL P. KING

EXPLORE ONLINE

- Nuestro Mundo Community School **nmcs.madison.k12.wi.us**
- Eagle Heights Community Gardens **eagleheightsgardens.org**

A University Garden for the Community

Just like schools, universities also host gardens. And the UW–Madison campus has its fair share — from Allen Centennial Garden near the Lake Mendota shoreline to the Botany Garden below Birge Hall. There's also the Eagle Heights Community Gardens, slightly off the beaten path. Located on the far west side of campus, these gardens are home to the F.H. King Student Farm, where students can practice sustainable agriculture, as well as a plot of land managed by the UW's GreenHouse Learning Community.

The GreenHouse gardens contain a diverse array of vegetable crops, including many varieties that were brought from Africa by African people or have been adopted by African people into their foodways. "There's such a rich heritage of Afro-diasporic crops in this country," says **Rue Genger**, a scientist with the horticulture department. The garden, which Genger helps maintain, sheds light on that rich heritage.

The Afro-diasporic garden is a culmination of people and ideas. **Yusuf Bin-Rella** is a chef who founded TradeRoots Culinary Collective, a Madison-based company aimed at promoting food sovereignty. Bin-Rella and Genger attended a presentation on Indigenous cropping methods during a public field day at West Madison Agricultural Research Station a few years back. Bin-Rella, who is African American, mused to Genger that he would love to see a similar project for the crops considered important to Black agricultural and culinary traditions. Then, in fall 2019, Genger heard graduate student **Christian Keeve** MS'20 give a presentation about Afro-diasporic crop and seed-keeping research.

"That moment, and the moment talking with Yusuf, came together, and I really wanted to get the two of them to talk," said Genger. "That's really how the garden came about in the first place."

The COVID-19 pandemic quickly complicated plans for the garden. Bin-Rella had planned to host community dinners with produce from the garden; instead, most of the produce was donated to Badger Rock Neighborhood Center. Bin-Rella also participated in Badger Rock's online weekly cooking demonstration with garden produce.

"It was really nice to see the ability to pivot and still get information out there to people about these crops and still be able to share the culinary traditions," said Genger. "It was great to be able to take that produce to Badger Rock every week and know that it was going to get onto people's tables."

Genger plans to contribute to the garden at Eagle Heights this upcoming school year, where it will be a resource for both students and Badger Rock alike. Every student at UW will have the opportunity to utilize the garden to learn about growing plants and come away with a better understanding of Afro-diasporic crops.

FINDINGS

CARBON-CAPTURING LIVESTOCK

A team of scientists, including researchers from the soil science and agronomy departments, recently studied the carbon storage effects of multiple soil health practices. They found that, compared to a conventional corn field with annual tillage, **18–29% more organic carbon and matter accumulated in perennial pastures that were managed with rotational livestock grazing**, highlighting this method's potential role in climate-smart agriculture. The researchers used data from the 29-year-old Wisconsin Integrated Cropping Systems Trial and published results in the *Proceedings of the National Academy of Sciences*.

TO GRAZE OR NOT TO GRAZE?

One way dairy operations can reduce costs is by raising heifers via managed grazing on pastureland rather than in confinement. But the transition to this system can be fraught with unknowns. Thankfully, **the Heifer Grazing Compass is helping dairy farmers predict and understand the cash flow and long-term financial outcomes** of making the switch. The new tool, developed by the Center for Integrated Agricultural Systems and Grassland 2.0, demonstrates that raising heifers using managed grazing results in savings of 25–50% per head per day and labor savings of 50–75%.

Where, Exactly, Are the Warblers?

New nationwide maps of bird species can help conservationists target their efforts to protect biodiversity.

By ERIC HAMILTON

As humans continue to drastically alter landscapes across the country, birds suffer the consequences. By at least one estimate, the population of North American birds has dropped by 30% in the last five decades, and declines are predicted to continue. But thanks to a team from CALS, conservationists now have a set of highly detailed and rigorous maps of bird biodiversity that could help them protect rare or threatened species.

Researchers in the Department of Forest and Wildlife Ecology developed the high-resolution maps to help conservation managers focus their efforts where they are most likely to assist birds — in individual counties or forests rather than across whole states or regions.

The maps span the contiguous U.S. and predict the diversity of birds that live in a given area, related by traits such as nesting on the ground or endangered status. Those predictions are based on both detailed observations of birds and environmental factors that affect bird ranges, such as the amount of forest cover or temperature.

This work was supported in part by the U.S. Geological Survey Landsat Science Team (grant G17PS00256) and the NASA Biodiversity and Ecological Forecasting Program (grant 20-BIO-DIV20-00460).

"With these maps, managers have a tool they didn't have before that allows them to get both a broad perspective as well as information at the level of detail that's necessary for their action plans," says **Anna Pidgeon**, Beers-Bascom Professor in Conservation, who worked with professor **Volker Radeloff** PhD'98, postdoctoral researcher and lead author **Kathleen Carroll**, and others to develop the maps.

The research was designed to address two outstanding problems in conservation.

"Across the world, we're seeing huge species losses. In North America, 3 billion birds have been lost since 1970. This is across virtually all habitat types," says Carroll. "And we're seeing a disconnect between what scientists produce for conservation and how that translates to boots-on-the-ground management."

Many resources previously available to conservation managers, such as species range maps, lack

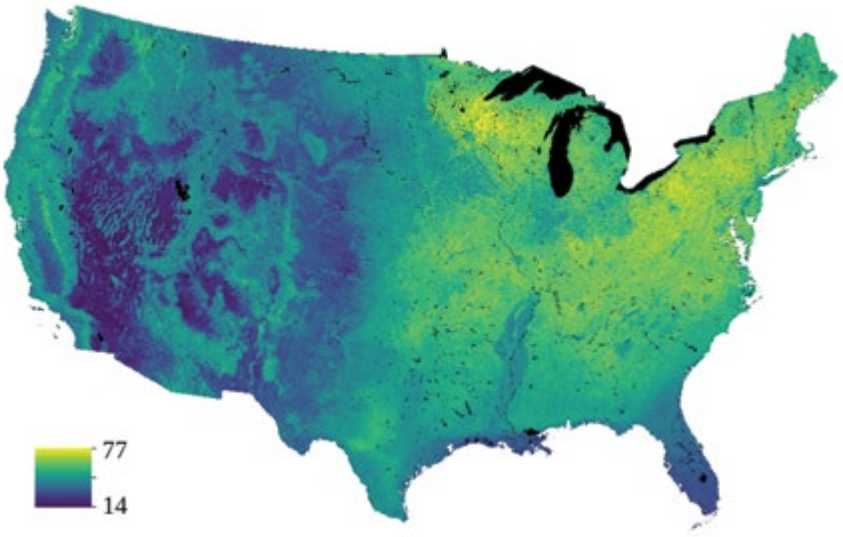
One of the rarest forest songbird species, the Kirtland's warbler breeds each summer in Wisconsin and Michigan. The Kirtland's warbler was one of the charter members of the Endangered Species Act of 1973, but it has reached a level of population recovery such that it was taken off the list in 2019. In Wisconsin, it is considered a state-endangered species.
Photo by ASHLEY OLAH PhDx'24

FINDINGS

Photo by ISTOCKPHOTO.COM/BRIAN BROWN

LESS WATER, SAME YIELD

A recent study by assistant professor Yi Wang and Ph.D. student Trevor Crosby of the horticulture department challenges the traditional practice of over-irrigating potato plants as an insurance policy for a marketable crop. The study, published in the journal *Sustainability*, was conducted over two years in the Upper Midwest. It found that **deficit irrigation (as low as 75% of the estimated amount of water the plants would consume each day) during the late growing season did not lead to any significant differences in potato yield and quality** as compared to overwatering by 125%.



Researchers mapped the number of bird species, or overall species richness, found across the contiguous United States. Blue areas host fewer bird species than green or yellow areas. Image by KATHLEEN CARROLL and ANNA PIDGEON

the detail and rigorous testing that are necessary for them to be useful and accurate.

To overcome those challenges, Carroll and her team wanted to develop data-driven maps of existing bird biodiversity. They produced the maps by extrapolating observations of birds from scientific surveys to mile-by-mile predictions of where different species really live. Those predictions were based on factors including rainfall, the degree of forest cover, and the extent of human influence on the environment, such as the presence of cities or farms.

To improve the maps' predictive power, the scientists clustered individual species by behavior, habitat, diet, or conservation status — such as fruit eaters or forest dwellers. These groups are called guilds. Many conservation decisions happen at the guild level rather than at the species level. Guilds can also make up for limited information on the most endangered species.

The final maps cover 19 different guilds at resolutions of 0.5, 2.5, and 5 kilometers. While the finest-grained maps were not as accurate, the 2.5-kilometer-resolution maps provided a good balance of accuracy and usefulness for realistic conservation needs, say the scientists. At the 5-kilometer resolution, the maps provide the greatest accuracy and are useful to conservationists operating across large areas.

"We see this being really applicable for things like forest management action plans for the U.S. Forest Service," says Carroll. "They can pull up these maps for a group of interest, and they can get a very clear indication of areas where they might want to limit human use."

The maps may also help private land conservancies decide how best to allocate limited resources to maximize biodiversity protections.

Carroll is now working to extend the analysis from guilds of species to individual species. The increased level of detail could help specialist conservation managers improve their work, especially those aiming to protect a single species.

EXPLORE MORE

This study and the final maps were published on April 11 in the journal *Ecological Applications*. The maps are available for public download from the open-access website Dryad, **datadryad.org**.

Photo by MICHAEL P. KING

NUMBER CRUNCHING

The Colorado potato beetle has evolved **resistance to more than 50 different kinds of insecticides**, which allows this "super pest" to wreak havoc on potatoes around the world. The beetle achieved this feat largely by turning to a deep pool of diversity within its genome, according to a recent study led by associate professor of entomology **Sean Schoville**. The beetle will be hard to control in the future, but this new understanding of its genomic resources could help scientists design management systems that keep it in check.

'A Home Wherever I Go'

For graduate students of color in the sciences, this campus community offers resources and the support and feel of a family.

By CAROLINE SCHNEIDER MS'11

Cellular and molecular biology graduate student Christiana Binkley and Hector Salazar, a lab manager at the UW Alzheimer's Research Center, greet a member of the Science and Medicine Graduate Research Scholars during one of the program's receptions. Photo by ROMULO UEDA

"What are you looking for in a graduate school?" That was the question posed to a panel of visiting undergraduates one April afternoon in UW's Biotechnology Center.

The answers were varied: a supportive mentor, interesting research, collaborations. But one answer stood out, mentioned by every one of the panelists: a sense of belonging.

"I want to feel safe and included," said one student. Another hit at the heart of the sentiment, saying, "As a Black woman, I want to know I have a home wherever I go."

The undergrad panelists all hailed from Howard University, a historically Black institution. They had come to Madison to visit with staff and graduate students from UW's Science and Medicine Graduate Research Scholars (SciMed GRS), a program created to support underrepresented graduate students in the biological sciences.

Abbey Thompson MS'06, director of SciMed GRS, sat in the front row, nodding. What the Howard students want is precisely what she and Sara Patterson, now an emeritus professor of horticulture, aimed to provide when they started the program in 2008 — a home and a community for BIPOC (Black, Indigenous, and people of color) students who often relocate far from relatives and friends.

"The program is really about connection and relationships. That's at the core of what we do," says Thompson. "Knowing the students is so important. It's really a community, a family. Everyone is invested in the students' support and success."

SciMed GRS is one of several graduate research scholar communities at UW formed to serve underrepresented students. Not only are many of these students beginning the challenge of graduate careers, but they're also members of the BIPOC community on a predominantly white campus. Being a person of color in a science field where you don't see many people who look like you can intensify the obstacles and isolation of graduate school. The SciMed program gives them a support system of helpful staff and empathetic peers.

"I've been able to connect with other fellows of SciMed and build a community," says Sierra Love, a fourth-year Ph.D. candidate in genetics. "There are times when graduate school gets to be extremely tough, and having support from those in the program is what keeps me going. My favorite part of SciMed is the family that I've gained."

In addition to a community, SciMed GRS gives BIPOC graduate students resources, funding, and opportunities for professional development. With Patterson's recent retirement, the program is now led by Thompson, faculty director Beth Meyerand, and program manager Michelle Parmenter PhD'17. They work with more than 40 graduate programs and departments across four UW schools and colleges: CALS, the School of Medicine and Public Health, the School of Pharmacy, and the School of Veterinary Medicine.

The program provides support throughout the graduate students' time on campus. Incoming students are nominated by their graduate programs, and as soon as students accept the offer to attend UW–Madison, they are brought into their cohort. The cohort model provides a community that connects them to students they may not otherwise meet from across campus or different schools.

"The cohort inspired instant camaraderie as we are all underrepresented students who all moved to Madison from around the country to begin graduate school in the biosciences," says Robbie Mejia, a first-year biochemistry graduate student from southern California. "SciMed GRS facilitated some of our first meetings before our first semester even began. That went a long way in making me feel desired by the community."

Once on campus, first-year students participate in a seminar to provide a solid base and strong interpersonal connections before they get entrenched in their research and classwork. Second-year students take part in sessions that prepare them for the expectations and rigors of their preliminary exam, an important doctoral program milestone. Monthly group meetings for the entire program, such as social gatherings and lectures, bring the different cohorts together and provide another opportunity for networking, support, and fellowship.

Program staff work with students individually as often as possible. "We do a lot of one-on-one advising," says Thompson. "We help them connect with resources and sort through different choices or ways to work through a situation. We want them to know we're here to support them in whatever direction they go."

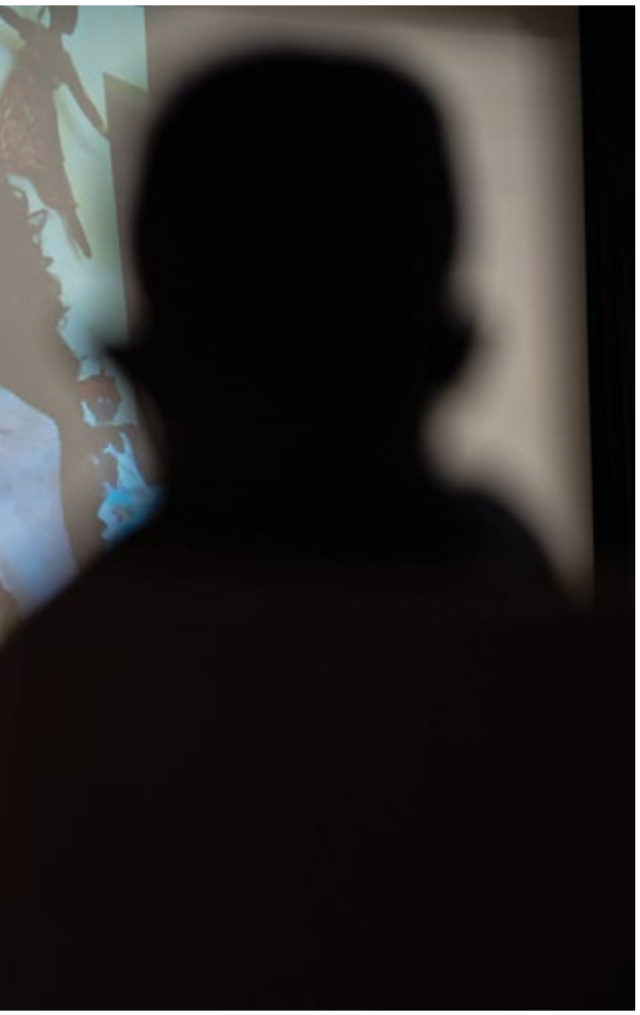
Peer mentors play an important role in SciMed GRS as well. They help with the first-year seminar and assist students with their adjustment to graduate school. Current students also join meetings with prospective students to share their experiences and act as a resource if there are follow-up questions or concerns.

"I was given a peer mentor, before I even started my program, who helped with everything from apartment hunting to facilitating cross-campus collaborations," says Corri Hamilton PhD'22, who earned her degree in plant pathology in April. "The experience was so impactful that I later became a peer mentor myself and started a peer mentoring program modeled off SciMed GRS within my department."

[Far left] Corri Hamilton, who earned her Ph.D. in plant pathology, donned her graduation attire for this portrait in Allen Centennial Garden in May 2022. She credits SciMed GRS for helping her navigate graduate school.
Photo by MICHAEL P. KING

[Left] SciMed GRS alumn Esteban J. Quiñones is pictured here in northern Nigeria, where he traveled for his work with Mathematica.
Photo courtesy of ESTEBAN J. QUIÑONES

[Below] Fabu Carter, a senior outreach program manager with the UW Alzheimer's Research Center, delivers a talk titled "Centering the Black Experience: Bringing You into Your Work" for SciMed GRS members in February 2022.
Photo by ROMULO UEDA



The last couple of years have thrown a few wrenches in the program's finely tuned gears. The COVID pandemic forced new methods of connection as Thompson and her staff switched to virtual office hours and online seminars. At the same time, Black Lives Matter protests and the national dialogue around racism had a dramatic effect on the lives of many students in the program.

"The SciMed staff and students helped me navigate a lot of unknowns and were a consistent buffer from systemic discrimination in Madison," says Hamilton, who was raised in rural Mississippi by her single Black mother and her grandmother. "The community support provided through SciMed GRS is invaluable."

For Thompson and Meyerand, it was the students who are to be admired for how they face the challenges of the last two years. "The grad students blew me away by how they navigated through all that," Thompson says. "Their resilience, perseverance, and flexibility have been truly inspiring," Meyerand added.

With the learning curve of the pandemic and almost 15 years of operation now behind it, the program is looking for new strategies to enhance the experience of BIPOC graduate students. One future focal point: students interested in faculty career paths. Meyerand hopes to find more ways to support those students given the underrepresentation of BIPOC individuals in the faculty ranks. This past year, she and Parmenter provided a research mentor training program for faculty mentors of SciMed students to help them understand the dynamics and needs of underrepresented students in their labs.

"Culturally responsive mentoring is critical to the success of young scientists of diverse backgrounds," explains Meyerand. "It can be learned, and it guides faculty mentors to understand the sources and impact of bias on diverse graduate trainees to improve the training environment."

SciMed staff also aim to expand alumni network connections. The program has more than 200 alumni, and the opportunities they provide continue to grow. Staff stay in contact with many of the program's alumni

Communities Across Campus

SciMed GRS is part of a growing network of organizations developed to support underrepresented students on the UW campus.

"Many SciMed GRS students are involved and networked in a variety of student orgs that offer mentoring and affinity spaces," says Abbey Thompson, associate director of SciMed GRS. "This enhances their connectedness on campus and broadens opportunities for professional development."

MOSAIC (Mentorship Opportunities in Science and Agriculture for Individuals of Color) was established at CALS in summer 2020 by Korede Olugbenle MS'21, Jenyne Loarca PhD'21, and Becca Honeyball, who were all graduate students at the time. Francisco Campos, a horticulture graduate student, has since joined the team and contributed to the program's goal of gathering professors, staff, and alumni of color to serve as mentors for graduate students and postdocs of color.

"After the murder of Ahmaud Arbery, I wanted to talk with someone who would share the same concerns I had, but with our department and institution being predominantly white, the amount of people available to me to truly confide in were limited," says Olugbenle. "We want MOSAIC to provide mentor-mentee connections for graduate students so they can talk to people with similar backgrounds who already went through what they are going through."

Tom Browne, MOSAIC mentor and assistant dean in the CALS Office of Academic Affairs, believes that much of the program's value stems from its student leadership. "At the core is student-focused support and engagement meant to aid in their emotional, physical, and professional well-being," he says. "It's also a great opportunity for mentors to sharpen best practices in advising and supporting students."

Other groups across campus that strive to form communities and support underrepresented students include Minorities in Agriculture, Natural Resources and Related Sciences (MANRRS); the Society for Advancement of Chicanos and Native Americans in Science; the American Indian Science and Engineering Society; the Black Graduate and Professional Student Association; and the Association of Asian American Graduate Students.

From left, Donale Richards BS'17; Leslie Holland, assistant professor of plant pathology; and Manika Clemente, who has a master's degree in biotechnology from UW, participate in a panel discussion during the MANRRS x MOSAIC 2022 forum on the UW campus. The panel was titled "My Perfectly Imperfect Non-Linear Career in Agricultural Science."
Photo by MICHAEL P. KING

Population health sciences graduate student Lauren Giurini participates in discussion during a Q&A session following a presentation by Fabu Carter for SciMed GRS members in February 2022. Photo by ROMULO UEDA

and often ask them to serve as resources, including as contacts for new graduates looking for jobs or sounding boards for students facing challenges in their labs. The visit from the Howard University undergraduates grew out of an alumni connection.

Expanding those connections and opportunities shouldn't be difficult. Many of the alumni want to give back and still look at SciMed GRS as an integral part of their graduate careers — a testament to the program and its people.

"Having the community that SciMed provided helped me to feel like I wasn't alone," says Nicholas Santistevan MS'17, PhD'21, a staff scientist at the University of Colorado Anschutz Medical Campus, who earned a degree in genetics. "SciMed was like a family, and they helped me get through the many challenges that I encountered."

For some, the program shaped not only their time in graduate school but who they are in their careers today.

"SciMed GRS was critical in supporting me and helping me find my voice as a scientist and an advocate for diversity, equity, and inclusion," says Esteban J. Quiñones MS'18, PhD'19, who earned his degrees in agricultural and applied economics and now works as a researcher at Mathematica in Chicago.

Lorraine Rodriguez PhD'19 still talks with SciMed staff members when career questions arise. "To this day, both Abbey and Sara are among my go-to people when it comes to my career path," says the plant breeding and genetics graduate. "Even as an alum of the program, I know I can always count on them, and that is a unique and special thing about SciMed."

Having defended her thesis in April, Hamilton now joins the ranks of those alumni who hold the program and the SciMed family in high regard. As she looks forward to her postdoctoral work in Vancouver, British Columbia, and ultimately becoming a professor, she views the staff of SciMed as inspiration.

"They make you feel like the program was built just for you," she says. "My favorite part of SciMed was feeling 'seen' by the staff. They champion the dreams of students like me, and I am indebted to them. I hope to be as impactful."

Hamilton seems to be reaching that aspiration — while she was in graduate school, she helped pay her brother's way through college, and she served as a student representative for a SciMed GRS committee and executive board. Now she has set her sights on leading a lab focused on research that includes stakeholders and students with diverse backgrounds, experiences, and skill sets.

"We know that research opportunities and quality mentorship increase student learning and STEM [science, technology, engineering, and math] persistence," says Hamilton. "Through my research, I aim to shrink the opportunity gap for underrepresented minority STEM students and foster creative minds for all students, providing a community where everyone feels they belong."

How to Time Travel Without Fear

STORY BY **KRISTIN BAIRD RATTINI** | PHOTOS BY **JEFF MILLER** | ILLUSTRATIONS BY **JACKI WHISENANT**

Astrobiologist Betül Kaçar devised a **molecular time machine** to help us understand the **origins and evolution of early life** on Earth. Her life, and her approach to the journey, are just as remarkable.

Betül Kaçar is a self-described *gözü kara*. The Turkish term refers to people from the Black Sea region of the country, but it has another translation as well.

"It means bold-eyed or fearless," says Kaçar, an assistant professor in the Department of Bacteriology. "It means that I don't know my place. I never did, and I think that served me well. It put me in a mindset that I could do anything."

That dauntless disposition propelled Kaçar from her humble roots in Turkey to the forefront of astrobiology. A highly interdisciplinary field, astrobiology examines the origin, evolution, and distribution of life in the universe. Through groundbreaking approaches in her research group and leadership roles in prominent NASA initiatives, Kaçar is rewinding Earth's clock billions of years to try to understand how life's emergence and its early biological innovations may assist in finding life beyond our planet.

'Set yourself free'

Kaçar's career in astrobiology would seem as remote to her childhood self as the celestial bodies that NASA is probing for signs of life in our solar system and beyond. She grew up in Istanbul, the child of parents from the Black Sea region who didn't complete elementary school. "There was a very clear message in my family," she says. "If you want your story to be different, you need an education. It's the only way to set yourself free."

Her world started expanding in high school, where she was exposed to poetry, arts, science, and literature, which gave her a sense she was part of a larger picture. While studying for her bachelor's degree in chemistry at Marmara University in Istanbul, Kaçar seized every opportunity to learn and do more. "I would camp out in tourist areas to offer to show tourists the museums and other sites, so I could ask about and learn about their cultures," she says.

A colorized photo of test tubes containing cultures of ancient DNA molecules in Betül Kaçar's research lab at the Microbial Sciences Building on the UW campus.

Betül Kaçar, assistant professor of bacteriology, is pictured in her research lab.

In the summer of 2002, she volunteered at an international meeting on Parkinson's and Alzheimer's diseases. The experience introduced her to the field of biomolecular chemistry — and changed her life. "I was amazed that scientists would come from all over the world to lock themselves in these seminar rooms for days to talk about a single molecule and what it did," Kaçar says. "I found that interaction, personal level of engagement, and devotion extremely inspirational. I wanted to be on that stage and contribute to that knowledge."

She next applied for a Howard Hughes Medical Institute summer undergraduate research scholarship, which led to her first trip out of Turkey to study proteins at Emory University under the guidance of Pat Marsteller, now a professor emerita of biology. The summer internship and Marsteller's influence changed her life, Kaçar says. The experience gave her the tools she would need to deal with the challenges later in her career. And it exposed her to protein engineering, the idea of playing with proteins simply for the sake of seeing and understanding what happens to them. "It blew my mind," she says. "It was amazing. There was no going back after that for me."

Kaçar returned to Emory the following year to pursue her Ph.D. in biomolecular chemistry. She has lived and worked in the United States ever since. "I was only 20," she says. "I didn't know anyone. But sometimes you must create your own roots and make a life for yourself."

'You have to look at its past'

Kaçar's research compared the expression of an enzyme called monoamine oxidase in zebra fish with its expression in humans. As she moved through her Ph.D. program, her questions grew bigger and bigger. "I wondered, 'Zebra fish have this enzyme; humans have this enzyme. Where is this enzyme coming from? What is the common origin?'" she says. "I started studying its phylogeny [evolutionary development and diversification] to understand its evolutionary route. It was evident to me that if you want to understand an enzyme's function today, you have to look at its past."

Ever eager to learn more, she started attending meetings in the evolutionary biology department, one floor below the lab where she worked. She quickly realized a fundamental challenge: "The majority of life's history and innovations are lost," she says. "We are dealing with whatever is left to us today. We are not capturing the full diversity of proteins when we ignore their past. We tend to think of the past as a failed state and that things get more optimal as they evolve, but that is not necessarily true. There is a past that we don't yet understand, but we should."

The readings Kaçar first encountered at the time introduced her to the origins of life and evolution, and she was hooked. "I thought, this is what I want to do," she says, "It was my eureka moment, my calling."

Kaçar applied for a two-year postdoctoral fellowship with NASA's astrobiology program with a radical research proposal: She would create a "molecular time machine." Using a process called phylogenic inference, she would develop synthetic ancient proteins, insert these resurrected sequences into a modern bacterial genome, and then evolve them experimentally in the lab. The goal would be to see if she could repeat an ancient protein's evolution in a way that matched its own natural history.

Colleagues warned her that her unorthodox proposal was a career killer. But Kaçar, ever a gözü kara, didn't listen. "I was in it to do the science that interests me," she says. "I knew that, after my high school and college degrees, I had already made it further than anyone in my family had done. So, the worst thing, I thought, would be that I would try, and fail, to figure out life's origins. That, to me, is a success."

And succeed she did: Her proposal was accepted. She started her fellowship in 2012, which launched a rewarding and ongoing affiliation with NASA, a decade of innovative research, and a dedicated outreach effort to encourage young women around the globe to pursue STEM fields.

'We are life and its origin in the universe'

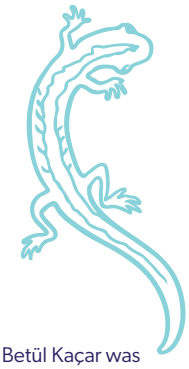
Kaçar herself was surprised that NASA was interested in biology. "In my mind, it was a space-related group that would be interested in only astronomical questions," she says. But NASA funded its first astrobiology project just one year after its founding

in 1958. (Back then it was called exobiology.) Forty years later, the NASA Astrobiology Institute was established to provide a scientific framework for all flight missions and to advance astrobiology research and training programs in concert with national and international science communities.

NASA's astrobiology research focuses on three key questions: How does life begin and evolve? Does life exist elsewhere in the universe? What is the future of life on Earth and beyond?

Kaçar, naturally, focuses on that first question. "Astrobiology aims to understand the origin of life in the universe," she explains. "We forget that's us, right? We are life and its origin in the universe, the only one we know of so far. So, we invest a lot in understanding our own origins and our own planet. We have to understand what we have here if we want to then go and find something else out there."

At NASA, Kaçar found an environment that was more inclusive, diverse, and interdisciplinary than anything she'd seen. "Through NASA, I met physicists, geologists, chemists who knew RNA inside out, experts who studied Martian surfaces, and we were all a part of the same community," she says. "I was made to feel welcome. My questions weren't ridiculed; they were celebrated. I felt at home."



Betül Kaçar was featured in this NASA graphic novel series in which her cartoon avatar rides a T-Rex and gathers ancient enzyme samples.

Artwork by AARON L. GRONSTAL

'Full of surprises'

Throughout Kaçar's decade of research — at the NASA Astrobiology Institute, Harvard University, University of Arizona, and now the University of Wisconsin–Madison — her molecular time machines have produced intriguing insights into not just how these ancient proteins may have changed themselves but how, in turn, they could have changed the environment.

For example, RubisCO is a key enzyme in the carbon fixation and photosynthesis process and thought to be one of the most abundant proteins on Earth. Kaçar studied as many types of RubisCO as possible to reverse-engineer the enzyme to its ancestral form. While RubisCO evolved over time, the carbon isotope that RubisCO converts from inorganic to organic carbon stayed uniform, despite billions of years of geological events, ecosystem turnover, and evolutionary innovation. "That's not what you would expect," she says. "Natural selection is full of surprises."

Furthermore, she found potential changes in the RubisCO enzyme that she thinks are implicated with the Great Oxygenation Event. During this turning point in Earth's history some 2.4 billion years ago, oxygen started building up in the seas and atmosphere of an anaerobic planet. Without that event, our current oxygen-rich environment — and life as we know it — might not exist.

"Betül has brought an understanding at a molecular level of the evolutionary events of life in Earth's history," says Shawn Domagal-Goldman, an astrobiologist who has known Kaçar since she was a postdoc at the NASA Astrobiology Institute and is now the branch head for the Planetary Systems Laboratory at NASA's Goddard Space Flight Center. "She's probably the foremost thinker on what that implies for what possibilities are out there for life on other worlds, whether in our solar system or beyond. She is one of the people who helps us understand what is possible in the first place. We incorporate her insights into our expectations for whether certain biological processes might be happening elsewhere and if the byproducts of those processes could be detectable out there."

The acceleration of space exploration technology increases the significance of Kaçar's work. "We are able to see further, see clearer, visit planets in our solar system, and bring samples back to our own world," she says. "We will be facing so much data over these next two decades. We will be tested to interpret what it all means."

Kaçar's research methods and results have established her as one of astrobiology's shining stars. She has received the Stanley Miller Early Career Award from the International Society of the Study of the Origin of Life, the NASA Early Career Faculty Award, and the Scialog Fellowship for Signatures of Life in the Universe. Her work has received funding support from NASA, the National Science Foundation, the Human Frontiers in Science Advancement Program, and the John Templeton Foundation. She's even featured in an issue of NASA's graphic novel series *Astrobiology: The Story of our Search for Life in the Universe*. Her cartoon avatar rides a T. Rex, climbs the phylogenic "Tree of Life" (which graphically illustrates evolutionary relationships among biological

entities), and scoops up RubisCO samples from ancient Earth.

"The most successful astrobiologists are collaborative. Betül is phenomenal at that," says Domagal-Goldman. "She has tremendous expertise in understanding the history of evolutionary events on Earth and does a great job at collaborating with people from other backgrounds to find other applications for the knowledge that she brings to the table."

'A Long Tradition and History'

There was tremendous excitement and anticipation about Kaçar when she joined the Department of Bacteriology at CALS in summer 2021. She transitioned from the University of Arizona, where she was an assistant professor in the departments of molecular cell biology and astronomy. At UW, she was the first professor recruited as part of a cluster hire focusing on the origins of life, a new interdisciplinary focus for the university that bridges bacteriology with the astronomy and geoscience departments.

Kaçar had been front and center on the bacteriology department's radar since January 2021, when she gave a tremendously popular virtual seminar about reconstructing ancient biosystems as a way to explore life's origins.

"We had around 130 people from departments as disparate as philosophy to bacteriology, chemistry to astronomy," says Katrina Forest, chair and professor in the Department of Bacteriology. "It was an extremely exciting indication of how popular her work could be on this campus . . . She certainly brings energy, enthusiasm, and creativity, as well as a new research approach and research area."

For Kaçar, the bacteriology department was a natural fit for her work. In particular, she saw it as a proper home for the NASA Center for Early Life and Evolution, which hosts the MUSE (Metal Utilization and Selection Across Eons) Consortium, as well as one of NASA's newly created Research Coordination Networks on Early Life. Kaçar serves as the director of these five-year multi-institute endeavors, funded by a highly competitive and prestigious NASA Interdisciplinary Consortia for Astrobiology Research Award and the NASA's Science Mission Directorate.

MUSE focuses on the evolution of metal use on Earth — specifically the biochemistry of carbon and nitrogen acquisition throughout time. The project looks at why life relies heavily on certain metals, such as iron, but not others, such as zirconium, and retraces the path of element selection during Earth's evolution to try to better understand Earth's unique form of life. The Center for Early Life and Evolution is after a big question: After life originated, what happened next? Kaçar's interdisciplinary team will focus on the first 2 billion years of life's history on Earth, illuminate early cellular innovations, and bridge molecular and microbial astrobiology with future space missions.

Betül Kaçar, left, and University of Arizona graduate student Kaitlyn McGrath look at and discuss Petri dishes containing cultures of ancient DNA molecules in Kaçar's research lab.

(Right) Petri dishes containing cultures of ancient DNA molecules.

In addition to her research, Kaçar will be leading a new summer field course titled "Alien Planet Analogs on Earth." It will familiarize students with searching for and interpreting microbial biosignatures through simulated surface lander missions at sites in Utah and Montana.

"Nothing makes me happier than growing these initiatives here, especially because the bacteriology department has a long tradition and history of exploring nitrogenases," Kaçar says, citing the enzymes that are integral to all known forms of life.

For more than a century, the bacteriology department has been a world leader in the study of biological nitrogen fixation, the conversion of nitrogen gas into the ammonia that plants use to make their proteins and DNA. Nitrogenase is critical to this process. Luminaries such as E.B. Fred, Ira Baldwin PhD'26, and Elizabeth McCoy published the definitive text on nitrogen fixation in 1932. In the

1970s, Winston Brill, former Vilas Chair Professor of Bacteriology, worked out the basic biochemistry and identified more than 20 genes required for nitrogen fixation. (See "Of Mutant Wranglers and Slime Whisperers" in *Grow*, Fall 2020.)

"Betül's work is really an example of thinking outside the box," Brill says. "She seems to be willing to take big risks in her research, the kind that lead to big breakthroughs." After attending one of Kaçar's virtual lab meetings early in 2022, Brill was so impressed by what he'd heard that he admits to gushing to his wife, "I wish I could be a student in that lab!"

'Your knowledge will be your power.'

Outreach has always been a top priority for Kaçar. She is eager and always willing to spread the word about the astrobiology field and to encourage young women of all ages around the globe to believe in themselves and pursue STEM fields. "I never thought I would end up on this journey," she says. "It is my responsibility to give back."

In 2012, as her astrobiology career was taking off, she cofounded SAGANet, an online education platform that offers curious minds a way to ask fundamental questions about life in our universe. SAGANet connects students worldwide with summer astrobiology programs, online mentors, and the latest research in the field. One of Kaçar's current undergraduates found her way into the astrobiology field through SAGANet.

Kaçar has delivered talks everywhere from the Boston Science Festival to the main stage of TED2021 to the Library of Congress. She has been profiled for the Smithsonian's "The Scientist Is In" series and appeared on numerous podcasts and TV programs, including a PBS documentary on the origins of life. She frequently participates in STEM mentoring meetings and, as the parent of a four-year-old, connects with other women and mothers in science.

One of her proudest moments came last year when she made a presentation on the future for women and girls in science to the United Nations Commission on the Status of Women. She pointed out how the COVID-19 pandemic further deprived girls around the world of learning opportunities that could advance their educational path.

"We should not forget that there is a part of the world that will pay the price of the pandemic throughout their lifetime," she says. "So many girls over the past two years have missed out on perhaps once-in-a-lifetime opportunities. I think about that summer I attended the scientific conference in Istanbul. What if there was a COVID outbreak that year and I couldn't go? That turning point would have been gone."

Kaçar encourages leaders to create even more opportunities for that "invisible population" to make up for lost time. And to girls, she speaks as a gözü kara, from experience and from the heart: "Your knowledge will be your power. Fight for your right to receive an education and an equal future for everyone. There will be a lot of roadblocks along the way. Stay true to yourself, surround yourself with people who inspire you and who get you. When in doubt, be your own role model, and make decisions that your childhood self will be proud of." g

Innovation through **Campus Cooperation** in America's Dairyland

As part of the Dairy Innovation Hub, a state-funded collaborative involving three University of Wisconsin System schools, CALS researchers are bringing new ideas that address big challenges. BY JIM MASSEY

Sadegh Ranjbar, a Ph.D. student in biological systems engineering, prepares a drone for a data collection flight over an alfalfa field at Arlington Agricultural Research Station.

Photo by MICHAEL P. KING

In 2019, Wisconsin dairy leaders approached state legislators with a long-standing problem and a request for help.

The state's dairy farm numbers were in a steady decline — today Wisconsin has about 6,500 dairy farms compared to more than 50,000 five decades ago — and at the time farmers were struggling with low milk prices. State milk production continued to set all-time records, but dairy leaders were still concerned that research wasn't keeping up with the pace of change on farms. So they asked for a research-focused program to help keep the state's dairy community viable.

Enter the Dairy Innovation Hub, an annual $7.8 million investment by the state of Wisconsin that focuses on research and development at UW–Madison, UW–Platteville, and UW–River Falls. The Dairy Innovation Hub was one of the top recommendations by a 2018 dairy task force made up of farmers, milk processors, dairy marketers, allied organizations, legislators, and university leaders and coordinated by the Wisconsin Department of Agriculture, Trade and Consumer Protection.

"We are often asked to 'do something' about the ag-industry crisis — I believe the Dairy Innovation Hub has the real potential to answer this call," said state senator Howard Marklein when he and state representative Travis Tranel introduced the bill to create the program in May 2019.

In the nearly three years since its launch, the Hub has funded more than 100 research proposals and created multiple mechanisms to manage the annual investments. The Hub has also hired 13 new faculty: five at UW–Madison, five at UW–River Falls, and three at UW–Platteville. Faculty hires have included dairy economists as well as experts in land and water stewardship, human health and nutrition, and rumen microbial physiology, among other fields.

> “We will be **more productive** in our research the **more we collaborate** instead of competing. We are making progress to keep Wisconsin a **dairy superpower**.”
>
> – STATE SENATOR HOWARD MARKLEIN

Starting this summer, Hub leaders expect to fund an additional 50 projects between the three campuses, which many say are collaborating like never before.

“I have heard that the data sharing across campuses has been extraordinary and unusual compared to past collaborations,” Marklein says. “They all share the same mission, and I am pleased with how it is going so far. We will be more productive in our research the more we collaborate instead of competing. We are making progress to keep Wisconsin a dairy superpower.”

The Hub is coordinated across the three campuses by its faculty director, Heather White, professor of nutritional physiology in the UW–Madison Department of Animal and Dairy Sciences. White leads research proposal reviews, helps with faculty hiring, and updates external stakeholders on the Hub’s progress.

“The Hub has done remarkable things to encourage collaboration for both research and instruction,” White says. “When leaders from the three campuses sit down together, we all have the same goals, and a lot of us have research that can be synergistic. Before the Hub was created, there wasn’t really anything that incentivized us to collaborate.”

Hub funding is split among the three participating UW campuses — 52% goes to Madison while Platteville and River Falls each receive 24%. Each campus has hired faculty members to make a long-term, deep impact on dairy research capacity. Faculty and other Hub scientists also carry out short-term, high-impact projects that provide an immediate benefit to the dairy community or answer pressing or emerging questions. Some examples: Hub researchers study ways to refine dairy crop rotations with cool-season annual grasses to help farmers develop sound fertilizer recommendations. They analyze dairy manure solids to recover manure nutrients. And they study consumer preferences for dairy products to help guide nutritional and marketing efforts.

White says one of the Hub’s primary goals is to attract top talent to Wisconsin to work on dairy-related questions and keep the state’s $45.6 billion dairy industry at the global forefront. So far, she is convinced it’s happening.

“During our first two rounds of faculty searches, we’ve hired some really incredible people, and they’re coming here, getting started, and hitting the ground running,” she says.

White says it is the job of Hub leaders to update the legislature on the program’s progress, so lawmakers are confident the state’s money is being spent wisely. “We certainly think it’s our job to be held accountable and to be good stewards of the funding,” she says. “Our reports to our advisory council, stakeholder groups, and legislators will allow us to keep everyone updated and knowing that we are doing what they challenged us to do.”

Cows are a big part of the Hub’s focus, but the program addresses the whole dairy system, including four priority areas that impact everyone’s life: enhancing human health and nutrition; ensuring animal health and welfare; stewarding land and water resources; and growing farm businesses and communities. With dozens of ongoing studies and projects, it’s difficult to describe the full scope of the Hub’s endeavors. But the examples of research that follow, one in each priority area, are a good start.

Where the Hub Homes In

The Dairy Innovation Hub has established four priority areas that address the whole dairy system in Wisconsin. Learn more at **dairyinnovationhub.wisc.edu.**

LAND & WATER

FOCUS: Water quality and use; soil health; air quality and land resources; alternative uses and income streams for manure.

FARM BUSINESS & COMMUNITY

FOCUS: Agricultural start-ups; growing the market for specialty milk and meat products; workforce development; supply chains; global markets and areas of opportunity.

ANIMAL HEALTH & WELFARE

FOCUS: Alternatives to antibiotics; animal health technologies; reproduction; animal stress and consumer trust.

HUMAN HEALTH & NUTRITION

FOCUS: Food-borne illnesses; using dairy foods to fight obesity and preventable health problems; lactose-intolerant and allergy-free alternatives.

Whey for Weight Loss

PRIORITY AREA: **Enhancing Human Health and Nutrition**

Obesity is a major problem in the United States. It affects one in three adults and contributes to inflammation, diabetes, cardiovascular disease, and premature death. Nutrition expert Denise Ney wants to do something about it. One solution may come from an unlikely source: cheese. Or, more specifically, a cheesemaking byproduct.

Ney, a professor in the Department of Nutritional Sciences, has determined through extensive research that a protein isolated from cheese whey has anti-obesity properties, especially in women. Based on studies in mice, the protein, called glycomacropeptide (GMP), reduces hunger hormones and tissue inflammation; improves the breakdown of fat; increases bone mineral content; and positively alters gut microbiota. Now Ney is examining the potential benefits of GMP for humans.

In her Hub-funded pilot study, 10 obese, postmenopausal women will each consume GMP supplements for two, seven-day periods at home. Then they will visit the UW Clinical Research Unit four times for meal-tolerance tests, followed by blood draws. Ney's goals are to gather additional data supporting GMP as a weight-loss supplement, garner funding for further study, and ultimately license a patent through the Wisconsin Alumni Research Foundation.

Ney has a track record of developing a health aid from GMP. She pioneered the use of medical foods made with GMP for the dietary management of phenylketonuria, or PKU, a rare genetic disease that allows an amino acid to build up in the body and cause complications. GMP lacks this amino acid. The medical food she helped develop is being used by PKU sufferers around the world. (See "New Clues to Healthy Bones for People with PKU" in *Grow*, Fall 2017.)

"It's extremely rewarding to see the impact of your research actually improve people's lives," Ney says. "For families affected by PKU, it has been huge. It has changed the standard of care for nutritional management of PKU."

Ney worked with a whey-processing company to develop the GMP powder, which is mixed with eight ounces of water and comes in chocolate and vanilla flavors.

"From our early subjects, we know the product is well tolerated and pleasant tasting," she says.

While there are countless protein supplements already on the market, this anti-obesity version Ney has developed is different because it contains GMP, which has unique properties to promote weight loss while supporting bone health. It's also a prebiotic, which helps nourish the growth of good bacteria that exist naturally in the gut.

Ney hopes to have data from all 10 study subjects by this summer. If all goes well with the pilot and with longer-term research, she says a company could license and commercialize the product, and it could someday be found on store shelves next to other protein supplements.

"It has many applications for weight control as a meal replacement, as a source of protein for anyone who wants to build muscle mass," Ney says. "When you lose weight, you lose bone, and that's a problem for postmenopausal women. I could see people using it long-term, once or twice a day, to support and maintain weight loss."

Nutritional sciences professor Denise Ney samples a supplement shake for weight loss that she developed using a protein isolated from whey, a byproduct of cheesemaking.

Photo by AUSTIN HELMKE

Help for Hot Hutches

PRIORITY AREA: **Ensuring Animal Health and Welfare**

When Wisconsin dairy farmers think about ways to limit heat stress on their animals during the hottest days of summer, their milk-producing cows are likely their top priority. Calves can adapt and thrive more effectively under these conditions, while cows show their discontent with reduced milk production. So it's more common to see various types of cooling methods for lactating cows and not for calves.

But Jimena Laporta PhD'14, an assistant professor in the Department of Animal and Dairy Sciences, believes more could be done to make hutch-housed dairy calves healthier and more comfortable. Through prior research, Laporta has established environmental thresholds at which dairy calves start to experience stress, data that can help improve monitoring. Now, through her Hub-funded study, she's looking for new methods of heat-stress abatement she can recommend to dairy farmers.

Early exposure to heat stress harms the welfare, health, and production of dairy calves, Laporta says, yet research on heat-stress abatement for dairy calves is primarily limited to animals living in subtropical and arid climates. As a result, there's a lack of information on how to prevent heat stress in dairy calves in the Midwest. This gap persists even as summer temperatures rise in the region due to climate change.

A native of Uruguay, Laporta first came to Madison in 2010 for a three-month study-abroad program. She came back the following year to pursue her Ph.D., which led to a tenure-track position in lactation physiology at the University of Florida. She says her five years in Florida — the "epicenter of heat stress" — were instrumental in piquing her interest in heat stress biology.

Wisconsin and its flagship university have reputations as world leaders in the dairy industry, which once again drew Laporta to UW in 2020. "I felt I could contribute to the research and extension efforts in the Department of Animal and Dairy Sciences and help the dairy industry succeed in Wisconsin and globally," she says.

Laporta's Hub research project investigates solar-powered continuous mechanical ventilation as a heat-abatement method for dairy calves housed in outdoor hutches. Her first study, conducted in summer 2021, provided one fan per hutch to supply extra ventilation and decrease the ambient temperature. The fans were set to kick in when the hutch temperature topped 70 °F. This summer, the project will direct air from a single fan into two or three hutches and record the results over a period of eight weeks.

Solar-powered fan ventilation units are attached to calf hutches at the Emmons Blaine Dairy Cattle Research Center at Arlington Agricultural Research Station.

Photo by MICHAEL P. KING

Jimena Laporta, assistant professor of animal and dairy sciences, uses a laser/infrared thermometer to measure the body surface temperature of a young calf at the Emmons Blaine Dairy Cattle Research Center.

Photo by MICHAEL P. KING

"These studies will allow us to see if we can improve the air quality in the hutch and whether it translates into growth and health improvements for the calves," she says, noting that poor ventilation can often lead to respiratory problems in young calves.

Over time, the goal is to set up more powerful solar panels that would provide electricity to fans serving multiple hutches. A short-term option might be to use other power sources until solar energy becomes more affordable.

"In the near future I can see rows of solar panels with rows of calf hutches underneath," Laporta says. "We are taking the first steps toward making that happen."

Laporta says more long-term studies are needed to determine the return on investment of this technology.

"We know that the better the animals do during their early life moments, the better they're going to perform later in life," she says. "There is a lot of interest from the research community and farmers to try to improve early life experiences. We have shown that heat stress impacts the productivity and welfare of the calf. These calves are not going to be productive animals in the herd for two years, but if you can do something early on to give them a good jump start, I think you definitely should."

Drones and Big Data for Decision-Making on the Farm

PRIORITY AREA: **Stewarding Land and Water Resources**

Zhou Zhang moved to Indiana in 2013 for graduate study at Purdue University. Her plan was to pursue the potential aerospace applications of remote sensing. At the time, she had no idea that what she was studying could someday be applied to the field of agriculture.

Zhang received both her bachelor's and master's degrees in engineering fields at Beihang University in Beijing. She was told that pursuing a doctorate degree at Purdue could advance her knowledge in the field of aerospace engineering.

"During the first year of my Ph.D. studies at Purdue, my supervisor told me that remote-sensing tools could be useful to agriculture to help accelerate crop breeding," Zhang says. "I started doing some fieldwork to see if what I had learned could help farmers manage their crops."

Zhang found her way to UW–Madison in March 2019, when she accepted a position as an assistant professor in the Department of Biological Systems Engineering. Now she combines advanced remote sensing with machine-learning techniques for agricultural applications.

Remote sensing uses airborne sensors on satellites or unmanned aerial vehicles (UAVs) to document environmental or structural information faster and more accurately than prior methods. And machine learning is the process by which a computer system develops the ability to mimic human reasoning. A familiar example is self-driving cars that can recognize obstacles and traffic signals.

Zhang is creating advances in remote-sensing techniques to permit data acquisition from multi-sensors across multi-platforms. In plain language, different types of sensors are mounted on platforms to collect data simultaneously. Data-science techniques are used to analyze the "big data," defined as high-dimensional, high-volume data, to provide farmers with decision-making tools for cropping, automated phenotyping, and yield prediction.

The M600 drone used by Zhou Zhang's Digital Agriculture Lab flies over an alfalfa field at Arlington Agricultural Research Station.

Photo by MICHAEL P. KING

Zhang has received two Hub grants to advance her research. One of the grants helped her upgrade her existing UAV-based hyperspectral imaging system to work in a precision farming system. The advanced equipment houses a high-resolution camera with LiDAR (light detection and ranging) capabilities. It can help crop-monitoring companies acquire crop height and maturity information to help predict forage yields and quality.

In summer 2021, Zhang used Hub-funded equipment to collect multi-sensor data over a variety of field crops across multiple agricultural research stations. The second grant funds the next steps.

Improved forage crop varieties provide economic opportunities for livestock and crop-farming operations and promote more sustainable agriculture. However,

Seen through the tailgate of a UW fleet minivan, postdoc Jing Zhou, left, and biological systems engineering Ph.D. student Jiahao Fan prepare a drone for flight over an alfalfa field at Arlington Agricultural Research Station.

Photo by MICHAEL P. KING

the existing laboratory-based forage quality assessment approaches are labor-intensive and time-consuming and greatly limit the genetic selection and forage-breeding efficiency.

Zhang's project aims to develop machine-learning tools that can estimate plant traits such as growth, development, yield, and quality in a high-throughput manner. Her hyperspectral imaging technique is uniquely suited for measuring the composition of forage in real time, saving the time and labor associated with traditional crop-scouting and lab-testing methods.

Zhang says it took her a while to learn about Wisconsin agriculture and understand the problems she might help tackle.

"It took me more than a year to understand the problems," she says. "I had never even heard of alfalfa. It was really challenging for me. When I was talking to collaborators with an agronomy background, it was like they were using a different language. They didn't know what I was talking about, and I didn't know what they were talking about.

"But once I understood, it became much easier. I can talk to the experts in agronomy and use technical language to explain what I'm doing."

Zhang says the hyperspectral camera on her UAV provides colors that can't be detected by the human eye. "A lot of the color and special information we can now see can be quite useful to detecting early disease and early stress in crops when the symptoms are not there yet," she says.

The equipment, however, comes with a steep price, so it's out of reach for most farmers looking to monitor their crops. But crop-breeding companies could use the system to glean important data that would otherwise have to be collected manually, which would benefit farmers indirectly. And down the road, Zhang says, the high-resolution camera on the UAV could also be used to fly over grazing cows to monitor animal behavior and health.

Plans for Pollution Control

PRIORITY AREA: **Growing Business and Community**

Much of the surface runoff problem in Wisconsin comes from manure runoff from farm fields. A Hub-funded research project set out to determine whether broader local regulations could do something about it.

A research team led by Jeremy Foltz, a professor of agricultural and applied economics, developed a way to analyze how and under what circumstances county-level manure regulations might reduce runoff and improve water quality.

The findings were not surprising. But they do provide concrete data supporting the need for more nutrient management plans in Wisconsin. A nutrient management plan, or NMP, documents all crop nutrient needs, soil test results, and nutrient applications (including manure). This kind of monitoring helps

farmers account for what they put on their fields and what runs off. Thirty-three Wisconsin counties require that all farms have an NMP, and about a third of the state's crop area is covered by a plan. Those numbers have been stagnant in recent years.

"Water quality is kind of a whack-a-mole type of a problem," Foltz says. "Nutrient management plans solve a lot of the problem. Mind you, it's not just having a plan, but following it."

If more counties required NMPs, and if county land conservation departments followed up to make sure they were being followed on farms, Foltz believes the state would see a major improvement in water quality.

"I don't think our study says making everyone have a nutrient management plan will solve all the problems, but I think what it says is having a nutrient management plan is shown to be an effective way to reduce manure runoff," he says. "Our research shows if you are in a watershed where more counties have an ordinance that says every dairy farm needs a nutrient management plan, you have cleaner water. If you want to clean up the waters of Wisconsin, you would want every county to have a requirement that all dairy farms have an NMP."

For this project, Foltz teamed up with postdoctoral researcher Marin Skidmore PhD'20 and research assistant Mason Flanagan BS'20 in the agricultural and applied economics department and Tihitina Andarge, a postdoctoral researcher at the University of Massachusetts.

Skidmore and Flanagan contacted every Wisconsin county to determine what types of regulations are in place. While nutrient management plans are a state regulation, they cannot be required by county officials unless county-level ordinances are put in place.

Foltz and his team focused on 10 county-level regulations and found NMPs to be the most effective for improving water quality. Other regulations reviewed by the researchers included manure storage rules; standards for different types of erosion; phosphorus limitations; and required spacing between tillage and waterways, among others.

The research team predicted that if an additional 10% of farms in a watershed had an NMP requirement, they would expect to see a 7.5% decrease in ammonia and an 8.8% decrease in phosphorus entering surface waters over a three-year period.

Skidmore says there are generally more state funds available for NMP implementation each year than are used, so the long-term question is why farmers have not been adopting the plans on their farms.

While people often think of large-scale farms as the biggest polluters, they are actually subject to stricter oversight than small farms, Skidmore says. Large livestock farms are generally subject to federal law, including an NMP requirement, and the Wisconsin Department of Natural Resources monitors those farms to make sure they are complying with the regulations. Smaller farms don't have the same requirements.

"When a county requires nutrient management plans on all farms, that puts somebody local, your county conservation agent, in charge of overseeing that regulation," Foltz says. "That county conservation agent has many ways to cajole you and say, 'Oh, you need to get in compliance during this time period or you could be fined.' At the federal level, with a (large-scale) concentrated animal feeding operation, it's often a full-on lawsuit."

Skidmore says county-level enforcement is generally more palatable to farmers, but with less than half of the counties requiring NMPs, that oversight and enforcement is "patchwork" at best.

A tractor hauls dairy cattle manure for a research project at the U.S. Dairy Forage Research Center in Sauk City, Wis.

Photo by SEVIE KENYON

Foltz notes that requiring NMPs would be neither elaborate nor technologically sophisticated, and they are typically a win-win proposition for the counties and the farmers. The study concluded that connecting farmers to their county conservation offices with an NMP requirement might also introduce them to additional information or cost-share opportunities that might help them manage their manure for better profitability.

"In general, a nutrient management plan tells the farmers if you do the following things, your crops are actually going to grow better," Foltz says. "Once farmers have an NMP on their farm, they have a pretty strong incentive to actually follow it because it helps their bottom line. In that sense, it's different than a lot of other regulations we've studied that just cost the farmer money." g

From Plant Hybrids to Human Health

Krishna Ella's unconventional pathway to the biomedical field has led to greater access to vaccines in the developing world.

Interview by NIK HAWKINS

Krishna Ella is pictured among potato plants in the Walnut Street Greenhouse during a visit to the UW campus in May 2022. Ella remembers fondly the months he spent at the Hancock Agricultural Research Station harvesting and weighing potato tubers for protoplast fusion research. "You don't get that in the classroom," Ella says. "Unless you touch the soil, unless you harvest a potato, you don't have a feel for what a farmer is doing. And that touch is very critical."

Photo by MICHAEL P. KING

When **Krishna Ella** PhD'93 arrived at CALS in 1987 to begin a doctoral program in plant pathology, his goal was to probe the mysteries of hybrid plants. He wanted to use that knowledge to help farmers in their fields. But an understudied cellular process captured his attention and ultimately redirected him to the medical sciences.

About a decade later, Ella and his wife, **Suchitra**, returned to India and founded Bharat Biotech in Hyderabad. Since that time, it has grown into a multinational biotechnology company that develops new vaccines and biotherapeutics. Bharat Biotech now holds 145 global patents, boasts a portfolio of 16 vaccines, and has delivered more than 5 billion vaccines worldwide, with a primary focus on the developing world. The company is a leader in pandemic vaccines, and its products have been prequalified for use by the World Health Organization.

UW has recognized Ella's accomplishments with the Distinguished Alumni Award in 2011 and an honorary degree in 2022, which he accepted at commencement in May. In this special alumni edition of Living Science, we catch up with Ella to talk about his academic path, what he gained from his time at CALS, and his goals for Bharat Biotech.

WHAT LED YOU TO STUDY PLANT PATHOLOGY AT CALS?

I chose UW because the plant pathology department [at CALS] was one of the best in the world. And I liked the diversity that was happening in the department — the type of faculty, their ideas, the purely applied aspect of it. Truly useful to farmers.

HOW DID YOUR ACADEMIC PLANS CHANGE AFTER YOU ARRIVED AT CALS?

I came for my Ph.D. to study protoplast fusion with [now professor emeritus] **John Helgeson**; but, somehow, after one year, I lost interest in that. At the time, signal transduction was well understood in bacteria, how bacteria can sense the environment

Protoplast fusion is a form of genetic modification used to combine two distinct plant species into a hybrid plant that has characteristics of both species.

and their surroundings, but nothing was understood about how plants and pathogens can interact. So, I told John I wanted to work on signal transduction — protein kinases, phosphorylation, dephosphorylation, and what makes differences in the disease. That was research that absolutely nobody was working on in the entire world.

John connected me with faculty in the Department of Bacteriology whom I could interact with and who understood some of the ideas behind the work. That's how I did my Ph.D. in a different field. When a member of the faculty gives you freedom to do something, even if it is not their core area of a subject, and they respect a graduate student to do what they like to do although it is not a part of the program in the department, I think that's very exciting and gives you freedom to think differently. And it also gives you the mindset to think differently in life. And then you know you can take a risk, you can do something different, whatever you like to. That helps in business also.

WHERE DID THIS ACADEMIC PIVOT TAKE YOU NEXT?

My experience at CALS led me to accept a National Institutes of Health fellowship at the Medical University of South Carolina in Charleston to work on signal transduction. There, I was asking questions related to the medical industry and using an indirect method of analysis, a genetics approach. If I take out a gene, is the cellular signal blocked? And if the signal is blocked, what happens to the cells? That's what my publications were about.

HOW ELSE DID YOUR TIME AT CALS PREPARE YOU FOR YOUR CAREER?

I had one course, a scientific methods course, with [now professor emeritus] **John Andrews**. That course was hypothesis driven. How do you do science? You hypothesize, you test and experiment, and then you make a good sub-hypothesis, and again, you test. And what do you do in business? Same thing. You make one business plan; if it doesn't work out, you make another one, and if it doesn't work, you make another one. So it's the same. A scientific methods course in a plant pathology department is very similar to business, to what you see in life. I realize this now; I was not realizing it then.

HOW HAS BHARAT BIOTECH DEVELOPED LOW-COST VACCINES?

We always look at it this way: What can be done for society and for people?

Our rotavirus vaccine, ROTAVAC, was part of the Indo-US Vaccine Action Program (VAP), a bilateral social innovation program between the two governments of India and the U.S. In 1998, I said I wanted to work with the rotavirus for two reasons. One, no vaccine innovation had ever been made in India. Number two, 300,000 children were dying per year in India because of diarrhea caused by rotavirus.

And then, in 2001, we were the first company funded by the Bill and Melinda Gates Foundation for this project. This was the first efficacy trial in the developing world, so we were showing the country and the developing world that an efficacy trial can be done in India the way it is done in the U.S. and Europe.

In the vaccine field, the major cost is not the fundamental science, it's the clinical research. Almost 80% of the cost of our project was for the clinical research program. We funded ours thanks to the Gates Foundation. And the Indo-US VAP program brought the best experts in the world, so we brought the same quality standards of the U.S. to India. Now we sell the vaccine at $1, and the same vaccine is sold in the U.S. at $68. We are now the largest rotavirus vaccine manufacturer in the world.

Our universal COVID-19 vaccine, COVAXIN, is also a fine example of success through public-private partnership.

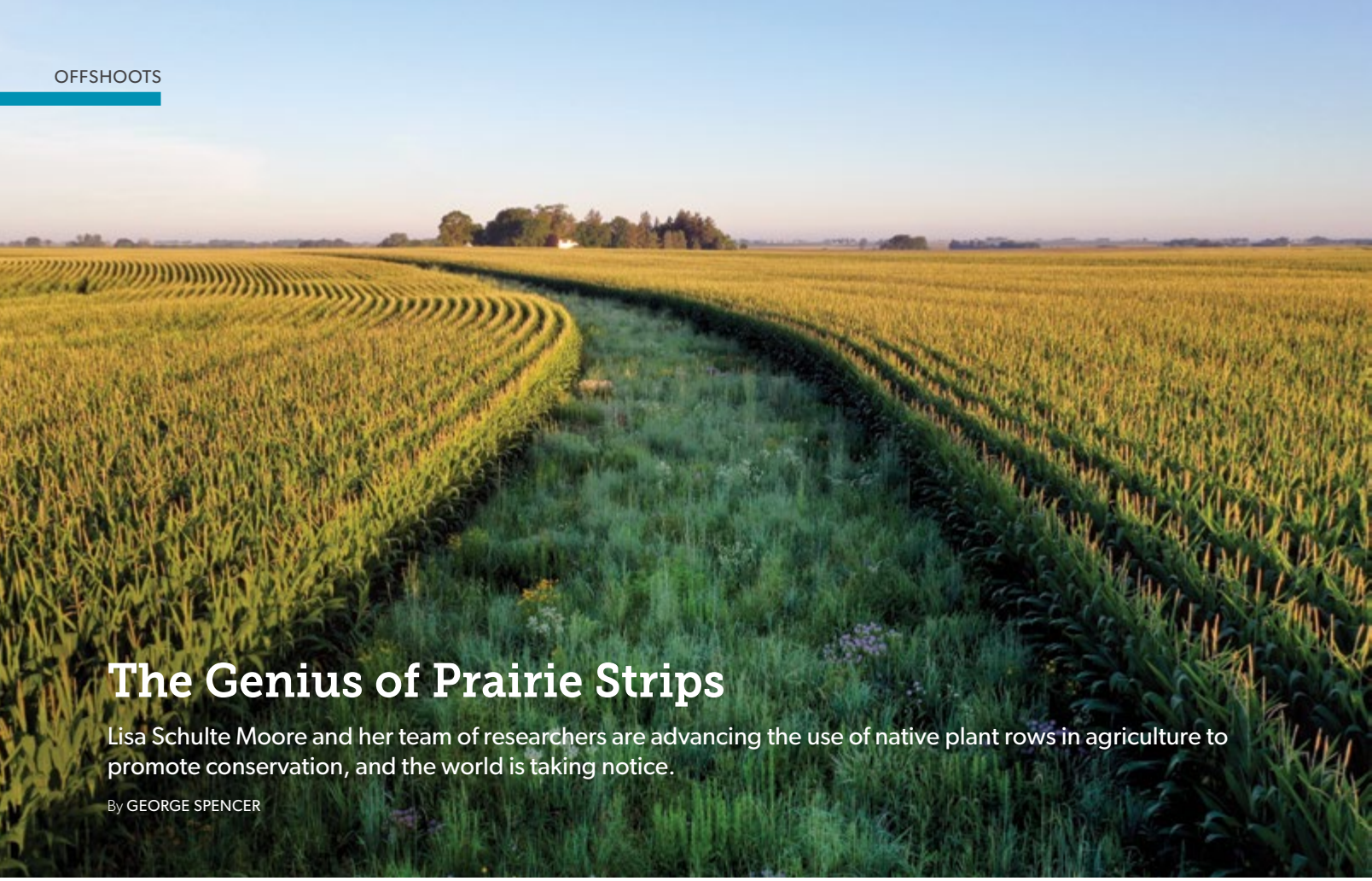
+ ONLINE EXTRA
Bharat Biotech focuses on creating vaccines for infectious and neglected diseases that persist in the developing world. Read more in the digital version of this article at **go.wisc.edu/grow-ella**

WHAT MAKES COVAXIN DIFFERENT FROM OTHER COVID-19 VACCINES?

For the COVID vaccine, I was always looking at one thing: safety, safety, safety. It's the first criterion. Efficacy can come a little later. If safety is compromised and efficacy is good, it's not good for the world. For people, safety is important. We chose an inactivated vaccine. So you just grow the live virus in the lab, and then you kill the RNA. The difference between a vaccine and a live virus is RNA. The live virus will have RNA; in the inactivated vaccine, the RNA is destroyed but all structurally safe, so it cannot multiply.

To do this, you need Biosafety Level 3 (BSL-3) containment because the live virus is so contagious. BSL-3 labs are all over the world, but not BSL-3 production facilities. We were the first company in the world to create a BSL-3 production facility for a polio vaccine project. So, when COVID came, we shut down the polio operation, and we switched over to a COVID vaccine. Scaling up capacities for inactivated vaccines is very limited, but the safety is the best. You give children three inactive injectable polio vaccines: three doses for lifetime immunity. You don't give the vaccine again and again for a child, except the flu vaccine. That is exactly what we created with COVAXIN. It has a high T-cell response, so it has a long memory, lifetime protection.

Biosafety labs are specialized facilities where research is conducted on infectious agents. The labs are ranked from 1 to 4 based on the potential threat posed by the organisms they study, and safety measures are enhanced with each level.



The Genius of Prairie Strips

Lisa Schulte Moore and her team of researchers are advancing the use of native plant rows in agriculture to promote conservation, and the world is taking notice.

By GEORGE SPENCER

Landscape ecologist **Lisa Schulte Moore** PhD'02 is planting new ideas in Midwestern fields. Thanks to her team's research, innovative farmers are putting in bands of native grasses beside staple crops such as corn and soybeans, a practice that holds the promise of revolutionizing farming practices nationwide.

A professor in the Department of Natural Resource Ecology and Management at Iowa State University since 2003, Schulte Moore predicts these multiuse fields will have powerful benefits: They will build healthy soil while keeping it in place; improve water quality; and enhance biodiversity — all while helping curb climate change.

"Native ecosystems are well adapted to agricultural landscapes, soils, and the climate," says the Eau Claire, Wisconsin, native who earned her B.S. in biology at UW–Eau Claire and her Ph.D. in forestry at UW–Madison before starting her career with the U.S. Forestry Service. "Theoretically, this should provide a broader suite of benefits because they're so well adapted."

The formal name for the strategy is prairie strips. These bands of native plants can serve as borders, run through fields, or skirt waterways. With widths of between 30 and 120 feet, they can occupy up to 25% of a tract.

When Schulte Moore and her prairie strips team first began sharing their research results more than a decade ago, the initial response from most farmers was as might be expected: Why should I plant weeds in my fields? But more and more farmers and landowners began to see the wisdom of the approach. The 2018 Farm Bill expanded its conservation program to include the practice, and now farmers and owners can receive compensation for enrolling their land.

"It's a perfect practice for our hilly land," says **Maggie McQuown**, the owner of Resilient Farms in Red Oak, Iowa, which is on the edge of the rich Loess Hills. An early adopter, she began putting prairie strips on her 130-acre farm in 2014. In addition to reducing erosion and attracting birds and pollinators, such as bees and butterflies, McQuown loves how the native plant rows make her property look. "It adds beauty to the landscape. Because it's on a hillside, you can see it from the highway along the hill," she says.

Now belts composed of native grasses, including big bluestem and Indian grass, and native plants such as butterfly milkweed, rattlesnake master, white sage, and wild bergamot have been sown on more than 114,000 acres of farmland in Wisconsin and 13 other states.

That's an amazing rate of change, according to Schulte Moore, whose family farm near Strum, Wisconsin, also boasts a prairie strip. She foresees even greater adoption of native prairie soon. A recent Iowa Farm and Rural Life Poll found that 31% of Iowa farmers indicated they were potentially interested in planting these borders on their land at some point; 20% said they would do so now. Though other conservation practices have called for using native plants in similar ways, the rapid adoption of prairie strips marks "a mental shift, a transition point" in American agricultural thinking, says Schulte Moore.

A prairie strip between corn fields. Photo courtesy of IOWA STATE UNIVERSITY

Besides winning fans among farmers, Schulte Moore's unorthodox thinking also attracted the attention of the John D. and Catherine T. MacArthur Foundation, which, in 2021, named her a MacArthur Fellow. Commonly known as a "genius grant," the fellowship is bestowed on high achievers in an array of disciplines and comes with a no-strings $625,000 award disbursed over five years.

"Pretty overwhelming" is how Schulte Moore describes the amount of overnight attention she received. "It's an honor, totally life changing, and really cool."

Winning the fellowship has supercharged her. "I want to figure out how we achieve this vision of making Iowa and the Corn Belt green, not just in the middle of summer but throughout the year, or at least have continually living roots in the soil, and have the landscape that supports this also be economically viable for farmers," she says.

She's also talking with engineers about the possibility of converting prairie plants into fabric for clothing. The idea came to her when she visited a Minnesota paper mill. While there, she learned that the mill also made a rayon-type fiber, used in apparel, from wood pulp. For Schulte Moore, this goal is personal. She owns a Patagonia dress decorated with a prairie print, and one of her dreams, she says, is to own a similar dress that's actually made from native grasses.

When she looks back on her days at UW, she singles out two mentors — Ph.D. advisor **David Mladenoff** MS'79, professor emeritus of forest and wildlife ecology, who created an "incredibly vibrant environment" in his lab, and conservation biology professor **Monica Turner**. "Having a top-notch female scientist like her to look up to opened my eyes in terms of the possibilities of what I could achieve," Schulte Moore says.

"Lisa had a very special combination of talents," recalls Mladenoff, who earned his forest ecology Ph.D. at UW as well. "She had the ambition, focus, personality, and smarts, and was really good working with a group."

A self-proclaimed "bridge person," Schulte Moore has lived up to that observation. Her systems approach to research has led her to find partners that span academic, business, government, and nonprofit worlds.

The enthusiasm of farmers who are learning to manage prairie on their land spurs her on. "This diverse, native, perennial polyculture of prairie is the antithesis of the exotic, highly engineered, annual monocultures they're used to," she says. "It's fun to watch them engage with the ecology of their farms as they learn about the history of prairie, the species in the seed mixes, what happens in soil under prairie strips, and the insects, birds, and butterflies they attract."

"I meld scientific skills with communications and collaborative skills," she says. "I love working both within and beyond academia. It's so important for our work to be grounded in ways that benefit people's lives."

STRIPS STRATEGY

Prairie strips, an agricultural conservation practice based on research by forest and wildlife ecology graduate and MacArthur Fellow Lisa Schulte Moore, involves planting bands of native grasses beside staple crops. The method could yield many environmental benefits, including:

- Erosion reduction
- Better water quality
- Improved soil health
- Upgraded wildlife habitats
- Enhanced biodiversity
- Climate change mitigation

More at **go.wisc.edu/macarthur-schulte-moore**.

Lisa Schulte Moore. Photo courtesy of THE JOHN D. AND CATHERINE T. MACARTHUR FOUNDATION

ENGAGE

HAVE A FIELD DAY

Summer is field day season at the CALS Agricultural Research Stations. On select dates during the 2022 growing season, stations from Madison to Spooner, Lancaster to Door County, will open to the public to share the latest research findings with agricultural professionals, home gardeners, and others. See a full list of planned field days at **ars.wisc.edu**.

ACCOLADES

SEVENTH-GEN SUCCESS STORY

Kyle Zwieg FISC'07,'08 and his wife, **Rachel**, of Zwieg's Maple Acres, a seventh-generation family dairy farm in Ixonia, Wisconsin, have received the 2022 Wisconsin Outstanding Young Farmer award. The couple was recognized for their community involvement and on-farm innovations that contribute to efficiency and conservation.

DAIRY AFFAIR DIRECTOR

Laura Herschleb BS'01 has been named general manager of the World Dairy Expo. Each fall, the expo brings tens of thousands from across the globe to Madison, Wisconsin, for the world's largest dairy-focused trade show. Herschleb spent five years as the expo's dairy cattle show manager in the late 2000s and returned in 2018 as marketing manager.

Alum Helps Sustain 'Another Level of Molecular Clarity'

By CATHERINE N. STEFFEL

Less than a decade ago, UW researchers began to gather and assemble the components of a powerful, advanced imaging technology called cryo-electron microscopy (cryo-EM) that would allow them to observe the structures of some of the tiniest building blocks of life. In 2021, they realized their vision as the Department of Biochemistry launched the Cryo-Electron Microscopy Center (CEMRC).

Contributions for the $17.5 million project came from across campus, including the Department of Biochemistry, Morgridge Institute for Research, Office of the Vice Chancellor for Research and Graduate Education, School of Medicine and Public Health, UW Carbone Cancer Center, Department of Neuroscience, and Department of Biomolecular Chemistry. To augment that shared investment, biochemistry alum **Daniel Klessig** BS'71 is providing financial support for scientists conducting research at the CEMRC.

"One of the reasons I became so excited as an undergraduate at UW–Madison about molecular biology is that it gave one the ability to alter genes and thus figure out what the encoded proteins do," says Klessig, who supports research and professorships at several institutions to advance his field. "Cryo-EM gives one another level of molecular clarity by being able to actually see where and how those proteins fit in a large biological structure. You can now look at very large molecular complexes and see the working parts."

Cryo-EM uses ultra-cold temperatures to capture detailed information about the smallest components and interactions in living cells, viruses, and more. The CEMRC provides technical assistance, instrumentation, training, and access to this advanced technology for researchers at UW and beyond. Work at the center has already yielded important achievements, including enhanced knowledge of SARS-CoV-2, the virus that causes COVID-19 (see "Virus Research Recast" in *Grow*, Spring 2022).

Professor and chair **Brian Fox** commends Klessig for his annual gifts, which the biochemistry department matches. "Dan's vision of supporting research in impactful ways stems from his insights and experiences in research," he says. "Through his generous and flexible endowment, the department is able to support advanced cryo-EM training for students and staff and invest in the operation and enhancement of microscopes needed to keep us at the forefront of this important technology."

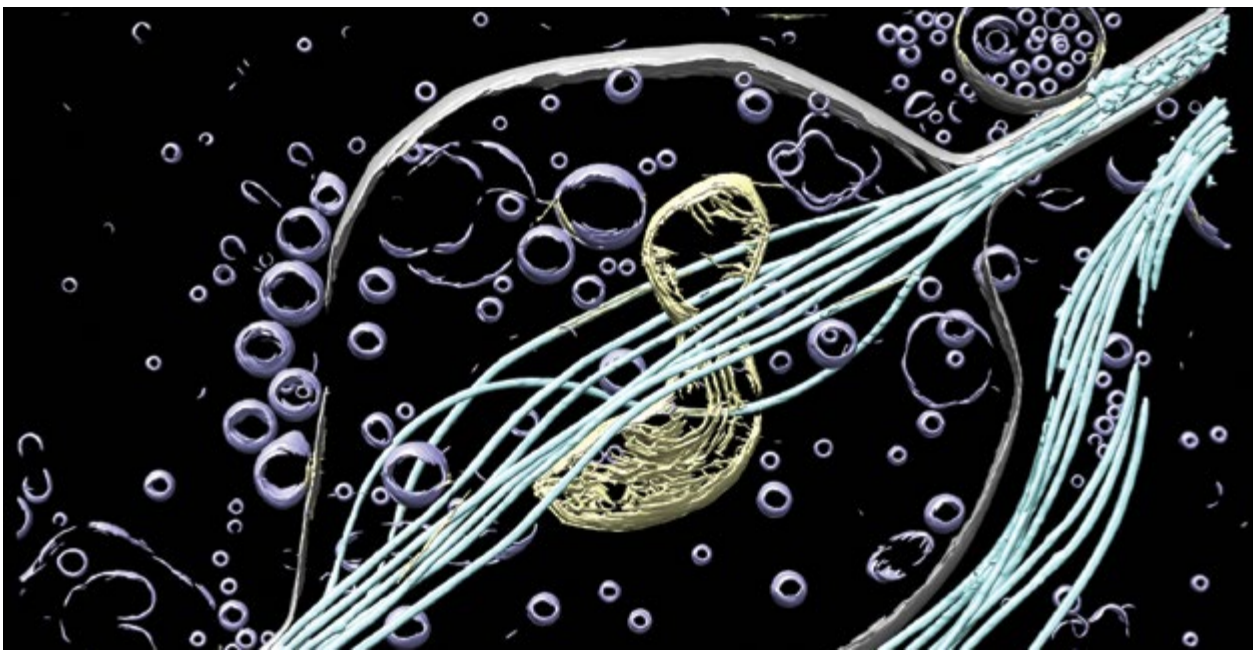
A life in academia was initially beyond Klessig's wildest imagination. He grew up on a dairy farm near Chilton, Wisconsin, where 18-hour days of hard farm work and intense studying helped him reach the top of his class despite his dyslexia. Those long working days were in part what drove him to leave the farm and follow in his brother's footsteps as a biochemistry student at UW.

Klessig, now an emeritus professor and former president and CEO of the Boyce Thompson Institute at Cornell University, says that the excitement, enjoyment, and satisfaction of working in research meant that he never realized his goal of holding a traditional nine-to-five job. But he wouldn't change a thing. He's still excited about the new, almost daily discoveries in biology and the potential of the CEMRC to advance so many different types of research.

"I've had a lot of opportunities in my life," Klessig says. "My undergraduate training at the University of Wisconsin and the Department of Biochemistry gave me a leg up, so they are pretty close to my heart. It's time to give back."

INVEST IN CALS

Want to support cryo-EM research at CALS? Contact Brandi Funk at 608-308-5204 or brandi.funk@supportuw.org.



This 3D view made with cryo-electron tomography at UW shows microtubules (in cyan) and mitochondria (yellow) — essential cellular components — of an individual neuron from the cortex of a mouse brain.

Image by JOSEPH KIM and TANNER TENPAS

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Members of Zhou Zhang's Digital Agriculture Lab place markers in an alfalfa field prior to a data-gathering drone flight at Arlington Agricultural Research Station. The work is part of a project funded by the Dairy Innovation Hub. Read more on page 26. Photo by MICHAEL P. KING