College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

FALL 2022 NEWSLETTER

CHEMICAL AND BIOLOGICAL ENGINEERING

LEARNING TOGETHER

A community of diverse students and faculty

Greetings from Madison!

We're so excited to welcome 20 new graduate students to our department! In addition to students joining us from U.S. schools, graduate students from Pakistan, Saudi Arabia, India, Nigeria, Ecuador, Korea and Taiwan add a global flavor to this year's class. Early in the fall semester, we welcomed our students with a reception and our annual tradition—a cookie contest—attended by our graduate students, faculty and staff.

Our newsletter cover features Francesca Gambacorta, a graduate student in the Pfleger research group, and a recipient of the Jennifer L. Reed Bioenergy Science award. Read about her award in this newsletter. During the summer, Francesca mentored Stephanie Brown, an REU student in the Pfleger lab. Stephanie was one of 18 undergraduates who participated in CBE's Research Experiences for Undergraduates (REU) program. In addition to the Pfleger Lab, participating students worked in the Huber, Palecek, Schreier, Krishna, Zavala, Gopalan, Hermans, Venturelli, Van Lehn, Gebbie, Shusta and Lynn research labs. We are proud to be part of this NSF-funded program that helps rising undergraduates work with graduate student mentors in our labs. It's a fantastic learning opportunity for both the undergraduate and graduate students.

Please join me in congratulating Richard H. Soit Professor Marcel Schreier. Marcel has received a prestigious Beckman Young Investigator Award from the Arnold and Mabel Beckman Foundation. Marcel was one of 10 awardees nationwide who, according to the foundation, "exemplify its mission of supporting the most promising young faculty members in the early stages of their academic careers in the chemical and life sciences, particularly to foster the invention of methods, instruments, and materials that will open new avenues of research in science."

Summer lab construction (or should we say "deconstruction") has commenced. The basement laboratory has been cleared of equipment, and the stockroom shelves that held chemicals, beakers, scales and pipettes have been relocated. The original stockroom is now empty, if you can imagine that. The selected contractor just finished a major construction project in the south end zone at Camp Randall Stadium. We are looking forward to the winning work that they will bring to CBE!

If you missed our spring town hall meeting, please visit our YouTube channel (UW-Madison CBE) to learn about our department's updates. You will also hear from Assistant Professor Siddarth Krishna about the exciting work going on in his sustainable catalysis research group.

Thank you for your ongoing support and interest in our department. We always love to hear from you, too! Please drop us a line at che@che.wisc.edu and let us know what you are up to.

On, Wisconsin!

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Gift will support plastics recycling and undergraduate scholars

UW-Madison alumni Ross (BSECE '67) and Michele (BSBiochem '68) Annable have committed $1 million to support research into solvent targeted recovery and precipitation (STRAP) processing, a plastic recycling technique developed by Richard L. Antoine Professor George Huber.

"We are passionate about solving the world's plastic waste problem, and Huber's research is leading the way," says Ross Annable.

Huber, director of the Center on Chemical Upcycling of Waste Plastics (CUWP), and his team will use the gift to more aggressively pursue and commercialize STRAP by supporting new graduate students and postdoctoral researchers and purchasing specialized laboratory equipment. STRAP enables the recycling of mono and multilayer flexible films, which cannot be recycled today. "We are incredibly grateful for the Annables' confidence in our work and the ability to more quickly pursue solutions that can benefit the world," says Huber.

The Annables have also committed $4 million to the Strategic Targeted Achievers Recognition (STAR) Scholarship Fund, enabling the college as a whole to recruit the nation's best and brightest students, while enhancing the diversity of the student body. Thanks to a generous commitment from The Grainger Foundation, this $4 million investment will be matched, creating an $8 million STAR Scholars fund.

Support a STAR Scholar

Effective solutions to today's challenges arise when we bring the brightest people to the table. When you make a gift to our STAR Scholarship fund, you'll help our college recruit the nation's best students so that they can become tomorrow's problem-solvers and difference-makers. Thanks to a commitment from The Grainger Foundation, there's also matching support available—meaning that you can double the impact of your support.

We need your help growing this important scholarship fund. To make a gift, contact Kyle Buchmann, senior managing director of development, at kyle.buchman@supportuw.org or (608) 630-1679.

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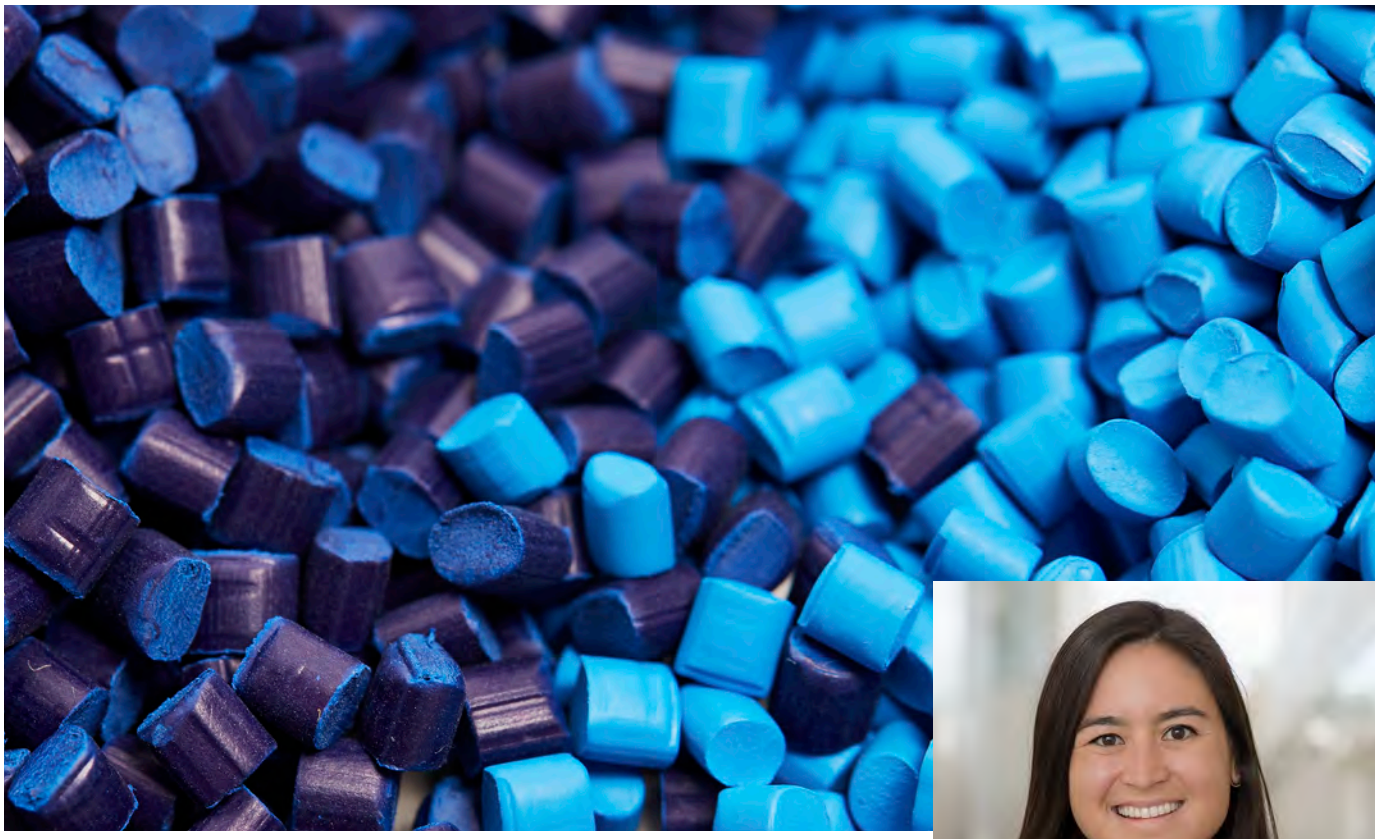


FOCUS ON NEW FACULTY

Whitney Loo wants polymers to be part of a sustainable future

Polymers are all around us—for most people, literally. Clothing, electronics, food packaging, cars and even medical devices are made from the long-chain molecules, which include things like plastic, nylon and synthetic rubber. While polymers are extremely useful, they have some major drawbacks; most are derived from petroleum products and are not optimized for recycling.

But Whitney Loo, who will join CBE in January 2023 as an assistant professor, hopes to develop polymers that enable new sustainable technologies. "The questions my lab will be thinking about are how we can leverage polymers for a more sustainable future," she says. "How can we design new polymers for battery electrolytes or fuel cell membranes for green energy technology as well as new functional everyday materials that are sourced from sustainable feedstocks?"

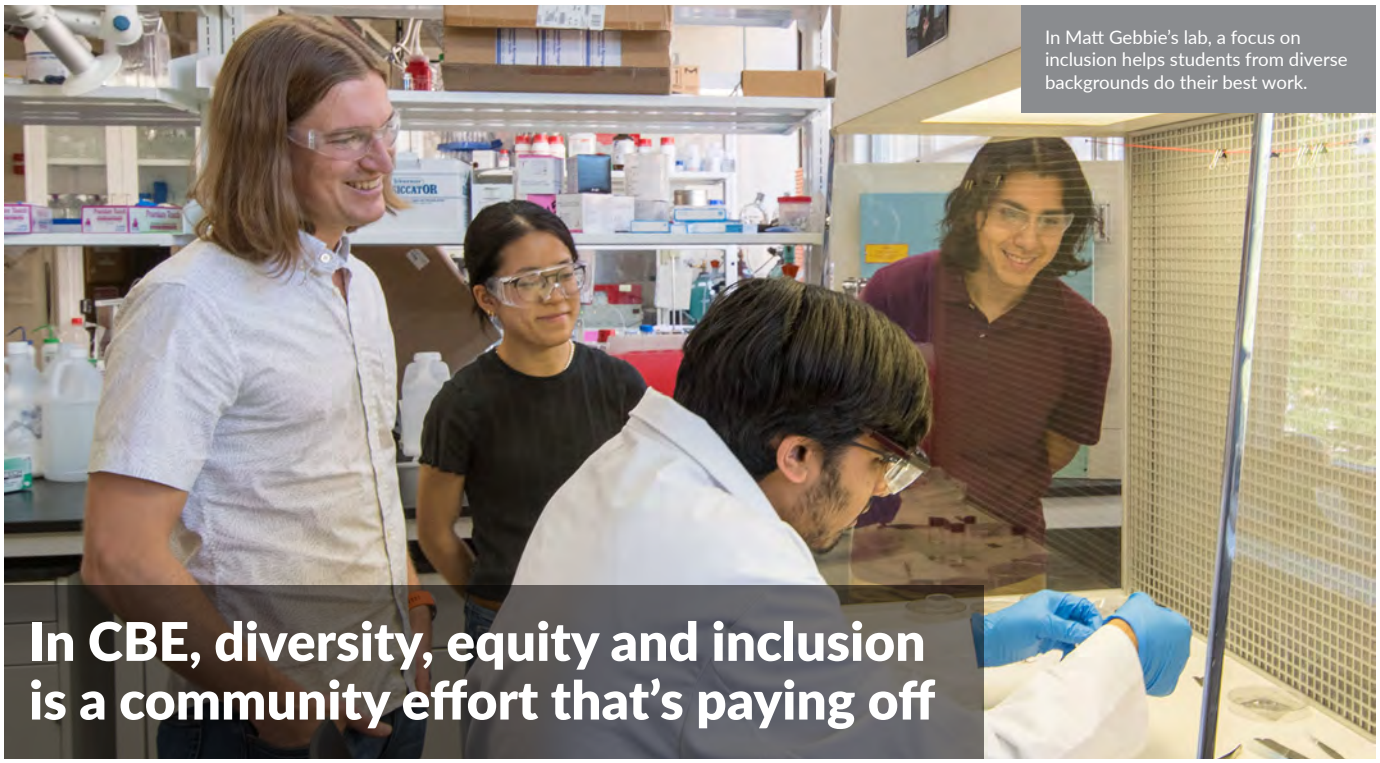
Loo's path to polymers began when she was very young. Growing up the daughter of two surgeons, she felt the need to apply her talents in the medical field, but did not want to be a physician. That led her to MIT where, as an undergraduate, she worked with chemical engineer Bob Langer, whose lab works on the interface between biotechnology and chemical science. While she enjoyed the materials side of the work, she found the biological elements time-consuming and slow.

So when she began her PhD work at the University of California, Berkeley, Loo focused on materials design and polymer science. There, she developed new block copolymers for use in batteries and energy storage devices. "I had the pleasure of working pretty much solely with materials that I synthesized myself," she says. "I think with that, there comes a lot of ownership over your research. Because after you do that synthesis, you think, wow, nobody else in the entire world has this exact molecule. I am the only person to synthesize it. And if I don't study it, and learn everything I can about it, nobody ever will."

In 2020, Loo began work as a postdoctoral scholar at the University of Chicago and the Molecular Foundry at Lawrence Berkeley National Lab exploring ways to use block copolymers in nanolithography for semiconductor manufacturing.

At UW-Madison, Loo plans on continuing her work in these areas and extending her research into finding more sustainable polymers. "We have such a large quantity of plastic waste out in the world," she says. "How can we develop new recycling or upcycling technologies to reuse and reduce the amount of plastic waste that we're currently generating?"

Loo thinks UW-Madison has the resources and collegial culture that will help keep her research moving forward. "UW-Madison's commitment to serving the public and serving the state is something that I really admire. I think that, as an engineer, it's always good to be reminded of who your work is supposed to benefit," she says. "And having that so clearly laid out at the university level is really helpful to keep yourself motivated to work on these really challenging problems."



In Matt Gebbie's lab, a focus on inclusion helps students from diverse backgrounds do their best work.

In CBE, diversity, equity and inclusion is a community effort that's paying off

At the beginning of each group meeting, the members of Conway Assistant Professor Matt Gebbie's lab pause for a short researcher highlight to discuss a notable underrepresented or minority researcher who helped shape chemical engineering, chemistry or broader science, placing their portrait on the wall. That gallery helps remind students and visitors that a career in research should be open to everyone.

It's just one way the lab puts diversity, equity and inclusion (DEI) at the center of its culture; in fact, since its beginnings just two years ago, the Gebbie lab has been built from the ground up with DEI as one of its core values. The lab is composed of graduate students from many different backgrounds, and getting to know and understand each other's perspective, they believe, leads to better working conditions and a better lab environment.

PhD students Hrishikesh Tupkar and Elvis Umaña serve as the lab's diversity officers, promoting DEI activities in the lab. They set up the researcher highlights as well as group lunches every few weeks for the students to get to know one another. The team also celebrates heritage and history month events, and encourages discussions on diversity topics. But Tupkar says their role is deeper than just event planning.

"We want to make sure that everyone feels welcome and comfortable," he says. "We are the people that others in the lab can talk to if they do see any issues or want any positive changes in the lab to promote equity and diversity."

It's not surprising that DEI initiatives are at the core of Gebbie's lab. He led a diversity focused group as a graduate student at the University of California, Santa Barbara, and co-founded a similar group while a postdoctoral researcher at Stanford University.

"That was something I just found very energizing for me. It was an awesome experience and let me learn much more about people who had overcome barriers to get into graduate education," he says. "I remain passionate about making sure that anybody feels like they can consider research as a career."

Gebbie's isn't the only CBE lab focusing on diversity. In fact, it's been a community effort. The department has taken a hard look at its diversity, particularly the underrepresentation of women. So it created a DEI committee, spearheaded by Professors John Yin and Victor Zavala and has taken tangible steps towards recruitment of more diverse faculty and graduate students. It has also raised awareness of DEI issues and provided resources and guidance for labs on how to improve diversity and inclusion, including the suggestion of appointing DEI officers, which many labs have adopted.

The Chemical Engineering Graduate Student Organization (ChEGS), co-led by Gebbie Lab PhD student Ryan Cashen, has also worked with the committee to organize get-togethers, international potlucks and opportunities for social interaction between students and faculty. The department has also created a Slack account for graduate students and faculty, including channels to discuss diversity and celebrate multicultural events.

"Things have improved significantly," Zavala says. "I think in the past these issues were kind of an afterthought. And now you feel they are present in every discussion, and people are thinking how they can improve things. But we still have a lot to do."

Beichen Liu, a PhD student in the Gebbie Lab, says she sees an impact. "I think these efforts do help in increasing the different kinds of people that we encounter in science," she says. "And that increases the number of perspectives that can add to the academic body of work."

Gebbie lab member Umaña was introduced to research when he attended a virtual REU program at UW-Madison in summer 2020. He liked the diversity of the students attending the program and was also impressed by the way the department used discussions to process the Black Lives Matters protests going at the time.

Now, Umaña is happy to continue those discussions in a meaningful way as a student, lab diversity officer and ChEGS social chair. His goal, and the goal of everyone in the lab, is to nurture an environment where students can thrive. "It can be difficult as a graduate student to have a welcome feeling, even when people aren't discriminating against you," he says. "You feel like an outsider if there aren't others who share the same cultural background. So being able to provide a comfortable space for people to pursue something they're passionate about really feels like it's helping them achieve their goals."

PhD student receives 2022 Jennifer L. Reed Bioenergy Sciences Award

Francesca Gambacorta, a graduate student in the lab of Jay and Cynthia Ihlenfeld Professor Brian Pfleger, received the 2022 Jennifer L. Reed Bioenergy Sciences Award. It's given to an outstanding female graduate student, postdoctoral fellow or junior scientist who shows leadership through research excellence while serving the Great Lakes Bioenergy Research Center (GLBRC). The award is named in memory of Jennifer Reed, a CBE faculty member and GLBRC researcher who won numerous national awards for her leadership in science before passing away in 2020.

Pfleger says Gambacorta is a natural leader. "Whether you're talking about how she takes charge of non-research duties in the lab or how she's successfully managed a project involving six GLBRC-PIs, Francesca has demonstrated that she is ready to guide research as an independent scientist."

Gambacorta's path to microbial engineering began with aspirations of a medical career, but after an undergraduate internship in a pathology lab, she knew a stethoscope wasn't in her future. It was during an internship at Argonne National Laboratory that Gambacorta found her passion in studying microbes, like *Saccharomyces cerevisiae*, or brewer's yeast. "The work is much more relatable for me because the organisms that I work with we see every day in our bread and in our beer, and making a hypothesis and testing it out is much easier than with humans," she says.

Francesca Gambacorta (right) has shown leadership in the lab, including mentoring Stephanie Brown (left) during the 2022 summer research experience for undergradautes program.

Since joining Pfleger's lab, Gambacorta has worked on building a strain of brewer's yeast, normally an ethanol-producing powerhouse, that can produce isobutanol instead. The energy-packed molecule, currently made from petrochemicals, is valued because of its versatility as a drop-in fuel or, when upgraded, jet fuel or diesel. "It's difficult to change the metabolism of something that has evolved for millions of years to do one thing. And I'm really trying to understand the minimum modifications needed to make the switch," she says.

In a recent publication, for example, Gambacorta and a team of GLBRC colleagues found that housing *Saccharomyces'* isobutanol-producing enzymes in the yeast's mitochondria, the powerhouse of the cell, rather than in the cell's open spaces, improved fuel production nearly four-fold. "This study was really comparing different engineering strategies, and now we know which one is the best one to start building the next generation of the strain," says Gambacorta.

Now, as she nears the home stretch of her PhD, Gambacorta is grateful for the time she's had outside the lab, too. "I've gotten the chance to do a lot of Engineering Expos and other outreach activities with kids. I want them to know that they can do whatever they want in their career," she says. "I didn't have a strong woman role model in the sciences, so I hope I can be a role model to them."

Not so precious: New discovery could replace expensive platinum in hydrogen fuel cells

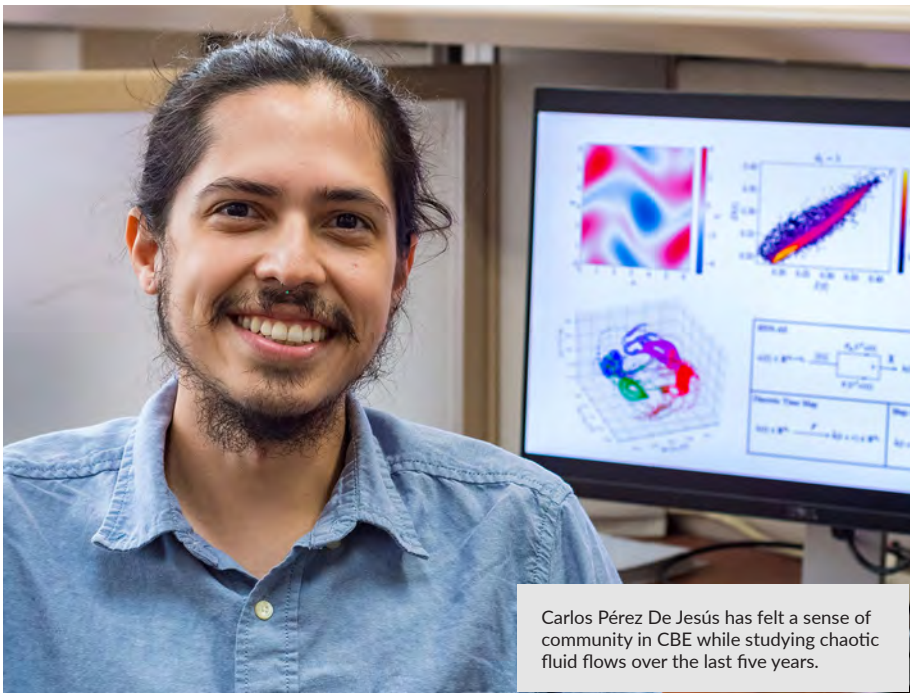
Hydrogen fuel cells are a promising source of clean energy. Currently, the best materials to catalyze the reactions in the cells are expensive precious metals, like platinum. Now, a team of researchers including Ernest Micek Distinguished Chair and Vilas Distinguished Achievement Professor Manos Mavrikakis, discovered a new way of catalyzing an essential reaction that could make the cells more affordable and practical. The research, which includes collaborators from Cornell University and Wuhan University, was published in the *Proceedings of the National Academy of Sciences.*

In their work, researchers designed a hydrogen fuel cell with an anode catalyst consisting of a solid nickel core surrounded by a carbon shell. When paired with a cobalt-manganese cathode, the resulting precious-metal-free hydrogen fuel cell put out more than 200 milliwatts per square centimeter.

"The bottleneck for this technology to become widely adopted is the cost of the materials needed, including the electrocatalysts employed, which in most cases are expensive platinum-group elements," says Mavrikakis. "In this work we demonstrated that cheap, non-precious metals, such as nickel, can be used effectively both for the cathode and anode electrodes of the fuel cell."

Mavrikakis and his team, including postdoctoral researcher Roberto Schimmenti and 2020 PhD graduate Ellen Murray, used quantum mechanical modeling to explain the superior performance of the anode catalyst.

The researchers hope this new anode will help dramatically lower the cost of alkaline fuel cells enabling their use in vehicles, energy production and other areas.



Carlos Pérez De Jesús has felt a sense of community in CBE while studying chaotic fluid flows over the last five years.

Graduate student Carlos Pérez De Jesús feels at home in CBE

When Carlos Pérez De Jesús first traveled from Puerto Rico to UW-Madison for the Summer Undergraduate Research Experiences (SURE) program in 2014, he was excited to attend a large campus and get a taste of the Midwest. But he was surprised at how familiar the CBE department felt.

"I didn't know what to expect. But in any corner of CBE, you can hear Spanish being spoken," he says. "There are a lot of students from Puerto Rico and Latin America here, and a lot of support. That's something I noticed and really liked. I wanted to have a sense of belonging and having people with the same background made me feel welcome."

Now, almost a decade later, Pérez De Jesús is a fifth-year PhD student working in the lab of Michael Graham, the Steenbock Professor and Harvey D. Spangler Professor. The sense of community he's experienced and the many friends he has made have helped Pérez De Jesús thrive as a graduate student.

An uncle inspired Pérez De Jesús to pursue chemical engineering and during his sophomore year at the University of Puerto Rico at Mayaguez he began working as an undergraduate researcher. During the 10-week SURE program, Pérez De Jesús worked in Graham's lab doing computational research on fluid flows, returning to continue the work the following summer.

When he decided to apply to graduate school, his previous experiences led him toward Madison, and he matched up with Graham as his advisor. In his research, Pérez De Jesús uses neural networks to simulate and study chaotic, two-dimensional fluid flows. In essence, using computational tools, his work simplifies the extremely complicated dynamics of the flows so they can be accurately simulated. His research earned him first place in the #LatinXChem 2021 Twitter Conference.

While hard work and good mentoring has contributed to his academic success, Pérez De Jesús says having a strong sense of community has also helped. "Working on a PhD is hard. Classes are hard, and when you get here there are big changes," he says. "There are people from all different backgrounds speaking in English and it can be hard communicating at first and understanding where they're coming from. That's why it's good our department and lab are building a strong graduate student community."

After graduation, Pérez De Jesús says he plans to join industry, inspired by some of the research and development PhDs he worked with during an internship at the pharmaceutical company AbbVie.

How zombie attacks could help fight the COVID-19 virus

John Yin

Virus replication is messy. Besides creating full copies of their genomes after they infect cells, viruses also produce lots of non-infectious particles. "It turns out the machinery that copies genomes in viruses can be quite error-prone," says Vilas Distinguished Achievement Professor John Yin, who studies these "zombie" viral particles.

In an opinion piece in *Scientific American*, Yin discussed the potential for using these particles to reduce the severity of COVID-19 and other viral diseases.

While these particles appear dead, when they infect a cell with an active virus, they can hijack the machinery for replication, coming back to life. In some studies, it appears these zombie genomes can trigger a protective immune response, leading to less severe infections. In other cases, the zombies appear to prolong or make disease worse. "The simplest way to interpret it is these particles interfere with normal virus growth and normal virus growth can cause severe disease," says Yin. "So maybe when these guys are present at high levels, it might tamp down virus growth and the severity of the disease."

Understanding these mechanisms and the way the zombies interact or interfere with viruses, Yin says, could help in the development of vaccines with broad protection against various viruses, including influenza and coronaviruses like COVID-19.

Faculty News

Several faculty members recently received named professorships, including Duane and Dorothy Bluemke Assistant Professors Styliani Avraamidou and Siddarth Krishna; Walter J. and Cecille Hunt-Hougen Associate Professor Reid Van Lehn; and Karen and William Monfre Professor Brian Pfleger.

Conway Assistant Professor Matt Gebbie received a WARF Accelerator Electrification Challenge Grant, which supports new technologies to help leverage electricity from sources other than fossil fuels to power our buildings, vehicles and world. Gebbie and his lab are researching a new class of electrolytes to support next-generation batteries.

Milton J. and A. Maude Shoemaker Professor Sean Palecek is part of a team that received a UW-Madison Research Forward grant, which supports groundbreaking, collaborative work that spans disciplines. He's working with Biomedical Engineering Professor Krishanu Saha on a project developing a new concept to treat brain injuries and disorders

Richard H. Soit Assistant Professor Marcel Schreier is one of 10 young faculty members from across the United States who received a Beckman Young Investigator Award from the Irvine, California-based Arnold and Mabel Beckman Foundation. The competitive award provides $600,000 in funding over four years. According to the foundation, the awardees exemplify the Beckman Foundation's mission of supporting the most promising early-career faculty members in the chemical and life sciences.

Baldovin-DaPra Professor Victor Zavala received an H.I. Romnes Faculty Fellowship from UW-Madison. The award recognizes faculty with exceptional research contributions within their first six years from promotion to a tenured position.

Student News

Graduate student Unni Kurumbail received a National Science Foundation Graduate Research Fellowship, which provides three years of financial support. Recent graduate David Cole and undergraduate Ryan Kong received honorable mentions.

Graduate student Aaron Simmons won the best poster award at the ECI Advancing Manufacture of Cell and Gene Therapies VII Conference.

Alec Linot, a PhD student in the Graham research group, was selected as a Givens Associate, a highly competitive program at Argonne National Lab.

CBE undergraduate students selected teaching assistants Von Rueden, Eun Seo Choi, Blake Lopez and David Cole for Ragatz Awards for outstanding teaching.

Ophelia Venturelli's model microbe communities are an important research tool for understanding the gut microbiome.

Machine learning takes on the human gut

Researchers at UW-Madison and the University of Michigan published research in the journal *eLife* showing how communities formed by human gut microbes can be predicted more accurately with a new computer model. The work suggests it's possible to scale up from models containing 25 microbe species to models representing the thousands of species in the human digestive system. The new algorithm could map out the entire landscape of 33 million possible communities in minutes, compared to the days to months needed for conventional ecological models.

Integral to this major step was Ophelia Venturelli, a CBE and biochemistry assistant professor whose lab runs experiments with microbial communities, keeping them in low-oxygen environments that mimic the environment of the mammalian gut. Her team created hundreds of different communities with microbes that are prevalent in the human large intestine, emulating the healthy state of the gut microbiome. The team then measured how these communities evolved over time, as well as their concentrations of key health-relevant metabolites, or chemicals produced as the microbes break down foods.

Machine learning researchers used Venturelli's datasets to train an algorithm to understand the relationship between the microbes and metabolites. The researchers used these relationships to design communities worth exploring in follow-up experiments.

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Summer lab returns to Spain in 2022

At the end of May 2022, a group of 14 CBE students traveled to Oviedo, Spain, restarting a tradition that had taken a pause during the pandemic years of 2020 and 2021. The group, led by CBE instructor Rafael Chavez, was there for the five-week, intensive summer lab course at the University of Oviedo.

For several decades, summer lab students have had the opportunity to finish the capstone course abroad in Spain, London, Vienna; Hangzhou, China; and Hong Kong. There were also plans to offer the course in Limerick, Ireland. But the pandemic put those sessions on pause and students completed summer lab remotely in 2020.

In 2022, however, CBE offered a single session in Oviedo—the 23rd time the course has been taught there. Chavez, who has led the course many times abroad, says this summer lab was similar to previous sessions, except most of the instructors and staff wore masks.

While the course has the same rigor as the sessions offered on the Madison campus, Chavez says doing the program abroad has some benefits. “Everything in Oviedo is well organized and well run. It’s good for our students to explore other cultures and it’s valuable to see how things are done in other places,” he says.

The other advantage, he says, is that it offers students a break between graduation and employment. Many students will take a few extra weeks after summer lab to travel Spain or other parts of Europe. Chavez, for one, took the opportunity to visit some islands in Greece. “It’s always a good experience. I would absolutely encourage all students to consider attending this or other available overseas session,” he says.

Summer lab students returned to Oviedo, Spain, after a two-year hiatus, getting a new perspective on chemical engineering.