UNIVERSITY OF WISCONSIN–MADISON
COLLEGE OF ENGINEERING

FALL 2021 NEWSLETTER

# CHEMICAL & BIOLOGICAL ENGINEERING


## FRESH INSIGHTS

New faculty and diverse graduate students are leading CBE in exciting directions

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In July 2021, Professor Eric Shusta took over from Regina Murphy as the Robert Byron Bird Department Chair of CBE. Shusta spent his early academic career at UW-Madison, where he received his bachelor's degree in chemical engineering in 1994. He then returned to UW-Madison as an assistant professor in 2001. Over time, he's watched the department continuously evolve and adapt to a changing and expanding field of study. As chair, he plans to help the department maintain its world-class standards and continue to push into new territory.

*What are your priorities for the department?*

The driving vision is to keep the CBE department among the top in the country. Some of the ways we do that is by building on our momentum, continuing to hire and train a diverse and talented faculty, and continuing to put top graduate and undergraduate students into the workforce. Our students go on to be leaders of Fortune 500 companies, innovators, entrepreneurs and policy drivers.

The other thing that's really interesting and exciting as we move forward is that we're undergoing a continued effort to renew our world-class infrastructure. For instance, at the instructional level, we're raising money for a new summer lab space. Those are areas we need to continue to progress in.

*What changes would you like to see in the department?*

We're working really hard to bring the faculty demographics more in line with our student population, which is quite good in terms of gender diversity. I think 40 percent of our undergraduates and a third of our graduate students identify as female. Having role models and mentors for our students who are diverse is something we're looking forward to as we expand our faculty.

*What is the current role of chemical and biological engineering in the world?*

What has become clear in recent years is that chemical and biological engineers can apply their fundamental principles to a variety of problems. That includes problems in materials science, biology, medicine, systems and high-level organization. The field and department have evolved to adapt these fundamental principles that chemical engineers live by to a whole host of different problems, many of them with substantial societal impact.

**Be part of the historic lab remodeling project that will create state-of-the-art student research spaces.**

**Lab construction will provide distinct opportunities for donors to contribute to the project and be recognized in the space for their support. If joining the team of investors is something that you would like to discuss, please contact the department's philanthropic advisors: Kyle.buchmann@supportuw.org or Mike.holland@supportuw.org.**

**Learn more about this project on page 4.**

# Focus on new faculty

## Styliani Avraamidou wants to close the loop on sustainable supply chains

The refineries and reactors that produce chemicals and petroleum products are massive, elaborate facilities. They take in crude oil, natural gas and other feedstocks and turn them into hundreds of types of chemicals, plastics and fuels. Over the years, chemical engineers specializing in process systems have developed sophisticated methods for managing and optimizing the inputs, energy use and outputs of these facilities.

Styliani Avraamidou, who joined CBE as an assistant professor in September 2021, plans to take the lessons learned by these process systems engineers and use them to transition chemical, plastic and food supply chains into more sustainable circular economy systems. The goal, she says, is to design restorative and regenerative systems as a means of achieving environmental, social and economic sustainability.

Avraamidou earned her PhD at Imperial College London, studying process systems engineering and developing algorithms to solve nested optimization problems, focusing most of her work on issues involving chemical supply chains. Prior to joining UW-Madison, she worked as an assistant research scientist at the Texas A&M Energy Institute.

A major element of Avraamidou's research at UW-Madison will be defining just what sustainability and circularity really mean when it comes to supply chain optimization. Traditionally, engineers optimize systems to minimize costs, waste or other well-defined metrics. "We don't know how to quantify circularity in its totality and we don't know how to optimize sustainability as a metric," she says. "So finding metrics for these things is something we'll be looking into."

Most of Avraamidou's work is computational, meaning she won't need a large physical lab, but she won't be lonely either: At UW-Madison, she feels like she'll be part of bigger team, since her work will be highly collaborative. "I'm working on the higher level, taking input from emerging technologies and using optimization and mathematical models to quantify how those technologies will be shaping the future," she says.

## Van Lehn receives NSF CAREER Award to study nanoparticle properties for efficient cell entry

Many of the most promising new treatments in medicine involve nanoparticles, or microscopic shells that can deliver finely targeted doses of drugs or other therapeutic molecules to various parts of the body.

One of the big hurdles with these applications, however, is getting therapeutic molecules into the interior of a cell. Doing so requires nanomaterials to cross the cell membrane, which is a thin barrier separating the cell interior from the external environment. Most nanomaterials that attempt the crossing get trapped in compartments called "endosomes," where they are digested or damage the cell. A few sub-10-nanometer particles made of certain materials are able to successfully cross the barrier and deliver the nucleic acids. However, it's not clear why these nanoparticles are able to cross the cell membrane while others cannot.

That's what Conway Assistant Professor Reid Van Lehn plans to study using funding from his recent National Science Foundation CAREER Award.

"In this project, we want to use computational modeling and machine learning techniques to identify what the mechanisms are that permit nanoparticles to enter the cell interior without being trapped in endosomes," he says. "The other part of the project is taking that understanding and using it to guide the development of machine learning workflows that can then discover chemically accessible, available nanoparticles that can enter cells by crossing the cell membrane."

Currently, the hunt for usable nanoparticles is relatively slow. Researchers must synthesize a new nanoparticle, test to see if it enters cells and eventually test it on mouse models. "Not only is the synthesis of the nanoparticles time-consuming, but you have to do these experiments with mice. This is a very laborious task," says Van Lehn.

Instead, Van Lehn and his group plan to model parts of biological systems to understand how nanomaterials interact with them. "This computational approach will permit the creation of new types of nanoparticles much more quickly than would be possible through experiments alone, enabling the rational design of next-generation nanomaterials for diverse biomedical applications," he says.

# CBE donors line up to support renovation of Summer Lab space

In the fall semester of 1979, Matt and Beth Koenings were assigned as partners during undergraduate transport lab, a core CBE class held in B103 Engineering Hall.

More than four decades later, the two are still partners: They got married a couple of years later and used their chemical engineering Summer Lab session in London as their honeymoon.

Room B103 is a storied space, where UW-Madison chemical engineering faculty have taught generations of students. For decades, it has been the home of the department's capstone Summer Lab experience. But even the Koenings, who have a special connection with the lab, admit that B103 is ready for a serious makeover.

"It's dark and enclosed and not very inviting. It's like going into somebody's basement," says Matt, who spent a 37-year career at DuPont, including a position as vice president of operations in North America. That's why the Koenings have generously invested in the remodeling effort, which would make the space larger and brighter and better meet the needs for chemical engineering instruction in the 21st century.

"We want to give back to the department that provided an extremely valuable degree that enabled the careers of so many alumni," say Matt and Beth. "We want CBE to be flexible and competitive in meeting the needs of future generations of UW chemical and biological engineers to enable them to apply their degrees to solving some of the world's toughest challenges."

The vision for the renovation is laid out in an advance planning study commissioned by the department. The plan calls for modernizing B103, creating a large open space around a clerestory that floods the basement lab with natural light. The update includes new lighting, windows, floors and storage space as well as flexible utility dropdowns and moveable benches. Rooms radiating from the central lab space will provide access to specialized analytical instruments, chemical fume hoods, computers and meeting areas.

The project will also incorporate the underused adjacent room B209, adding roughly 4,500 square feet of new lab space. That will allow the department to install large laboratory equipment such as distillation and humidification towers, solvent extraction units, packed-bed reactors, heat exchangers and membrane filtration units.

The plan also redevelops the dark and cluttered hallway leading to the lab with updated restrooms, brighter lighting, collaboration areas for students and dedicated wall space to display the department's history.

The remodeling effort is exciting for many alumni who fondly remember spending

time in B103. John Kuetemeyer (BSChE '61), left, founder of Spartan Adhesives & Coatings, has committed to a major gift and the updated lab space will bear his name. "I consider it a privilege and an honor to endow and to have the new, state-of-the-art, CBE instructional laboratory entitled in my name," he says. "Summer Lab was a very significant segment in my earning of a chemical engineering degree at the UW. Knowledge gained in the summer lab provides a 'working path' to the actual realities of the chemical industry for CBE graduates."

Don Baldovin (BSChE '57), who spent his career with Amoco as a leader in operations and purchasing, thinks the laboratory project is one of the best ways to position the department for the future, which includes plans to expand the College of Engineering significantly in the coming decade. "Improving instructional lab space is fundamental to the college's plans to expand enrollment," he says. "The only way that's going to come about is to increase the number of faculty as well as having expanded laboratory facilities. I think having state-of-the-art facilities would be helpful in attracting new faculty members to UW-Madison."

Baldovin, Kuetemeyer and the Koenings all realize that having flexible, up-to-date instructional space is critical to continuing the CBE's legacy and ushering its education into the future.

"We need to keep the department future-focused and have a flexible space that can change when technology changes to keep coursework meaningful," says Matt Koenings. "We had a great education at UW-Madison and want to make sure future generations have the same type of hands-on lab work critical to making that possible."

# Grad student group aims to build a strong community vibe in CBE

When Maya Venkataraman joined CBE as a graduate student in 2019, she got to know many other grad students in the department through game nights, volleyball tournaments, mixers, pizza parties, hikes and an array of other activities. It wasn't until later that she learned those activities were organized by other graduate students.

Now, Venkataraman is co-president of that organization, the Chemical Engineering Graduate Student Association, aka ChEGS, along with Hayley Boigenzahn. ChEGS helps to build a community among students and faculty in CBE, offers peer mentoring for first-year grad students and provides the opportunity to socialize and blow off steam for everyone.

As part of its mission, ChEGS performs some important functions within CBE, like helping to host visiting graduate student candidates and setting up seminars for graduate students to talk about their research.

The group also hosts social events once or twice a month, which have included activities like pumpkin carving, running, stand up paddleboarding, art nights, ultimate frisbee and board game nights, among many other activities.

While the social activities are fun, Boigenzahn says they are more important than they may seem. Life as a graduate student can be difficult to navigate and making friends, even in the same department, can be hard. "Sometimes you're so focused on your own work that you rarely have reason to go somewhere else," she explains. "If you want friends outside of your year or lab, there needs to be an organization for that."

In 2020, during the pandemic when many graduate students were more isolated than usual, ChEGS tried to fill the social gap hosting virtual get-togethers, online video games and even a virtual wine tasting.

In June 2021, ChEGS kicked off in-person events once again with a volleyball tournament, and leaders hope to be able to keep live events going throughout the new school year. The CBE department hopes they can continue as well, and is a fan of the group, providing it funding. "It's nice to see the department being supportive of the students getting to know each other and supporting grad student happiness," says Boigenzahn.

# Energy star

## PhD student Christine Lucky brings an industry perspective to electrochemistry

Mixing teenagers and all-terrain vehicles may lead to no good. But that's not the case for Christine Lucky. As a high schooler in Alexandria, Virginia, she took a course on integrated systems engineering. During the class, she helped convert a loud, smoke-spewing ATV into a quiet, clean electric vehicle. It was an ah-ha moment for Lucky; not only did she find she really enjoyed the engineering aspects of the project, but she found she was deeply interested in energy systems—both the technical challenges and societal impacts.

Those twin interests in energy and improving society led Lucky to UW-Madison, where she's a third-year PhD student in the lab of Richard H. Soit Assistant Professor Marcel Schreier. "I've always wanted to merge the things I find intellectually interesting with giving back to the community," she says.

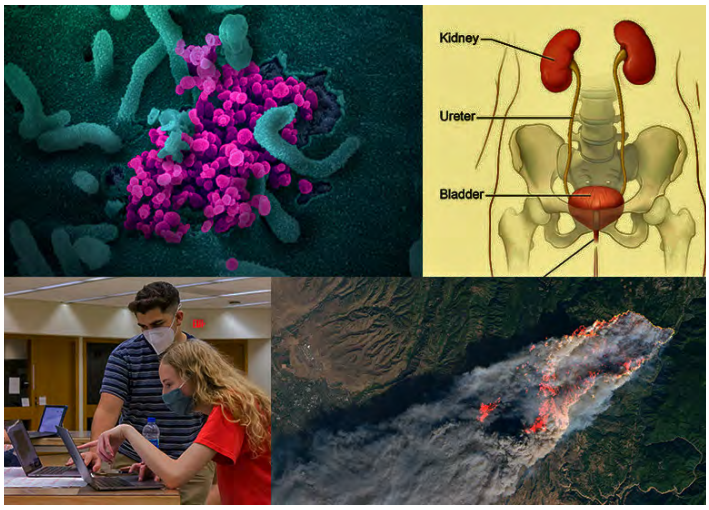
Lucky studied chemical engineering at Washington University in St. Louis as an undergraduate before moving to industry, spending two years as a chemical engineer at Barr Engineering in Minneapolis. Much of that time she worked in a partnership with the University of North Dakota's Institute of Energy Studies. There, she says, she helped take processes from the lab to the bench scale and then to the industrial scale. To lead similar work herself, however, she realized she would need a PhD.

In Schreier's lab, Lucky, who recently received a prestigious NSF Graduate Research Fellowship, is looking at ways to use electricity—preferably produced by renewable energy sources—to transform low-value, readily available chemicals on the molecular level into more valuable substrates that can be converted into chemicals on the industrial scale. It's an important step in making chemical production a more sustainable process.

Lucky's brief time in industry has given her a unique perspective on her research. "It changes how you think about some projects. We work on small reactions that we'd like to see go to the commercial scale someday," she says. "You think about what would make this meaningful to people who might want to license this technology or drive this tech to market one day."

# Class projects bring biological engineering into the real world for graduate students

Chemical and biological engineers spend a lot of time studying small stuff like molecular-level catalytic reactions. But in the fall semester of 2020, graduate students taking CBE 781, *Biological Engineering: Molecules, Cells & Systems*, got a broader perspective, investigating how the principles of biological engineering, data analysis and complex modeling can apply to contemporary societal issues.




The course, taught by Vilas Distinguished Achievement Professor John Yin, is designed as an introduction to biological engineering for chemical engineers since the two disciplines often cross over. It is a detailed primer on biological concepts, but Yin wanted students to take an even broader view and investigate how biological engineering can impact society as a whole.

That's why for one of two team projects, he tasked students with developing computational models to address contemporary societal issues using chemical and biological engineering principles. "I think it adds an extra dimension to the course," says Yin. "Students realize the ways they can work on problems that we read about in the newspapers."

One team looked at the health impacts of recent California wildfires and several teams modelled COVID-19 dynamics. The final project for the class was writing a research proposal for a bioengineering project or aiding Yin in a research project modeling the human urinary tract in the hope of developing new bladder control therapies.

For her final project, graduate student Lisa Je analyzed the Camp Fire in California. She developed a research proposal recommending deployment of specific novel technologies like sensors to obtain quantitative emission rates from wildfires and connect this data to health issues experienced by first responders.

"The class exceeded my expectations," says Je. "I got a lot of real-world experience and the problems I worked on are ones I care about and could see myself working on in my future career."

# The future of recycling involves elephant toothpaste, Skittles and a few smart kids

Skittles and mini-marshmallows are not typical laboratory supplies, but in April 2021, the treats, along with dry yeast, rubbing alcohol, egg cartons and other household items were the primary equipment for a group of would-be young scientists scattered across Kenosha, Milwaukee, Racine and Waukesha counties in Wisconsin.

The kitchen-table labs were set up for the virtual Plastic Fest, a 4-H event co-hosted by the Center for Upcycling of Waste Plastic, a multi-university research center led by Richard L. Antoine Professor George Huber. The program included two hour-long sessions held on two different nights presented by graduate and undergraduate students in the course *Chemical Engineering in the Community*, and was designed to introduce the young chemists to some of the emerging concepts behind chemical recycling of plastics.

One presenter developed a module discussing upcycling, asking the younger students to create new, creative products out of used plastic bottles, CDs, egg cartoons and other items considered trash. Another led students in an exercise to learn about solvents, directing an experiment where the young learners used rubbing alcohol to strip the candy coating off Skittles. The demonstration led to a discussion of STRAP processing, a new solvent-based technique pioneered by CBE faculty that uses solvents to separate multilayer plastics.

Chemical and biological engineering graduate student Edgard Lebrón-Rodríguez taught catalysis by leading students in the classic "elephant toothpaste" science experiment, in which dry yeast (the catalyst) added to hydrogen peroxide accelerates its decomposition and creates a massive flood of foam. "It's a fun and colorful way to show

what a catalyst does and gets the students engaged quickly," he says.

Distinguished Faculty Associate Andrew Greenberg, who led the course, says ideally it will provide a spark of interest to the kids to look more deeply into chemical engineering and recycling and gives the presenters a chance to practice their non-technical communications skills. "That can be especially valuable for undergraduate students moving into professional engineering careers," he says.

# Faculty News


Renewable chemical company Pyran, Inc., founded by Richard L. Antoine Professor George Huber and alumnus Kevin Barnett (PhDChE '18) announced it has received nearly $4 million in its latest round of funding. This will allow the company to take several major steps toward full commercialization of a sustainable version of 1,5-pentanediol.

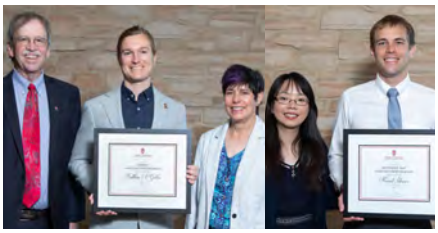
The North American Catalysis Society selected Vilas Distinguished Achievement Professor Manos Mavrikakis as the recipient of the 2021 Robert Burwell Lectureship in Catalysis. The award recognizes substantial contributions to one or more areas in the field of catalysis.

The National Academy of Engineering invited Richard H. Soit Assistant Professor Marcel Schreier to be one of 83 innovative early-career engineers to participate in the 2021 United States Frontiers of Engineering Symposium, held in Irvine, California, in September 2021.

# Student News

The Department of Energy's Office of Science has selected graduate student William Cordell for its Office of Science Graduate Student Research program. Cordell is one of 78 graduate students from 26 states selected for the program, which supports researchers working on projects that address societal challenges at the national and international scale.

Four graduate students, Kyle Chin, Lisa Je, Edgard Lebrón-Rodríguez and Christine Lucky, have received prestigious National Science Foundation Graduate Research Fellowships, awarded to high-potential scientists and engineers training in STEM fields.



In a June recognition ceremony, Matt Gebbie was named Conway Assistant Professor, an honor established in 2019 by alumni Mike (BSChE '78) and Ginny Conway. Marcel Schreier was named Richard H. Soit Assistant Professor, established in the will of Frances M. Soit in honor of her brother Richard Soit (BSChE '44).

# Alumni News

The Mid-Michigan Local Section of the AIChE has selected alumnus Pranav Karanjkar (PhDChE '16) as its Young Chemical Engineer of the Year for 2020-2021. He is currently a senior process engineer at Dow Corning Corporation.

Samira Azarin (PhDChE '11) was recently promoted to associate professor at the University of Minnesota where she researches the role of cell microenvironments in the development of healthy and diseased tissue.

Over the past year, 2021 PhD graduate and Argonne National Lab postdoc Sungho Shin has received three major awards, including the Computing and Systems Technology Director's Student Presentation Award at the AIChE annual meeting, and young author awards from the ADCHEM and IFAC-NMPC Conferences.

The career and achievements of Arturo Jiménez-Gutiérrez (PhDChE '82), a professor at the Instituto Tecnológico de Celaya in Mexico, was recently celebrated with an online symposium. He has been a visiting professor at UW-Madison teaching summer lab for the last 42 years.

## Remembering Charlie Hill

Professor Emeritus Charles G. Hill Jr. passed away March 26, 2021.

The Elmira, New York, native earned his PhD from MIT in 1964 and joined UW-Madison in 1967. Hill was internationally recognized for his research on enzyme technology, kinetics and catalysis, and membrane separations. Throughout his career, he mentored 38 PhD students and was author of more than 325 refereed publications.

Hill served as associate department chair on three occasions and was department chair from 1989 to 1992. He officially retired in 2006—after nearly four decades on the faculty—though he remained active long after that.

An enthusiastic instructor, his proudest achievement was his dozens of teaching awards. In 1977, he authored the widely used undergraduate text, *An Introduction to Chemical Engineering Kinetics and Reactor Design*, which he updated in 2014 with colleague Thatcher Root.

Some of Hill's fondest professional memories were of his time spent teaching the CBE's capstone Summer Lab course. He was also a great advocate of the broadening experiences gained in the overseas lab sessions in London, Vienna and Oviedo, Spain.

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# Pfleger leads $3.5 million Department of Energy project to produce carbon-negative chemicals

The Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) has awarded almost $3.5 million in funding to the University of Wisconsin-Madison for a project investigating methods for producing carbon-negative chemicals led by Jay and Cynthia Ihlenfeld Professor Brian Pfleger.

The award is part of ARPA-E's ECOSynBio program, which promotes technologies focused on innovative synthetic fermentation and biorefining processes that make the production of biofuels and chemicals more efficient and lower carbon emissions.

The UW-Madison project is titled "Acetate as a platform for carbon-negative production of renewable fuels and chemicals." The goal of the project is to eliminate the release of carbon dioxide in the production of chemicals by integrating unique microorganisms into the process. One organism produces acetate, an important chemical precursor, from carbon dioxide and hydrogen. The second organism then upgrades the acetate into higher-value chemicals. The carbon dioxide released during the process is recycled internally to produce more acetate, creating a system with zero carbon dioxide release. The platform can be located and scaled to match existing sources of carbon dioxide emissions, as long as a source of hydrogen is available.

The project is one of 15 selected by ECOSynBio, which awarded a total of $35 million in funding in May 2021. The program is part of an effort create new pathways for biofuel conversion that reduce carbon waste and maximize the amount of renewable fuel produced in the conversion process. These advancements in clean energy technology are critical in helping the United States reach its goal of a 100% clean energy economy and net-zero emissions by 2050.