College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

SPRING 2024 NEWSLETTER

DEPARTMENT OF

CHEMICAL AND BIOLOGICAL ENGINEERING

Greetings from Madison!

In April, we celebrated the grand opening of the John C. Kuetemeyer Instructional Laboratories. After years of watching (and hearing!) our basement construction progress, we are excited to mark the full use of our state-of-the-art laboratories. The space encompasses a two-story pilot plant, fermentation suite, chemistry-compatible experimental stations, flexible experimental rigs, classrooms and faculty offices. Students at our upcoming Summer Lab session (starting this month!) will have full, functional use of the laboratories. Next on the project list is the completion of our department's history wall which will showcase departmental highlights that have led to its educational leadership.

For those who were unable to make the laboratory grand opening ceremony, a video of the event will be posted on our YouTube channel. Details on this to follow.

Our cover features the CBE 324: *Transport Phenomena Laboratory*, now in session in the Beth and Matt Koenings Chemical Engineering Sciences Laboratories located within the John C. Kuetemeyer Laboratories. The new modular equipment and lab space design allows students to conduct their collaborative experiments in a well-lit, spacious area.

This newsletter also features one of our newest labs: the Bluemke Family Bioengineering Research Laboratory. In October 2023, we welcomed Duane and Dorothy Bluemke and their family—David and Bonnie, Sue, Chris and Scott—who joined us for the historic ribbon-cutting ceremony and formal opening of this laboratory. The research groups of professors Dudley, Ngo, Palecek and Pfleger, plus my own group, share this lab space. It is a community of faculty researchers and students working together seeking solutions to major societal challenges in human health and sustainability.

The research lab focuses on the following broad-based endeavors: protein engineering, blood-brain barrier modeling, and brain drug delivery; human pluripotent stem cell engineering and anti-fungal drug design; metabolic engineering for value-added fuels and chemicals, and engineering plants to produce medicine and fuels. Our students and faculty are eager to continue, and in some cases start, new research in this state-of-the-art lab space.

If you missed our town hall meeting, please tune in to "2023 Winter CBE Town Hall Meeting" on our YouTube channel @uwmadison-cbe. Learn more about Conway Assistant Professor Rose Cersonsky's research, and the latest news in the department.

Thank you for your support! The evidence of our CBE family's connection to our department is in your dedication to our initiatives. We were able to build our new laboratories, instruct the next world-altering generation of undergraduate and graduate students, and conduct critical research thanks to you.

We'd like to hear from you! If there's news you'd like to share, please e-mail your news to che@che.wisc.edu.

On, Wisconsin!

Eric Shusta
Howard Curler Distinguished Professor
and R. Byron Bird Department Chair
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On the cover: Undergraduate students in CBE 324: Transport Phenomena Lab work in the newly refurbished B103 lab. From left to right: Madison Herman, Emily Nelson, Wojciech (Voytek) Klos, and Nathan Zawicki. Photo: Joel Hallberg.

Excitement is building

Our engineering campus is getting a facelift. With formal approval of state funding for a new 395,000-square-foot building, we're continuing our growth initiative.

The seven-story building will span parts of the existing Engineering Mall and the space currently occupied by 1410 Engineering Drive (which will be demolished), and feature refreshed green space and indoor and outdoor gathering spaces.

The $347 million facility, funded through $150 million in private giving and $197 million from the state of Wisconsin, will be a catalyst for research while allowing the college to educate many more exceptional students.

Explore more, follow along with the building's progress, and support the project at engineering.wisc.edu/new-building.

The grand opening of the new B103 Summer Lab Space took place in April, but we still need support to finish the job. To learn more about the history of the project follow the QR code below.

To donate to the project, contact:
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The biolab has provided new CBE Assistant Professor Quentin Dudley and graduate student Sarah Noga the equipment and resources to quickly launch their research efforts. Photo: Joel Hallberg.

The new Bluemke Family Biolab brings biological engineers closer together

UW-Madison is known for its collaborative spirit, and few researchers on campus demonstrate that ethos more than the biological engineers in CBE. The group constantly shares insights, ideas and equipment. Now, that collaborative spirit is getting a big boost through the Bluemke Family Bioengineering Laboratory, a 6,000-square-foot open-plan laboratory on the third floor of Engineering Hall that brings together five research groups into one space.

About a decade ago, as the biological engineering program at UW-Madison continued to grow, researchers realized their spaces in Engineering Hall were no longer ideal. Many of their labs were small and isolated from their colleagues. Sometimes students would have to carry sensitive experiments from one lab to another through public hallways. But the most frustrating part was that these segmented, closed-off spaces meant that the type of free-flowing conversations, collaborations and idea-sharing that can be so valuable in research were not taking place among labs, or even within research groups.

"That really motivated us to think about what kind of space would address those issues and really be inviting to new faculty, graduate students and undergraduate researchers," says Howard Curler Distinguished Professor and R. Byron Bird Department Chair Eric Shusta.

The new open-concept lab, which took almost two years to construct, currently houses four research groups, including Shusta's, as well as those led by Milton J. and A. Maude Shoemaker Professor Sean Palecek, Karen and William Monfre Professor and Vilas Distinguished Achievement Professor Brian Pfleger and Assistant Professor Quentin Dudley. New Assistant Professor Mai Ngo will also use the space when she joins the department in summer 2024.

The lab is designed to adapt as the department grows and needs evolve. There is enough space to house 45 researchers. All of the bench placements are movable and flexible, allowing for reconfiguration when necessary. The open concept encourages and facilitates shared equipment and resources across multiple research groups.

"When the concept was explained to me it was apparent there would be many advantages to a shared lab space," says Duane Bluemke (BSChE '55), a longtime supporter of the department along with his wife Dorothy and their children. "Accordingly, we decided it would be a very desirable project to support. Ultimately we expect there will be great benefits between different research groups working together to achieve maximum results."

Dudley, who joined the faculty in January 2024, says the upgraded lab space made an impression when he was recruited by CBE. "The new Bluemke Family Bioengineering Lab was one of the most compelling factors in my decision to locate to Madison," he says. "The collaborative environment has helped my group get started more quickly and has enabled me to redirect my startup funds toward specialty equipment, since many of the basic molecular biology devices are already available within the shared lab space."

Shusta says the last couple of months have served as a settling-in period for the researchers as they configure and adjust to the space. "Then, I think in the next phase we're really going to see the impact of the open concept, where they can spend less time organizing and more time exploring what other groups are working on and helping out on experiments," he says.

Submitted photo.

FOCUS ON NEW FACULTY

Mai Ngo wants to eavesdrop on how cell types talk with one another

Modern medical technology is pretty good at making damaged organs and tissues last longer or function better. However, with the exception of organ transplants, it's not possible to replace damaged tissue—like cardiac muscle lost during a heart attack or lung tissue damaged by an infection.

Assistant Professor Mai Ngo hopes to change that. Ngo is developing techniques that will advance regenerative medicine, a multidisciplinary field in which researchers aim to replace damaged or diseased tissues and organs through tissue engineering, cellular therapies, artificial organs and other strategies.

"We're going to be building human tissue models in order to study how different cell types within a tissue talk to each other," says Ngo. "And in studying the cell-cell communication within these engineered tissues, we're hoping to elucidate the control knobs by which these cell-cell interactions contribute to processes within tissue development, tissue repair and regeneration, or disease progression."

During graduate school at the University of Illinois Urbana-Champaign, Ngo worked on tissue engineering and biomaterials; in particular, she developed three-dimensional tissue models to study how tumor cells interact with blood vessels in the brain. From there, she moved to Boston University as a postdoctoral researcher to learn new skills in molecular biology, cell engineering, and microfabrication.

"My lab at Wisconsin is going to combine elements of all of the skills that I've gained in my training," she says.

In particular, she plans to build tissue models to study how different cell types in tissues communicate. "It can be combinations of many things, like cancer cells and blood vessels or immune cells and fat cells. Using this knowledge, I then hope to be able to repurpose these tissue models into therapies that we can implant inside the body, such that we can control regenerative events or improve disease outcomes by controlling cell-cell signaling."

Ngo says UW-Madison is an ideal place for her lab. "Overall, I think Wisconsin just has this amazing strength in stem cells and regenerative medicine across CBE, biomedical engineering and all of these other institutes on campus," she says. "I'm really excited to work with everyone and collaborate on those types of projects."

With CAREER Award, Schreier is using electricity to make chemistry smarter

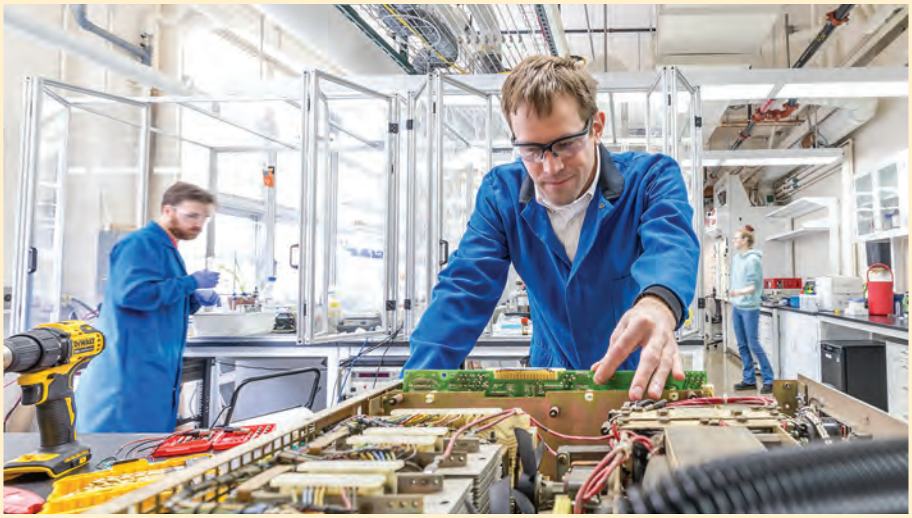


Photo: Joel Hallberg

Oxidation reactions are incredibly important to society. For instance, full oxidation, or combustion, powers our cars and planes. Partial oxidation transforms natural gas and other petroleum products into chemical precursors for thousands of products, including paint and plastic. But these processes aren't very well-controlled, leading to wasted energy, pollution and waste products.

That's why Richard H. Soit Assistant Professor Marcel Schreier will use a National Science Foundation CAREER award to develop methods to finely control the various phases of full and partial oxidation reactions using methods from electrocatalysis, which provide precise control of chemical reaction steps with renewable electricity.

"The dream is to build an 'assembly line' that allows us to position atoms in molecules step by step," says Schreier. "In doing so, we want to open a new kind of manufacturing technology and develop smart chemistry."

Oxidation is actually a multistep process involving adsorption, oxidation and desorption at the surface of a catalyst. Each of these steps performs best under mutually exclusive conditions, like different temperatures. However, in conventional combustion and chemical production, those differences aren't often taken into account.

In this project, Schreier and his research group will use methods developed over the last several years to use electricity to optimize the reaction conditions for each step. Then the team will be able to move the hydrocarbons though an electrochemical "conveyer belt," completing each step separately.

If successful, the project could help unlock several new technologies. For instance, it could be used for long-term energy storage if sustainable fuels derived from electricity and captured carbon dioxide could be efficiently transformed back into electricity, creating a closed loop system. The process could also lead to methods for recycling plastics back into partially oxidized plastic precursors, one of the puzzle pieces of a circular, sustainable economy.

A catalytic success for undergrad Kyuhyeok Choi

CBE junior Kyuhyeok (Brian) Choi is passionate about using catalysis to make cleaner, more sustainable chemical reactions. That passion earned him a top-3 finish out of 400 student poster presentations at the 2023 AIChE Annual Meeting and Student Conference.

How did you discover catalysis?

I began to be interested in catalysis when I was taking organic chemistry and joined the Huber Research Group four semesters ago. Learning about the critical role of catalysts in chemical reactions during class and witnessing its potential in the research lab was what intrigued me and allowed me to think about the prospect of designing catalysts for cleaner and more efficient reactions.

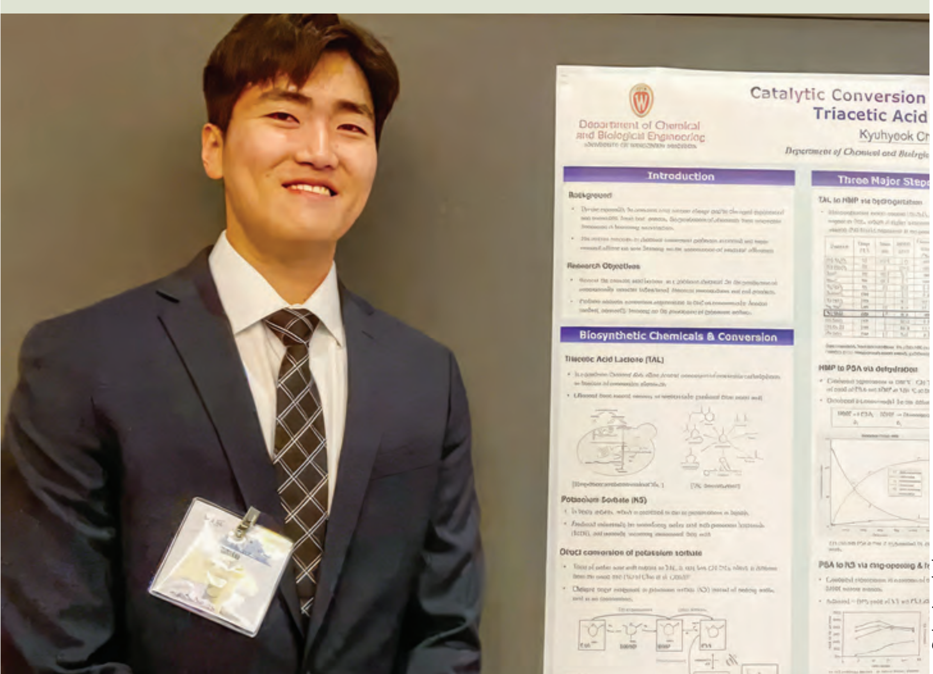
The Huber group's commitment to addressing real-world challenges in sustainable energy and chemical production resonated with my academic interests as well as my aspiration of making a positive impact on society.

Can you describe your poster research?

The poster I worked on focuses on the catalytic conversion of triacetic acid lactone (TAL) to potassium sorbate, which is a commonly used food preservative. TAL is a platform chemical that can be derived from biomass, like agricultural waste, and has great potential to produce a variety of chemicals that are currently derived from petrochemicals. I hope that this research can contribute to the transition toward more sustainable feedstocks and inspire further exploration in this field.

What are the other applications of the results of this research?

This could have far-reaching applications beyond potassium sorbate. I believe our findings may contribute to discovering sustainable pathways for new potential target molecules. Additionally, the insights gained can ultimately inform the development of more efficient industrial processes, reduced environmental impact and enhanced resource use.



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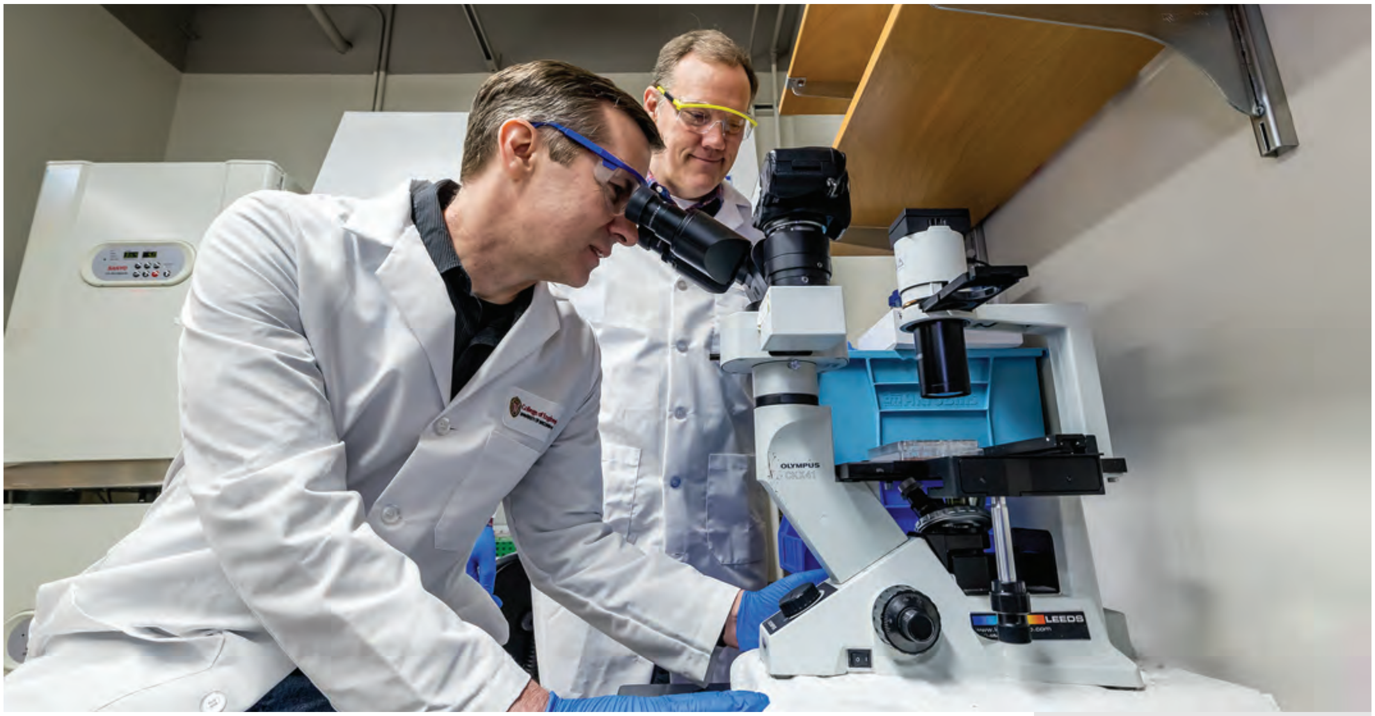
D.C. internship illuminates career pathways in public policy for CBE undergrad

Since his freshman year, CBE senior Evan Erickson has worked as a researcher in the lab of Baldovin DaPra Professor Victor Zavala, learning in detail about how to optimize energy, waste and recycling systems. The experience has taught the chemical engineering senior the ins and outs of academic research and has been a boot camp on the future of sustainability. It also led him to think deeply about the wider impact of that work and how decision-makers hear about, understand and put impactful research—like his—into action.

That's why, in summer 2023, Erickson traveled to Washington, D.C., for an eye-opening internship with Washington Internships for Students of Engineering (WISE), a multidisciplinary program sponsored by several scientific societies that shows engineers of all stripes how science and scientists can work in and with government. "Through undergraduate research, I started thinking about larger policy questions relevant to developing a national infrastructure for plastics recycling," he says. "It seemed like policy questions could be informed by my current research. I wanted an opportunity where I could combine the two."

Erickson, who plans on attending graduate school, says the nine-week-long WISE program brought together his interests. The program focuses on the process government officials use to make decisions on complex technological issues, and how engineers can contribute to the legislative process and regulatory public policy decision-making.

Erickson says the program introduced him to new mentors and even led to a presentation at the AIChE annual meeting. But the most impactful aspect was simply meeting a wide variety of people in Washington, D.C., who influence science policy. "There are so many different opportunities for people with technical backgrounds to get into policy spaces across all branches of government, which was really exciting for me to realize," he says.



Researchers Sean Palecek (seated), Eric Shusta (standing) and their students have developed a method for producing a line of neural pericyte-like cells that could aid research into neurological diseases like Alzheimer's disease. Photo: Jason Daley.

For researchers, new serum-free cell line could advance understanding of brain disorders

Milton J. and A. Maude Shoemaker Professor Sean Palecek and Howard Curler Distinguished Professor Eric Shusta have developed a process to generate a new cell type that may aid researchers in understanding the progression and treatment of Alzheimer's disease and other neurological disorders.

For the last two decades, the pair have worked with human pluripotent stem cells. They've developed methods that use chemical signals and other environmental cues to coax these cells, which have the potential to develop into many different types of cells in the body, into cell types found in the blood vessels of the brain.

Blood vessels in the brain exhibit a tight barrier between the blood and the brain, known as blood-brain barrier (BBB). The BBB protects the brain but also blocks delivery of drugs that could treat neurological disease. Researchers can use BBB cell types derived from human pluripotent stem cells to test how drugs and other therapies cross the BBB to treat brain disease.

In previous work, the researchers developed methods to generate the endothelial cells that line blood vessels in the brain. In the latest study, they sought to produce a different cell type called pericytes, which wrap around capillaries, or the tiny blood vessels that deliver oxygen and other nutrients to cells throughout the body. In the brain, a special type of pericyte derived from a precursor cell type known as the neural crest helps in developing and maintaining the blood-brain barrier by directly interacting with the endothelial cells to reduce molecular transport between and through them.

"These neural pericytes are recognized as a very important cell type because they are thought to be very involved in the process of Alzheimer's disease," says Shusta. "Because of that, and their impact on BBB development and function, we're very interested in trying to derive these cells from human pluripotent stem cells."

To create cells similar to the pericytes found in the brain, they first needed to coax the stem cells to form neural crest cells, following a technique developed by other researchers. They discovered that turning on a gene in the neural crest called *NOTCH3* causes the neural crest to develop into cells that resemble brain pericytes.

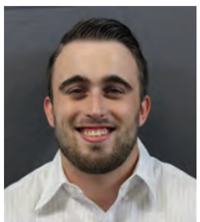
The team used a genetic tool called a lentivirus to add genetic code to the neural crest cells, which causes an active form of the *NOTCH3* gene to be expressed. Once this gene is delivered to neural crest cells, it induces them to develop into pericyte-like cells.

Another advantage of the technique is that it's serum-free. Serum is a growth medium supplement used in cell and tissue culturing that can vary widely in its exact chemical makeup. By avoiding the use of serum, the researchers believe their end product will be more consistent and reproducible.

"I think there's a lot of interest out there from drug developers and people who research Alzheimer's disease," says Shusta, pointing out that the loss of pericytes in Alzheimer's disease may cause BBB deficits that contribute to disease progression. "You could imagine using these cells as screening tools for drugs that could prevent pericyte loss in Alzheimer's disease. This could play an important role in researching stroke and other neurological diseases as well."

Undergraduate researcher predicts the path, impact of viral mutations

When Brad Schwab was a sophomore, he decided to try his hand at research, joining the lab of Vilas Distinguished Achievement Professor John Yin. “I just wanted to give it a shot. I had some friends who came into school already on a PhD track,” he says. “It’s not something growing up I had ever really thought about. So I decided I should give this research stuff a try.”


Brad Schwab

Now, Schwab is the author of a paper in the journal *Virus Evolution*. Eventually, the research could play a part in predicting the severity of viral infections.

In his research project, Schwab took a computational model of the vesicular stomatitis virus (a “model” virus used in medical research) and used it to simulate how various mutations affect the “fitness” of the virus, or how well virus particles can be made inside a cell.

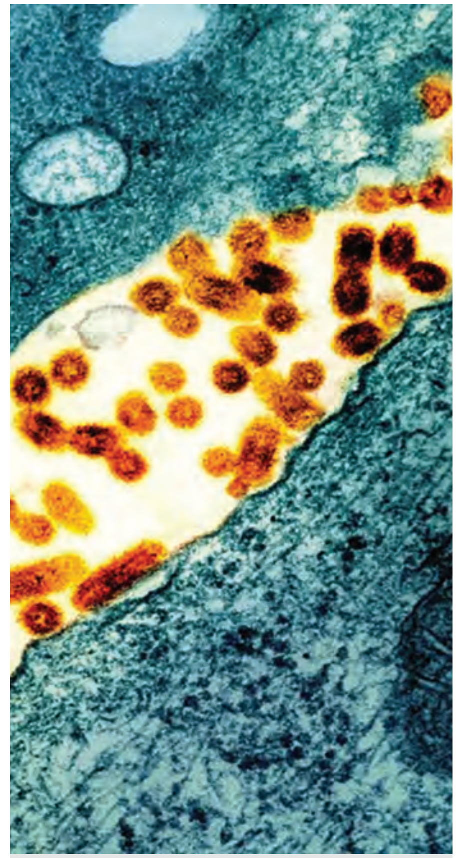
By using the computer model, Schwab was able to run hundreds of thousands of iterations, creating various scenarios to better understand how mutations and combinations of mutations affect how quickly a virus spreads and how many virus particles it makes.

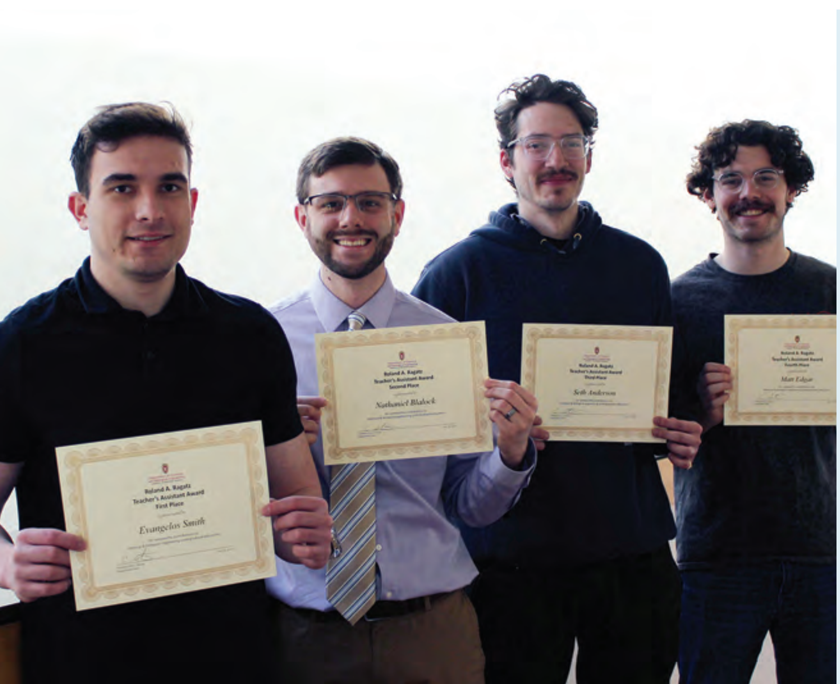
“Because the models that we build are really based on the many decades of advances in molecular biology, biochemistry and our understanding of how viruses grow, we essentially translate biologists’ descriptions of the molecular processes into equations. And the equations are ones we can put on the computer, and we can begin to simulate,” says Yin.

Being able to simulate the spread of viruses can help medical and public health researchers better understand virus progression and predict the potential impact of mutations on disease. Yin says it will be helpful in the emerging era of predictive health as well, enabling physicians to create “digital twins” of patients—in other words, mathematical and computational representations of individuals based on their genetics, health history and other personal data. This will allow doctors to predict health outcomes and decide what interventions are most helpful.

Schwab graduated with bachelor’s degrees in chemical and biological engineering and applied mathematics. Ultimately, he did not decide to continue on in academic research, instead taking a position with AGC Biologics, a pharmaceutical company in Washington state where he currently manages a team of manufacturing science and technology (MSAT) engineers. But he says he’s proud of the work he did in Yin’s lab, which taught him many important lessons.

Schwab says that he recommends all engineering students at UW-Madison, whether they aspire to go to graduate school or industry, should spend at least a semester in the lab. “Trying to tackle some of the complex problems that are being studied at UW-Madison can have a really beneficial impact on your ability to think abstractly and approach new problems,” he says.


A transmission electron micrograph of the vesicular stomatitis virus, the model virus a UW-Madison team used to computationally simulate viral fitness. Credit: National Institute of Allergy and Infectious Disease.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Congratulations to our 2023 fall Teaching Assistant Ragatz awardees, recognized at our graduate student seminar. Awardees were selected by undergraduate students who received mentorship and teaching from these graduate students.

Evangelos Smith (who also won in the spring of 2023), who works in the lab of Ernest Micek Distinguished Chair, James A. Dumesic Professor, and Vilas Distinguished Achievement Professor Manos Mavrikakis.

Nathaniel Blalock, who is part of Biochemistry Assistant Professor Phil Romero’s lab.

Seth Anderson, a member of Assistant Professor Matt Gebbie’s lab.

Matt Edgar, a member of Assistant Professor Siddarth Krishna’s research group.

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Regina Murphy retires from CBE

After 34 years, Professor Regina M. Murphy has retired from the department. Her career started as CBE's first female faculty hire; she also was first female chair of the department and, in 2019, the first R. Byron Bird Chair recipient.

Murphy was and continues to be a leader within CBE, the College of Engineering and the UW-Madison campus. She redesigned the department's introductory course, Process Synthesis, and developed a textbook to accompany it. She served on various campus committees and organizations, including the Physical Sciences Divisional Committee, the Athletic Board and a chancellor search and screen committee.

As department chair, she enjoyed meeting alumni and hearing their stories about their student experiences and what paths their lives took after graduation. During this tenure, she was thrilled to see how department faculty and staff worked hard to establish common goals and then achieve them, and how individual people really stepped up to contribute their time and skills. "Regina was a tireless departmental leader who greatly moved our department forward with impressive faculty hires, world-class infrastructure upgrades and a focus on departmental climate," says Professor Eric Shusta, her successor as department chair.

Even in retirement, Murphy is still very much involved in the department, serving among leaders in planning our new instructional lab. She is currently working on the history wall portion of the project.

We will remember her leadership and dedication to students. When asked what she enjoyed most in the department, her response focused on the student experience. "I really enjoyed the time in the classroom—especially when students were engaged with each other and with problem-solving. It was great when there was energy in the classroom. Working with graduate students on a tough research problem, and then seeing experimental data that was both unexpected and exciting was a thrill," she says.