UNIVERSITY OF WISCONSIN–MADISON
COLLEGE OF ENGINEERING

SPRING 2021 NEWSLETTER

CHEMICAL AND BIOLOGICAL ENGINEERING

LEARNING BY DOING

CBE undergraduates get a hands-on education

Hello from Madison!

In this spring issue, we highlight some of the achievements of our undergraduate students. We showcase students who are leading the way in STRAP processing recycling research and we introduce you to our inaugural Jennifer Reed Award recipient. We also have some faculty research news and awards that we're excited to share with you.

But first, we have sad news. A pillar of CBE—Professor Emeritus R. Byron Bird—passed away on Nov. 13, 2020, at the age of 96. The chemical engineering field has lost a scientific pioneer, an exceptional teacher and prolific writer—in English, Japanese and Dutch, to name a few. For us, we have lost a mentor and friend. Bob created word puzzles, composed music and continued his scholarly writing well into his ninth decade. He led us on hikes and canoe trips and entertained us with his stories and limericks. Bob was with the department for over 60 years!

Another friend of the department, Ernest Micek, passed away on Oct. 29, 2020, at the age of 84. A 1959 ChE graduate, Ernie's 42-year career was spent at Minnesota-based Cargill, Inc. He also served on the Wisconsin Alumni Research Foundation board and was the director and chairman of the Morgridge Institute for Research. Ernie was a longtime member of CBE's visiting committee, providing our department with sage advice and support.

More about Bob and Ernie's contributions to the department are in this newsletter.

For the spring semester, we have settled into a new routine as we continue to abide by campus safety regulations. Most lecture-based classes are held remotely and synchronously, while instructional labs and some discussions are held in person. Research labs are open and fully functional, with safety practices in place. The department's office is staffed daily to assist students and faculty. For those who come to study and work on campus, the university has a stringent testing protocol prior to admittance in campus buildings. We have all developed new skills at drooling into a tiny plastic tube! We miss the energy and chatter of students in our hallway and working with them shoulder to shoulder. The plan for the fall semester is to be fully operational on campus, and we are looking forward to that.

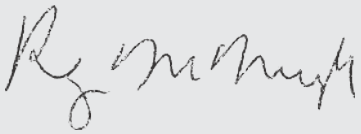
This year's recruitment events for prospective graduate students were all held remotely. We welcomed 70 students from around the country and around the world who connected online to learn about our department, our research and faculty. We created virtual maps of the campus and city, posted short videos highlighting research lab activities, held numerous one-on-one meetings between faculty and students and hosted a Wisconsin trivia contest online! (How many cows are there in Wisconsin? What band recorded the album with the swimming baby on the cover?)

Please join me in congratulating Assistant Professor Reid Van Lehn for winning a prestigious NSF CAREER award! Reid's research accomplishments were also recognized with a Vilas Associate Award. Accolades also go to Prof. Manos Mavrikakis, who was awarded the 2021 Robert Burwell Lectureship in recognition of his substantial contributions in the area of catalysis.

Undergraduate alumni fondly remember spending many hours in the basement room B103 taking Transport Lab and Summer Lab. We are starting a major project to completely renovate and expand our instructional lab spaces, which will transform our basement into a bright, flexible and modern facility. When completed, the project will provide our students with world-class facilities where they will gain experience operating chemical engineering equipment and will develop skills in teamwork, experimental design strategies, data analysis, and resourcefulness, skills that will serve our students well as they progress through their academic and professional careers. We are excited about the impact of this project on future generations of students. Details on this project are in this newsletter.

Thank you for staying connected with us. Our hope is that you and your loved ones stay safe during these times.

On, Wisconsin!



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FAMILY INSPIRES TAYLOR ADKINS' SUCCESS

When she was very young, Juda, Wisconsin, native Taylor Adkins remembers being impressed when her aunt told her she had earned a PhD in engineering, even though she didn't really know what it meant till later (trains popped into her mind). "That let me know the opportunity in engineering existed, and it was something I could possibly do," she says.

Throughout high school, that inspiration never wore off, and Adkins' deep love for math and science as well as the experience of her older sister, also a UW-Madison engineer, convinced the class valedictorian that engineering was indeed the right path for her.

It wasn't until participating in the six-week residential Engineering Summer Program hosted by the UW-Madison College of Engineering Diversity Affairs Office that she decided Madison was the right place for her. An inspiring counselor at that program introduced her to chemical engineering, which she now studies.

Academically, the sophomore is flourishing and particularly relishes difficult classes like calculus II and the chemistry 115/116 honors sequence.

While she is more than capable of handling her heavy academic load on her own, Adkins says she's grateful for the support she's received from the College of Engineering and UW-Madison. She is part of the Leaders in Engineering Excellence and Diversity Scholars Program, which supports women and students from groups historically underrepresented in the field of engineering.

The program has not only aided Adkins financially, but it also helped her adjust to campus life. "I have to pay for college all on my own, so having a LEED scholarship lifts a huge part of that burden," she says. "But the really, really important part is getting to know other people in my year and older students from the weekly LEED scholar study tables. I even met one of my roommates there."

While Adkins always thought she would go into academia and spent summer 2020 conducting research in a chemistry lab, she's now considering options in industry as well, in areas like plastics or pharmaceuticals. "I'm waiting to see where my classes take me," she says.

ADVISORY CAPACITY:

Class helps graduate students learn to mentor undergraduate researchers

Graduate students and postdocs in CBE master all sorts of sophisticated tasks, but there is one critical skill that their education often doesn't directly address: managing and mentoring other people.

A good mentor can help guide the course of a career, open doors to new opportunities, and accelerate growth and learning; a bad relationship with a mentor can lead to unneeded stress, or worse, push someone out of research completely. That's why Andrew Greenberg, distinguished faculty associate, runs a one-credit research mentor training practicum for graduate students to help them create a meaningful experience for the undergraduate researchers who often work alongside them in the lab.

The one-semester course, offered three times per year, is aimed at helping CBE graduate students understand how to establish healthy relationships with junior researchers and handle problems that might arise while dealing with undergraduates. "For new researchers, they're entering a whole new culture," Greenberg explains. "It's a new educational paradigm for our undergraduates in particular. They're going from taking in knowledge in their courses to generating knowledge in their research. So, it's completely turning around their academic experience."

Andrew Greenberg

Having a good mentor early on can help smooth that transition. The practicum is limited to 15 participants and takes the form of a group discussion, following a curriculum based on *Entering Mentoring*, a widely used text on mentoring in STEM fields developed at UW-Madison. During the practicum, students work through case studies in the book and discuss real-life scenarios happening in their own labs.

While training graduate students to become better mentors benefits the undergraduates they supervise, Greenberg says the course enables the graduate students to develop more positive relationships with their own advisors and other researchers. "The major outcome of this really is that the graduate students and postdocs learn how to take a role in their own mentoring," he says. "There's been positive outcomes beyond just working with the undergraduates. When mentoring is strong, productivity in the lab is stronger."

Tianyi Jin

John Yin

Undergraduate researcher helps fill in the blanks on virus lifecycle

Viruses are likely the most numerous biological entities on Earth, yet, despite more than a century of studying them, researchers still have a limited understanding of them. Chemical engineering undergraduate student Tianyi "Herry" Jin and his advisor Professor John Yin recently unraveled some lingering questions about viruses.

They investigated one-step growth behavior, or how long it takes from the time a virus enters a host cell to the time it releases copies of itself, to see if there were any correlations with the size or growth rate of the host cells. The researchers wondered if any characteristics of the host cells would impact the replication rate of the viruses infecting them.

"The largest cells are one million times larger than the smallest cells. We thought maybe there would be a pattern," says Yin. "Maybe the largest cells would make a lot more virus."

Collecting data on viruses meant combing through a massive mountain of literature on virus reproduction from the last 70 years, a task that fell to Jin.

"It was my first time doing real research," says Jin, who graduated with a bachelor's degree in chemical engineering and mathematics in August 2020 and is currently a PhD student at MIT. "There's, like, an infinite number of papers online. So, I had to work hard to find the relevant research."

At first, Jin collected data about a dozen types of viruses of various sizes and plotted the data. The information was compelling, and Yin asked Jin to dig even deeper. Eventually, he collected data on more than 100 virus-host pairs, including viruses of bacteria, humans and even obscure marine algae.

What the data shows is that the replication rate of a virus is about the same as the time it takes for a healthy cell to reproduce. That could be useful in calculating how quickly a virus can replicate and spread after infection. "I would love to see this in textbooks in the future," says Yin. "It's a pattern across all biology and it's logical. I'm hoping others will embrace it."

NEW TECHNIQUE PROVIDES EVIDENCE FOR CENTURY-OLD THEORY OF TURBULENCE

Stirring a little cream into a cup of coffee seems like a simple act, but as the two liquids mix together, things get very, very complicated. The resulting turbulence, the chaotic changes in flow velocity and pressure, is one of the most difficult aspects of fluid dynamics to characterize.

About a century ago, researchers hypothesized that turbulence involves self-similar structures—in this case the swirls—repeated at various scales. But finding quantitative evidence of that has been difficult.

Now, a new approach called data-driven wavelet decomposition designed by Daniel Floryan, a postdoctoral research associate in the lab of Professor Michael Graham, is providing direct evidence of that hypothesis.

"In turbulent flows in nature, the size of the biggest scale compared to the smallest scale is an enormous ratio, and the entire range of scales is present at once," says Floryan "That's one of the difficulties of trying to tackle this problem."

The new computational method extracts these localized multiscale features from a dataset. For instance, images of the surface of Jupiter reveal turbulent swirls of all different sizes throughout the gas-giant's atmosphere. The new method works from the bottom up, first learning how the very smallest swirls are structured and simultaneously extracting them from the data, then moving on to the next largest swirls, all the way up to the largest swirl patterns. Researchers then can compare and contrast these structures of various sizes, which are represented by wavelets learned from the data.

Graham and Floryan hope to use the technique as a starting point to explore other turbulent flow data and other complex multiscale systems. With a few tweaks, it could be used to understand hierarchical structure in systems like biological tissue, ocean dynamics and weather, computer and social networks, and image processing.

"There are a lot of problems where we have multiple scales present and features that are spatially isolated," says Floryan. "This is a way to discover and extract these structures in an automated way from the data."

Daniel Floryan

Michael Graham

PLANNING UNDERWAY TO OVERHAUL CBE LAB SPACE IN ENGINEERING HALL

Chemical and biological engineering majors spend lots of time in the lab, and anyone who has graduated from UW-Madison in the last half century is intimately familiar with the instructional space in the basement of Engineering Hall currently known as B103. Not only is it where students in many lab courses gather during the fall and spring semesters, it's the home of Summer Lab, the intensive capstone experience that turns undergrads into true chemical engineers.

B103 has served its purpose well, but it's time for a complete makeover. That's why the department has developed a design that will transform the area into a modern, flexible, welcoming and state-of-the-art space for CBE undergraduate laboratory instruction.

The plan renovates and modernizes B103, centering this large open space around a clerestory that floods the basement lab with natural light, and includes new lighting, windows, floors and storage space. Flexible utility dropdowns and moveable benches will allow more space for the experimental rigs used in the required CBE 324 transport lab, a key course for undergraduates.

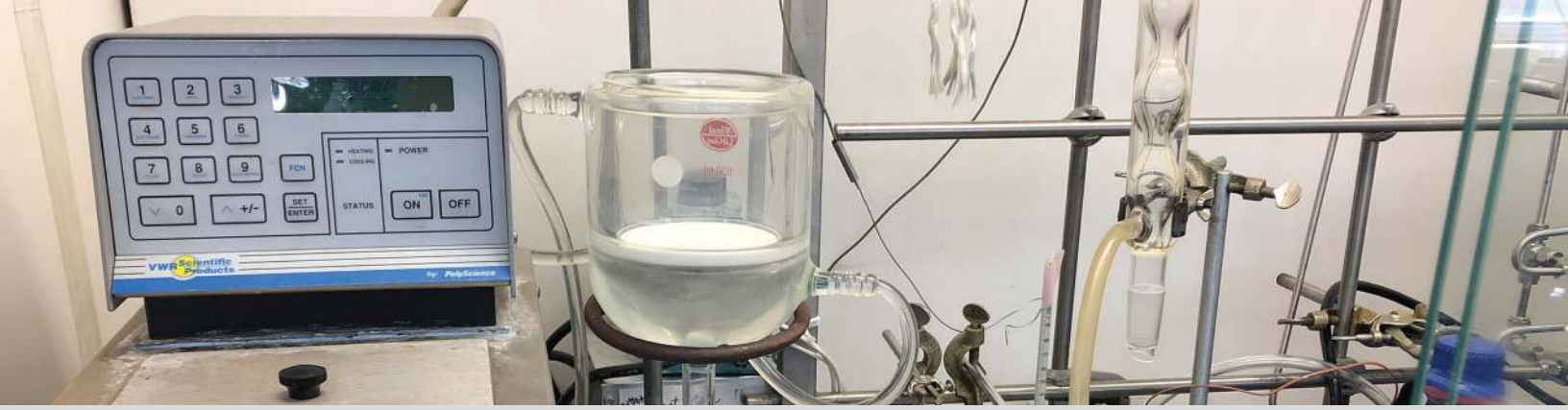
Rooms radiating from the central lab space will provide access to specialized analytical instruments, chemical fume hoods, computers and meeting areas. Glass partitions will maintain the open feeling of the lab and allow for safe observation of experiments. The design aims to provide an open and inviting area for experimentation and collaboration, one that is readily adaptable to changing instructional needs.

Additionally, the project adds roughly 4,500 square feet of lab space by completely gutting and redoing the adjacent underused room, B209. Because B209 is a high-bay room, it's the perfect spot to install large equipment such as distillation and humidification towers, solvent extraction units, packed-bed reactors, heat exchangers and membrane filtration units.

New lighting, windows and floors will provide the finishing touches to convert B209 into a "hard hat" workspace, allowing students to gain hands-on experience with pilot-plant-scale equipment. Adjacent rooms will be repurposed for instructor use and student meeting space and will also include a gallery for visitors.

The plan also calls for a redevelopment of the dark and cluttered hallway between B103 and B209. The hall would include updated restrooms, brighter lighting, collaboration areas where students and faculty can gather together and dedicated wall space to display some of CBE's storied history.

The vision is laid out in an advanced planning study commissioned by the department. Making it a reality by the proposed grand opening—Summer Lab 2023—is the department's goal. "The faculty and staff who teach our lab classes are a dedicated group who provide a fantastic, rigorous education to our talented and hardworking students. They deserve to work and learn in a modern, attractive space. I am incredibly excited about seeing this project through to completion," says R. Byron Bird Department Chair Regina Murphy.



Undergrads were key contributors to new solvent-based plastic recycling process

For many undergraduates, a semester or two of working in a professor's research group is a great way burnish their resumes or grad school applications. But the experience of two undergraduate chemical engineering majors was a little more intense: both made contributions to a project developing a new technique for recycling multilayer plastic, earning them coauthor credits on a paper in the prestigious journal *Science Advances*.

Jesse Banick signed up for a semester of independent study in the winter of 2019 to cap off his degree in chemical engineering. He was interested in investigating whether solvent-based reactions could be used to separate and recover polymers from multilayer thermal plastics used in food and medical supply packaging.

Jesse Banick

He brought his idea to catalysis expert George Huber, who was intrigued by the idea and tasked grad student Ted Walker to oversee the project.

"The question was whether we could leverage our understanding of solvent effects to deconstruct multi-layer plastics," says Walker, who earned his PhD in chemical engineering in 2019. "Because if we could do that, at least in part, it would solve one of the big technical hurdles in recycling plastic."

Walker assigned the experimental part of the project to another undergraduate, Nathan Frelka, who earned his bachelor's degree in chemical engineering in 2019.

Frelka ran with the assignment, using predictive tools to identify a set of solvents he believed could dissolve the individual elements of a three-polymer plastic. He then designed an experimental apparatus and found that the process worked. "It was pretty exciting; the proof of concept translated really well to the plastic," he says.

Nate Frelka

Those experiments are now part of the Solvent-Targeted Recovery and Precipitation (STRAP) processing technique being developed by Huber and CBE colleague Reid Van Lehn.

"This really exemplifies the best-case scenario for an undergraduate researcher," says Walker. "Nate proposed and managed a set of experiments with almost no oversight. And in that first pass of experiments, he was able to demonstrate something that had not been done before."

Ted Walker

Remembering chemical engineering pioneer Robert Byron Bird

Robert "Bob" Byron Bird was one of the most influential chemical engineers in the history of the field, but for his colleagues in CBE he was more: a mentor, a friend and a source of endless inspiration. Bird passed away on Nov. 13, 2020, at age 96.

After serving in World War II, the Texas native enrolled at the University of Illinois at Urbana-Champaign, completing his bachelor's degree in 1947 before earning his PhD in physical chemistry at UW-Madison in 1950.

He joined the faculty of UW-Madison in 1953, where, over the next 40 years, Bird's contributions were foundational to modern chemical engineering. He conducted groundbreaking research in fluid dynamics, transport phenomena, the kinetic theory of polymers and the rheology of polymeric liquids. He was a prolific textbook writer, including the seminal text *Transport Phenomena*, co-authored with CBE colleagues Warren Stewart and Edwin Lightfoot, which has been used in engineering curricula worldwide for six decades now. He also authored texts on polymeric liquids and polymer science.

Bird received countless honors for his work, including nine honorary doctorates, a knighthood from the Netherlands, and election to the National Academy of Engineering, National Academy of Sciences, the American Academy of Arts and Sciences, and the Wisconsin Academy of Sciences, Arts, and Letters. In 1987, he received the National Medal of Science from President Ronald Reagan.

Bird officially retired from UW-Madison in 1992, but he was a familiar face on the engineering campus for almost the rest of his life. In February 2014, CBE hosted a symposium and banquet to celebrate his 90th birthday. In 2019, thanks to generous donors, the department established the Robert Byron Bird Department Chair in Chemical and Biological Engineering in his honor.

"Bob was an extraordinary intellect and one of the most celebrated chemical engineers of all time," says Regina Murphy, first recipient of the chair. "But what I will miss most is his gentle spirit and his abundant curiosity."

CBE alumnus Joseph B. Powell (PhDChE '84) was recently elected to the National Academy of Engineering. Powell served as chief scientist-chemical engineering for Shell, where he led enhanced oil recovery and biofuel research.

Assistant Professor Reid Van Lehn is a 2021-2022 Vilas Associate and recipient of a National Science Foundation CAREER Award to study how nanoparticles are able to cross cell membranes.

The North American Catalysis Society has selected Professor Manos Mavrikakis as the recipient of the 2021 Robert Burwell Lectureship in Catalysis. The honor recognizes substantial contributions to the field of catalysis.

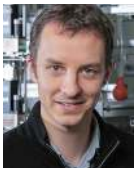
2015 PhD graduate Kushal Sinha was included in the AIChE's list of 35 under 35 in the innovation and entrepreneurship category. Sinha leads an advanced modeling and simulation group for the biopharmaceutical company AbbVie.

Professor Emeritus James Dumesic and Professor George Huber were both selected for the Web of Science Highly Cited Researchers list for 2020. The honor acknowledges authors who rank in the top 1% of cited papers between 2009 and 2019.

Suzy Wu, who works in assistant professor Matt Gebbie's lab, is the recipient of the inaugural Jennifer L. Reed Memorial Undergraduate Research Award. The award was created by Reed's family and friends to honor the CBE faculty member who passed away in July 2020.

Professor John Yin is part of a new multi-institution grant from the National Institute of Health's Stimulating Peripheral Activity to Relieve Conditions (SPARC) program. The goal of the project is to create a computational model to guide the development of new therapeutic electrical signal stimulations for bladder control.

The American Institute for Medical and Biological Engineering has elected alumnus Michael F. Wolf (BSChE '88) to its College of Fellows. Wolf, a long time scientist and fellow at Medtronic, Inc. in Minneapolis, was cited for outstanding contributions to the medical device industry.



Jeremy Luterbacher, a former postdoctoral researcher in James Dumesic's lab and now a professor at the École Polytechnique Fédérale de Lausanne in Switzerland, is one of three winners of the 2021 ACS Sustainable Chemistry & Engineering Lectureship Awards. The prize recognizes researchers working in green chemistry, green engineering and sustainability.

Professor George Huber and Associate Professor Victor Zavala received a new Department of Energy grant to develop biodegradable polymers that can replace the polyethylene currently used in packaging applications.

Remembering CBE alumnus Ernest Micek

A native of Arcadia, Wisconsin, Ernest "Ernie" Micek graduated with a BS in chemical engineering in 1959. From there, he began a 42-year-long career at Minnesota-based food and agriculture corporation Cargill Inc., one of the largest privately held businesses in the United States.

Beginning as a night supervisor in an oilseeds plant, Micek worked his way up the corporate ladder, eventually serving as president, CEO and chairman of Cargill in the late 1990s.

He also gave back to his beloved university. Micek served on the Wisconsin Alumni Research Foundation board for 17 years, was Director and Chairman of the Morgridge Institute for Research and was a longtime member of CBE's visiting committee, which provides advice, support and recommendations to the department.

In 2015 the Ernest Micek Distinguished Chair in Chemical and Biological Engineering was established and awarded to professor James Dumesic. He also established the Ernie and Sally Micek Scholarship to support undergraduates.

He passed away on Oct. 29, 2020, at the age of 84.

CBE grad wins MacArthur Foundation genius grant

In October 2020, the MacArthur Foundation notified alumnus Paul Dauenhauer (BSChE '04) that he was selected as one of its fellows, an honor also known as the "genius" grant. The award recognizes exceptional creativity across many disciplines with a no-strings-attached grant of $625,000.

Now a professor at the University of Minnesota, Dauenhauer focuses on producing sustainable fuels and chemicals from renewable resources. In particular, he's known for developing a technique that allows catalytic reactions to surmount the Sabatier maximum—also known as the catalytic speed limit—which can increase reactions up to 10,000 times their normal rate. That breakthrough could make prohibitively expensive processes more feasible.

Dauenhauer says his time at UW-Madison deserves a lot of credit for his success. "The education and training that I received at the University of Wisconsin was absolutely first rate. The engineering college and the university as a whole provided fundamental grounding in core principles such as mathematics and thermodynamics, but our education also included application of these skills to research and technology," he says.

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Meet Distinguished Achievement Award recipient Michael Conway

Michael F. Conway (BSChE '78) is a 2020 recipient of the College of Engineering Distinguished Achievement Award. Conway rose to the top of the international oil trading business as president of Shell Trading while serving as an exemplar for management practices that reflect his values of integrity and civic responsibility.

How did your experience in the College of Engineering shape your career path?
What you've really got to get out of your university experience is the ability to adapt to change when you're faced with questions you've never had to face before. How do you work yourself through it? I think the engineering degree is really good at that—to help you solve problems, to continue learning and put the pieces together. That made a big difference for me in my professional career.

Why did you choose engineering and decide on your major?
Growing up, I loved science. When I was six or seven, I took the 12-volt transformer from my racing car set, put the terminal wires in water and added salt to see if I could separate the water into hydrogen and oxygen. I used table salt as the electrolyte and created chlorine gas instead, which caused a bit of a problem in my bedroom. Figuring out why it didn't go the way I planned it was interesting as well. In my senior year of high school, I wanted to choose a college discipline that had lots of chemistry, physics and math. Chemical engineering was a natural fit.

Was there a class that made an impact on your future?
The transport phenomena class Professor Bird taught got me hooked on rheology and polymer flow. Professor Hill taught reactor engineering. That combination led into polymer chemistry, rheology and reactor engineering, which influenced where I went to work after graduation.

What advice would you give students today?
Do something you really have a passion for. If you enjoy it, it's not work anymore. Having an engineering degree teaches you to continually learn, well after you leave university.