FALL 2019

CHEMICAL AND BIOLOGICAL ENGINEERING

UNIVERSITY OF WISCONSIN-MADISON

MEET TOMORROW'S CBE LEADERS:

INQUISITIVE, ENTHUSIASTIC, SCIENTIFICALLY STRONG

CHAIR'S MESSAGE

Hello from Madison!

As you're reading this newsletter, we're in the midst of the fall semester of the 2019/2020 academic year.

It's an exciting fall for CBE, as we welcome two new outstanding assistant professors to the department. Marcel Schreier is coming to us after completing his postdoc at MIT, and Matt Gebbie was most recently a postdoc at Stanford. Their complementary expertise in electrocatalysis and ionic liquids will further strengthen the department. We can't wait to see what they accomplish!

Our current faculty continue to make us proud, earning prestigious awards and publishing in top-tier journals. We're especially excited for Victor Zavala, the Baldovin-DaPra associate professor, who received a Presidential Early Career Award for Scientists and Engineers, one of the highest honors for a young researcher bestowed by the U.S. government. Victor was nominated for the PECASE award by the Department of Energy for his contributions to computational strategies for advanced control of power systems and for service to the educational community as an enthusiastic professor and mentor.

We're especially excited that the award nomination called out Victor's outstanding mentorship, as CBE prides itself as being a department where today's students are molded into tomorrow's leaders.

That ethos is exemplified in the annual summer research experience for undergraduates, where students spend a few months immersed in chemical engineering under the watchful guidance of a graduate-student mentor. This past summer, 10 undergraduates completed the program, including one in my own lab, Marisa Hardy. Marisa worked with my graduate student Maddie Pont (who appears on the cover of this newsletter).

Mentoring undergrads provides grad students valuable experience for when they go on to become professors. And CBE also produces exceptional PhDs who go on to successful careers outside of academia. For example, Pyran, a spinoff helmed by Kevin Barnett, who started the company when he was in George Huber's lab, has won several entrepreneurship awards, and its technology continues to impress investors nationally.

CBE sets up our alumni for success, no matter what path they pursue, and every fall we honor some of our outstanding former students at the Engineer's Day award banquet. This year we're presenting the Early Career Achievement Award to Amanda Engler, who spent several years in the nanomedicine division at IBM and currently works as an experimental scientist for 3M. Our Distinguished Achievement Award recipient, Sunny Lo, is chairman of the board of Café de Coral holdings LTD, the largest Chinese fast food restaurant group in the world.

Our alumni are successful because CBE offers so many opportunities to solve problems and learn by doing, such as in the time-honored operations and process laboratory course, much better known simply as summer lab (and lovingly called "boot camp" by those who've been through it). This past summer, five cohorts of students finished their summer lab classes, and one of the groups had the chance to meet with Sunny Lo in Hong Kong. What a great chance for our students to gain insight from one of our distinguished alums.

On a more bittersweet note, longtime faculty member James Dumesic will become professor emeritus in 2019. Jim was recently honored with the 2019 Eni award for his transformative energy research in the biofuels field, just one of many honors and recognitions of his long and distinguished career. Luckily, Jim will remain an active member of our community, co-advising students and continuing his many research collaborations. Please join me in thanking Jim for his numerous contributions to the department, and wishing him well on this next phase.

Have a wonderful autumn, and please don't hesitate to keep in touch!

ON, WISCONSIN!

Regina M. Murphy, PhD
R. Byron Bird Department Chair
Kreuz-Bascom Professor
regina.murphy@wisc.edu • (608) 262-1587

MATT GEBBIE FOLLOWS THE INTERESTING QUESTIONS ABOUT INTERFACES

Peculiar things happen at the boundaries between liquids and solids.

At the interface between neatly ordered solid molecules and the more chaotic constituents of a liquid, is a region where the rules that govern each individual substance don't strictly apply.

A better understanding of how molecules behave at interfaces could help engineers solve a whole host of problems for the modern world. For example, interfaces are important for batteries, solar cells and many other energy storage and generation devices.

"Starting with the basic questions about why something happens at the molecular level often leads to something surprising or interesting that we can follow through to design or create materials," says Matt Gebbie, who will join the faculty in December 2019 as an assistant professor.

> **"One of the cool things about being a faculty member is training students to ask important questions, and to pursue research that makes an impact."**
>
> **— Matt Gebbie**

Gebbie plans to initially focus his research at UW-Madison on interfaces where the fluid component carries a charge—so-called electrolytes. These types of junctions are widely found in our devices and in our environment, including inside fuel cells, batteries and even the sticky slime that adheres barnacles to boats.

Ionic liquids are electrolytes that are made entirely out of charged ions and are especially interesting because there's a tremendous diversity of different structures we can design to make materials with unique properties, says Gebbie.

One example use for ionic liquids is in electrocatalytic devices that use renewable electricity to drive the conversion of carbon dioxide into fuels and chemicals. Another application is as a replacement for the corrosive acids and flammable liquids inside batteries. The stability of ionic liquids could all but eliminate the risk of catastrophic flame-outs.

During his PhD studies at the University of California, Santa Barbara, Gebbie explored ionic liquids through a physics-focused lens. His research took him down some unexpected channels, including a side-project studying how marine mussels stick to rock surfaces in harsh saltwater environments.

Gebbie also helped overturn some long-held assumptions about the very nature of interfaces involving ionic liquids. His measurements revealed that the interfacial transition zone formed at the boundaries between charged surfaces and ionic liquids can be roughly 10 times thicker than researchers previously thought.

"That result was one of the things that got me super excited about the impact of science," says Gebbie. "I could see how experiments we did in the small seaside town of Santa Barbara spawned discussions all over the world."

After completing his PhD in 2016, Gebbie pursued a postdoctoral fellowship at Stanford University. There, he worked toward developing new tools and materials to study interfaces with exquisite sensitivity.

And his tools hinged on a material that many people find exquisite: diamond.

Lab-grown diamonds sometimes contain irregularities known as color-center defects. And while the imperfections might ruin an engagement ring, diamonds with color-center defects can be incorporated into advanced sensors, as well as quantum computers, thanks to their unique optical properties.

Before Gebbie could get started on creating diamond-based sensors, however, he needed to answer another basic question.

"We really had to understand, at the most basic level, why you can grow diamond in the first place," says Gebbie.

Growing diamonds in the lab involves subjecting a feed gas to intensely powerful microwaves to yield a hot reactive plasma. It's a high-temperature process, yet the first few steps of lab-grown diamond formation share surprising commonalities with a common low-temperature phenomenon: freezing water.

Those similarities occur in the first few moments of a diamond's growth—a process called nucleation. And contrary to prior hypotheses, diamond nucleation doesn't happen all at once; instead, nucleation occurs in multiple steps, similar to recent proposals for how ice crystals form.

That insight will allow Gebbie's colleagues at Stanford to design and grow diamonds with specific color-center defects, tailored for use in quantum computers and sensors. But while diamonds might be forever, postdoctoral fellowships come to an end, and now, Gebbie's research at UW-Madison will come full circle, with an initial focus on interfaces involving ionic liquids.

Some of the first questions Gebbie will be asking involve how the structures and dynamics of interfaces control chemical properties. And those insights will be important for tuning interfaces for use in energy storage or electrically driven chemical reactions.

He's open to exploring other questions and materials, too, however, as he grows his lab and begins mentoring students.

"One of the cool things about being a faculty member is training students to ask important questions, and to pursue research that makes an impact," he says.

FOCUS ON NEW FACULTY

MARCEL SCHREIER USES ELECTRICITY TO DRIVE CHEMICAL TRANSFORMATIONS

Marcel Schreier, who is joining the department as an assistant professor, has ambitious plans to develop more efficient and sustainable ways to interconvert electrical and chemical energy.

Today, chemical transformations, such as the ones that create the plastics we use every day, are almost exclusively driven by heat derived from chemical energy stored in fossil fuel sources.

If those transformations could occur with sufficient efficiency using electricity that comes from renewable sources, the chemical industry might someday be able to substantially reduce its carbon footprint.

"If we believe that the energy system is moving away from using fossil fuels as energy carriers and more into using electricity, the moment will come when we need to interface the chemical and electrical energy streams," says Schreier.

Interface is an apt word for the combination of electricity and chemicals, not only at the massive systems- and industry-level scale, but all the way down to molecular details.

When a conductor for electrons (called the electrode) meets a medium that can carry charged chemical species (known as and electrolyte), an electrochemical interface appears. And that interface can drive chemicals to transform using electricity.

During his PhD studies with Michael Grätzel at the École Polytechnique Fédérale de Lausanne in Switzerland, Schreier created devices that employ such electrochemical interfaces at the surface of semiconductors to harvest energy from sunlight and drive the transformation of carbon dioxide to more useful products.

In other words, the devices drove combustion backwards, using energy from the sun to create useful chemicals from CO_2.

He was highly successful: Schreier still holds the world record for the most efficient solar-powered transformation of carbon dioxide into chemical energy.

And in the process of developing those devices, Schreier had an epiphany.

"While I started with the application goal, I realized the real beast we are missing in our field is a molecular understanding of how electricity drives catalytic processes."

Consequently, understanding how the catalyst surface chemistry and the properties of the electrochemical interface impact catalysis was the main focus of Schreier's postdoctoral work at the Massachusetts Institute of Technology.

It's a tricky question, complicated by the sheer number of parameters that may influence electrochemical reactions and the complicated nature of the chemistry taking place at the interface. That's why Schreier opts for an approach using well-defined model systems to uncover the pathways employed by individual reactions.

"Electrochemical interfaces are so complicated that often the data is convoluted by several competing factors," says Schreier. "Yet, when you intelligently design your experiments, you can parse out how individual parameters influence the rate of reactions at the interface to be confident that you are looking at the pathway that mediates the transformation in which you are interested."

This approach has helped Schreier reveal surprising results and even upend previously held assumptions about the sequences of reactions that take place at electrochemical interfaces.

In particular, he was able to demonstrate surprising connections between the role of heat and electricity in driving reactions.

While at UW-Madison, Schreier's group takes a bottom-up approach, focusing on catalytic methods to introduce electricity as a driving force in industrially relevant chemical transformations.

It's the continuation of a globe-spanning career arc, driven by Schreier's wide-ranging interests inside and out of the physical sciences and engineering.

During his education, Schreier carried out research at BASF in Germany, where he worked on the electrolyte chemistry for lithium-ion batteries. He also gained experience in process design at a chemical contract manufacturer, and later worked at the University of Alberta, where he investigated the mechanism of olefin oligomerization in Fischer-Tropsch refining. Later, he obtained his master's degree at the Swiss Federal Institute of Technology in Zurich, but not before a stint at Caltech where he researched fuel cells.

"My research has always been at the intersection between renewable energy and the traditional chemical industry," says Schreier.

At UW-Madison, he's looking forward to building his lab and mentoring some of the outstanding graduate students in the CBE department.

"When I visited campus, I talked to students working in catalysis and I was impressed by their enthusiasm, inquisitive attitudes, and strong scientific backgrounds," says Schreier. "I'm excited to work with these people."

RENEWED ENERGY FOR BIOFUELS

Identifying up-and-coming commodity chemicals

Petrochemicals, the oil- and gas-derived compounds that serve as the molecular backbones for much of modern commerce, commanded a $539.3 billion market value in 2018.

Replacing just a few of those petroleum products with chemicals made from plants or microbes could put a substantial dent in the world's fossil fuel consumption.

That's why a team of engineers from UW-Madison developed a method to identify bio-based compounds that hold promise as potential replacements for petrochemicals.

"This will provide guidance for product design and discovery," says Wenzhao Wu, who conducted the research before earning his PhD in chemical engineering from UW-Madison in 2018. "It will also help the biofuels community focus on what chemicals to produce."

"If biofuels are able to be adopted at a large scale, their coproducts should have significant demand. If we were only producing specialty chemicals, there wouldn't be a large enough market."

— Christos Maravelias

What chemicals to produce is a crucial question—and the answer could make or break whether biofuels are able to compete, cost-wise, with petroleum.

"We study chemical production, in addition to fuels, to improve the economics of biorefineries," says Professor Christos Maravelias. "The logic is that converting biomass into fuel is relatively inefficient compared to oil and gas, but chemical production could be more cost-effective."

Oil and gas refineries produce a whole host of commodity chemicals alongside fuel products to satisfy an insatiable demand from numerous industries, including agriculture, pharmaceuticals and electronics.

Replacing some of those commodity chemicals with bio-based products could help chip away at our reliance almost exclusively on petroleum. In fact, Maravelias already studies which current-day commodity chemicals might be best produced from plant or microbial sources.

Yet that relatively narrow "current-day" view doesn't capture the wide array of chemicals that could be made from plants of microbes. So, the researchers sought a strategy to identify "up-and-coming" chemicals—bio-based compounds not yet in widespread production, but potentially capable of substituting for a petrochemical in use today.

The researchers dubbed the up-and-comers "replacement chemicals," identified through a careful analysis of everything from market volumes and prices to atomic compositions.

As is the case with petroleum-based chemicals, replacement chemicals, too, would someday be sold alongside biofuels. As a result, researchers needed to find compounds that could generate substantial revenue as coproducts.

They also considered demand. For example, numerous chemicals (such as the complicated molecules used to synthesize prescription drugs or pharmaceuticals) can command high prices, but those expensive compounds make up a tiny fraction of the total market.

"If biofuels are able to be adopted at a large scale, their coproducts should have significant demand," says Maravelias. "If we were only producing specialty chemicals, there wouldn't be a large enough market."

Broadening the equation to include market volumes as well as prices, the researchers identified characteristics of chemicals that are both highly in demand as well as difficult to obtain from fossil fuels.

And by layering in a third step of analysis based on molecular structure, the researchers narrowed in on characteristics that enable successful bio-based chemicals to balance the tradeoff between price and demand—and, importantly, to be easily produced from biological sources.

They hope those characteristics will motivate other biofuels researchers to take the next steps: designing and developing plant- or- microbe-based pathways for synthesizing molecules that will become tomorrow's replacement chemicals.

INDUSTRY-READY PROCESS MAKES CHEMICALS FROM PLANT SUGARS

James Dumesic (left) and Ali Motagamwala developed an efficient and economically feasible process for producing HMF

Developing renewable, plant-based alternatives for petroleum-derived chemicals is a major piece of the effort to transition toward a more sustainable and environmentally friendly economy.

But integration of novel and unproven technology into existing industrial systems carries a significant challenge.

Chemical engineers from UW-Madison are addressing that challenge, with new research that describes an efficient and economically feasible process for producing a versatile plant-derived chemical called HMF, or 5-hydroxymethylfurfural.

The process is simple and compatible with the existing infrastructure in the high-fructose corn syrup industry.

"We integrated into a current process to reduce the initial risk quite a bit and decrease the initial capital required to put things on the ground to prove the technology," says Ali Hussain Motagamwala, who led the project while a CBE graduate student.

HMF can be used to make a wide range of chemicals, plastics and fuels. It is an appealing candidate for commercialization in part because there is already an established market for many of the products made with HMF. For example, Coca-Cola, Danone, and BASF have already invested in the production of furandicarboxylic acid, an HMF-derived chemical used to make 100-percent bio-based plastic bottles.

To date, however, HMF's use has been limited by its high production cost.

CBE Professor James Dumesic, senior author of the paper, has been working for more than two decades on technologies to sustainably and economically produce HMF from biomass-derived sugars.

"We have known for many years that HMF is a platform molecule with tremendous potential, but it has been an ongoing challenge to produce HMF in a cost-effective manner from sustainable carbohydrate resources," Dumesic says.

The problem has always been the solvent in which HMF has been produced.

"Now we have shown that we can make HMF in really high yield—close to 95 percent—with an inexpensive solvent system that can be removed very easily," says Motagamwala.

Dumesic earns international award

Ernest Micek Distinguished Chair James Dumesic was named the winner of the 2019 Eni Energy Transition Award.

The internationally renowned Eni Awards were established in 2007 to recognize excellence in energy and environmental research. The Energy Transition Award honors recent research and technological innovation that promote the transition toward low-carbon energy systems. Dumesic was selected for his pioneering work on novel catalytic processes for converting plant material into advanced fuels, biodegradable plastics, and other renewable chemicals.

"Word that UW-Madison's James Dumesic has again been cited for his critical work to advance renewable energy from biomass and help society transition from less sustainable resources is fantastic news," says UW-Madison Chancellor Rebecca Blank. "Professor Dumesic is a creative and prolific researcher and innovator. His work will help make the world better and more sustainable as we seek to capitalize on the vast but latent potential of biomass. This recognition is well deserved."

Emeritus, but not slowing down

After more than four decades with the chemical and biological engineering faculty, James Dumesic is becoming a professor emeritus. Despite "retiring," Dumesic will remain an active and valued member of the CBE department, maintaining his groundbreaking research program and co-advising students.

Since joining the department in 1976, Dumesic has mentored more than 70 PhD students, established collegial and productive collaborations, and has been a stalwart leader in maintaining and expanding CBE's long tradition of excellence.

Dumesic has contributed numerous seminal discoveries to the catalysis and biofuels fields. He also is co-founder of two successful companies, Virent and Glucan Bio, based on processes developed in his lab. More recently, he and his students have used gamma valerolactone (GVL), a chemical that can be produced from plants, to deconstruct biomass in a one-step process. This is a disruptive new technology with the potential to create low-cost renewable fuels and chemistries for a wide variety of industries.

The department will honor Dumesic with a symposium in November 2019.

UNDERGRADS LEAD THE DRIVE TOWARD HIGH-DEMAND BIOFUELS

Diesel and jet fuels are notoriously difficult to obtain from non-oil, plant-based sources, which is a major hurdle in biofuels research.

But "difficult" didn't deter a group of undergraduate students in a process design course at UW-Madison: In fact, the students made key initial steps toward overcoming that obstacle through their work on an open-ended class project aimed at producing a diesel fuel blendstock using readily available bio-ethanol as a starting point.

"What you try to do in the classroom is teach the fundamentals of engineering with real-world research projects," says George Huber, the Richard Antoine professor. "Here in our department, we have a long history of integrating teaching with research."

For many of the students, the class was their first experience working on problems without predetermined solutions. Throughout the semester, the 82 students crunched real data from Huber's lab to devise plans for a process so that ethanol refineries could one day produce high-value diesel and jet fuel.

They chose ethanol as a starting point because it is the most common biofuel and America is a top-producer of the corn-derived biofuel. The United States made nearly 16 billion gallons of ethanol in 2017, and fuel blends containing up to 15 percent ethanol are widely sold at gas stations around the country. The state of Wisconsin currently has nine ethanol refineries that produce more than 500 million gallons of ethanol per year, contributing to some $4.2 billion of economic activity for the state, including 19,000 jobs, $982 million in wages and $306 million in taxes, according to figures from the Wisconsin Corn Grower's Association.

Currently, ethanol is produced from corn and sugarcane; however, ethanol doesn't work in diesel and jet engines. What's more, demand for ethanol as an alternative is starting to dwindle as more and more people opt to drive hybrid and electric vehicles.

"We want to take advantage of the existing ethanol infrastructure to make diesel fuels," says Nathaniel Eagan, a fifth-year PhD student whose research with Huber provided data for the course.

One measure of diesel fuel's "bang for the buck" is a metric called the cetane number, and that number needs to be high for diesel fuels. Ethanol has a low cetane number, but it's possible to convert this small molecule into a diesel fuel blendstock that has a higher cetane number.

Eagan's research focuses on accelerants for chemical reactions called catalysts, which speed up the reactions without themselves being consumed in the process. He's collaborated extensively with researchers at ExxonMobil to develop catalytic reactions to combine ethanol molecules into longer chemical chains that can be used as diesel fuel blendstocks.

Yet identifying effective catalysts is only one step in fuel production.

Biorefineries will need to perform a complicated series of chemical reactions, separations and purifications that are all integrated and optimized to minimize energy input to produce large quantities of usable diesel and jet fuel. Those processes haven't yet been worked out.

Enter the undergraduates.

For 16 weeks, the students grappled with simulations, calculations and economic projections in hopes of sketching out workable and feasible designs.

"This is what real engineers do," says Huber. "They analyze data and design a process in an open-ended way."

Now, Huber plans to collaborate with Associate Professor David Rothamer in the Department of Mechanical Engineering to study how ethanol-derived diesel fuels perform in real engines. Additionally, he's working with chemical and biological engineering colleague Christos Maravelias to further analyze their economic feasibility and environmental impact.

Even though the semester ended in May 2019, the students' groundwork will keep moving forward, with support from ExxonMobil and the Department of Energy.

"Now we have a much more rational way of designing this because of the undergraduates' designs," says Eagan.

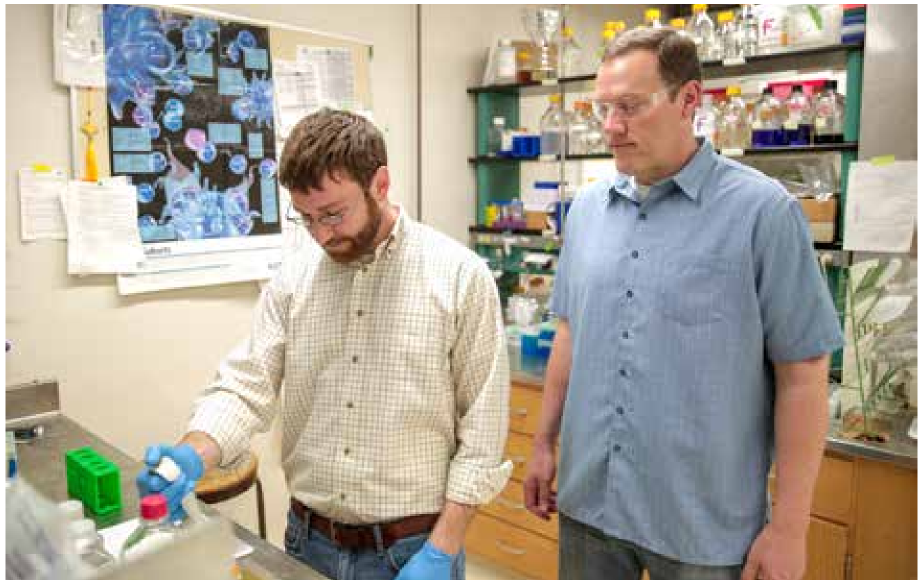
After a busy summer, students in our Research Experience for Undergraduates program presented their results at a poster session on July 31, 2019.

JAWLESS FISH TAKE A BITE OUT OF THE BLOOD-BRAIN BARRIER

A jawless parasitic fish could help lead the way to more effective treatments for multiple brain ailments, including cancer, trauma and stroke.

One major challenge in treating cancers and other disorders of the brain is ensuring that medicines reach their targets. But a team of chemical and biological engineers and clinician-scientists borrowed molecules from the immune system of the parasitic sea lamprey to deliver anti-cancer drugs directly to brain tumors.

Unlike most currently used medicines, which target specific features on or inside individual cells in our body's organs and tissues, the lamprey-derived molecules take aim at a different target— the extracellular matrix, which is a tangled mesh of proteins and sugars that supports and surrounds all cells in the brain.



Professor Eric Shusta (right) and postdoctoral researcher Ben Umlauf in the lab. *Photo: Sam Million-Weaver.*

Lampreys and humans have similar immune systems. But instead of producing antibodies to neutralize threats (that's how vaccines help protect us against measles), they produce small defensive molecules.

The researchers believe the molecules could be adapted and combined with a wide array of other therapies, offering hope to treat numerous brain ailments beyond tumors, such as multiple sclerosis, Alzheimer's disease or even traumatic injuries.

"This set of targeting molecules appears somewhat agnostic to the disease," says Howard Curler Distinguished Professor Eric Shusta. "We believe it could be applied as a platform technology across multiple conditions."

The technology takes advantage of the fact that many diseases disrupt one of the body's natural defense mechanisms: the blood-brain barrier, which lines the blood vessels of the central nervous system and protects the brain from potential threats such as circulating toxins or pathogens.

Lampreys have similar immune systems as people, but instead of producing antibodies to neutralize threats (that's how vaccines help protect us against measles), they produce small crescent-shaped defensive molecules called VLRs. To obtain their drug-delivery molecules, the researchers "vaccinated" lampreys with components of the brain extracellular matrix and then hunted through many thousands of VLRs to find one that stuck specifically to brain matrix.

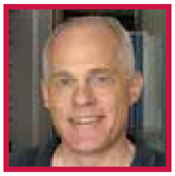
Importantly, in the mouse studies, the lamprey-derived molecules circulated throughout the body without accumulating in healthy brain tissue or other organs.

In the future, the researchers plan to link the matrix-targeting molecules to additional anti-cancer drugs, such as immunotherapy agents that activate a patient's own immune system to destroy tumors. They have filed a patent on the technology with the Wisconsin Alumni Research Foundation.

They also see promise in using the molecules as diagnostic tools to detect blood-brain barrier disruption by linking the matrix binders with probes for advanced imaging with PET scanners or MRI machines.

And because the molecules appear to be quite adaptable, the researchers speculate that many other medicines for the brain could become more effective if they were targeted to the matrix.

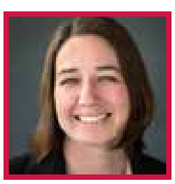
"I'm excited about trying this strategy in different disease model systems," says collaborator John Kuo, a neurosurgeon-scientist and professor of neurosurgery in the Dell Medical School at the University of Texas at Austin. "There are several disease processes that disrupt the blood-brain barrier and we could conceive of delivering a variety of different therapies with these molecules."

An article titled "Transport phenomena and thermodynamics: Multicomponent mixtures," written by Professor Emeritus **Robert Byron (Bob) Bird**, who recently celebrated his 95th birthday, and Associate Professor **Ross Swaney,** was highlighted as an editor's pick in the February 2019 issue of the research journal *Physics of Fluids*. In the new paper, Bird and Swaney build on their previous work together that revealed unappreciated relations between the equations of transport phenomena and those of thermodynamics in pure fluids, extending the observations to more complex multicomponent mixtures.

The American Institute of Chemical Engineers (AIChE) selected **Michael Graham**, the Vilas Distinguished Achievement and Harvey D. Spangler Professor, to deliver the William R. Schowalter lecture at the 2019 AIChE annual meeting in Orlando in November 2019. Each year, the Schowalter lecture alternates between a focus on fluid mechanics research and general interest topics. Graham, a world expert in the field of fluid mechanics, was tapped to present on his pioneering theoretical and computational work on a wide range of problems spanning transport phenomena, fluid mechanics, complex fluids and rheology.

The Wisconsin Alumni Research Foundation awarded a named professorship to **Manos Mavrikakis**, the Vilas Distinguished Achievement Professor and Paul A. Elfers Professor. Mavrikakis opted to name his professorship after Professor James Dumesic, the Ernest Micek Distinguished Chair.



Jennifer Reed was named the Karen and William Monfre Professor. Her research group studies bacterial metabolism and regulation using a combination of computational and experimental approaches. Her work has applications from developing new strains of bacteria for chemical production to understanding how microbial communities interact synergistically.

Reid Van Lehn is the inaugural recipient of the Conway Assistant Professorship. His group develops and applies molecular simulation techniques to engineer the properties of synthetic and biological soft materials. A gift from Mike (BSChE '78) and Ginny Conway established the professorship.

Victor Zavala, the Baldovin-DaPra associate professor, earned several honors for his outstanding teaching and research.

Zavala was one of 20 outstanding young faculty invited to present at the 2019 Computer Aids for Chemical Engineering conference in Breckenridge, Colorado, July 19-20, 2019, to report on his efforts to enhance student learning with technology.

AIChE, the world's leading organization for chemical engineering professionals, honored Zavala with the 2019 computing and systems technology division outstanding young researcher award, a distinction reserved for exceptional scientists under age 40 who have made substantial contributions to the chemical engineering computing and systems technology literature.

For his contributions to computational strategies applied to advanced control of power systems, and for service to the educational community as an enthusiastic professor and mentor, Zavala received a 2019 Presidential Early Career Award for Scientists and Engineers, the highest honor bestowed by the U.S. government on young researchers for their contributions to the advancement of science, technology, education, and mathematics and for their community service.

Honoring our outstanding alumni

College of Engineering **Distinguished Achievement Award recipient Sunny Lo** is chairman of the board of Café de Coral Holdings Ltd., which is the largest Chinese fast food restaurant group in Hong Kong and the world. During his time as CEO of the restaurant group, Lo oversaw the business' expansion to 13 brands with more than 580 locations throughout Hong Kong and mainland China.

Our college **Early Career Award recipient Amanda Engler** has been a prolific scientist, co-authoring 19 patents and 33 publications. She began her professional career with LTS (later acquired by IBM), where she designed degradable polymeric systems for drug delivery and antimicrobial applications. Today, she focuses her expertise and creativity on developing medical adhesive products as an experimental scientist with 3M.

DOUBLE DIPPING

Dual-action 'slippery' catheter fights bacteria

David Lynn and graduate student Harshit Agarwal are developing super-slippery coatings to reduce bacterial growth on implanted medical devices, such as catheters. *Photo: David Tenenbaum.*

A super-slippery coating in development could benefit medical catheters, factory equipment, and even someday, oil tankers.

The coating contains a lubricating oil that resists the attachment of bacteria. A first commercial target is catheters, which are used to deliver or remove fluids in medicine.

Catheters are frequently colonized by bacteria that form a tough "biofilm" that resists agents that would otherwise kill them.

Between 250,000 and 500,000 catheter infections in the United States each year cost billions through increased use of antibiotics, longer hospital stays, and the need to replace the catheter.

David Lynn, Duane H. and Dorothy M. Bluemke professor and Vilas Distinguished Achievement professor, creates the patented coating by alternately dipping an object in two polymer solutions.

The Wisconsin Alumni Research Foundation holds several patents on Lynn's work and has enrolled the project in the WARF Accelerator Program.

The new coating can also be infused with slow-release antibiotics, which could kill fungi and bacteria in the bloodstream or urinary tract where catheters are often used.

Lynn's slippery coatings were inspired by certain plant leaves, which cause water to bead up into nearly spherical drops. "There's been a lot of effort in materials science to develop synthetic mimics of those leaves," Lynn says.

Many processes, such as those used in computer chips and solar panels, can coat flat objects. But Lynn's dip-and-redip process can coat complex or curved surfaces like both surfaces of a catheter.

About a year ago, funding and support from WARF began to support "de-risking" the coating process. Catheters, Lynn notes, must withstand bending, sterilization, coiling, and sitting on a shelf for six months without getting dry or brittle.

Lynn's coatings feel ultra-smooth, but their rough interior can store chemicals. "These cargoes could kill bacteria or fungi," Lynn says. "That could help further prevent fouling by bacteria and prolong the lifetimes of these materials."

And because the coatings prevent the adhesion of many substances, including water, oil, ketchup and mustard, they may be useful in food processing.

Former CBE department chair Bowen passes away

Jewell Ray Bowen, a valued member of the faculty from 1963-1980, died April 15, 2019, at age 85.

Nationally recognized for his research on the chemical engineering of combustion, Bowen served on the leadership councils of several professional scientific societies, including the American Association for the Advancement of Science and the American Society for Engineering Education. During his time at UW-Madison, Bowen served as CBE department chair twice, first leading the department from 1971-1973 and again from 1978-1980.

He also contributed to campuswide leadership in his role as UW-Madison associate vice chancellor from 1972-1976. Later in his career, Bowen also was dean of engineering for 15 years at the University of Washington. He is survived by his wife of 63 years, Priscilla, and his three children, Jewell Ray, Sandra and Susan.

Alumna named to Society of Women Engineers board of directors

The Society of Woman Engineers appointed Andrea Clewley (BSChE '00) to its national leadership board as director of engagement for the 2019 fiscal year. Clewley is a lifetime member of SWE, and has served in several leadership roles for the organization, including section president and region governor. Since receiving her bachelor's degree, Clewley has forged a successful career working on consumer products. She currently works as a product approval manager for Tempur Sealy International, responsible for four test labs in two locations where she oversees the team responsible for testing and qualifying new products across the Stearns & Foster, Sealy and Tempur-Pedic mattress lines.

ALL-STARS ON THE FIELD AND IN THE CLASSROOM

Grit, dedication and perseverance are all essential qualities for athletes, and they're also indispensable for students who hope to excel academically, especially in the challenging chemical engineering degree program.

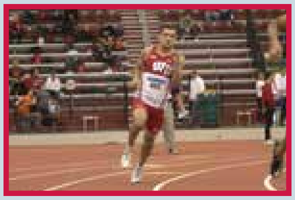
Little wonder, then, that CBE counts several athletes among its academic ranks.

"Chemical engineering is a very tough degree," says sprinter Kallen Bentz. "It taught me not to give up when times were really trying and that's exactly what I brought to my workouts."

These Badgers not only balance their coursework and training, but they also excel both on and off the field, making the dean's list while racking up titles and trophies.

Breanna Blesi

Hockey player Breanna Blesi was a member of the 2019 National Championship team, finishing out her sophomore year as goalie with a 90.9 save percentage. That same year, Blesi also was named a Krampade All-American Scholar by the American Hockey Coaches Association.



Kallen Bentz

Track athlete Kallen Bentz had an outstanding season in 2018, winning the 200 meters with a personal best time and earning a runner-up finish in the 100 meters at the Wisconsin Twilight meet. Off the track, Bentz's performance in the classroom earned him recognition as an All-Big Ten Honoree.

Rachel Lenz

Figure skater Rachel Lenz held leadership positions in both the figure skating club of UW-Madison as well as the campus chapter of AIChE. Her performance on the ice has helped the club earn titles at Skate On Wisconsin, the midwestern region's intercollegiate competition, and she's held multiple internships at 3M and Appleton Coated LLC.

Sarah Mondschein

Ultimate frisbee player Sarah Mondschein began her athletic career on the soccer team when she was a freshman in 2014. Now, Mondschein is a valued member of UW-Madison's premiere ultimate frisbee team, Bella Donna, which has been in national college championships numerous times and is a frequent competitor for best in the country.

And we expect to see great things from these athletes as they pursue chemical engineering after graduation.

"I treat everything like a competition," says Bentz, who was a senior in 2018. "That's helped me reach a lot of my goals so far."

UNDERGRADUATE NEWS

Margaret Snyder won a Hilldale Undergraduate/Faculty Research Fellowship for the 2019/2020 academic year to support her studies on different cell types within the blood-brain barrier, under the mentorship of Howard Curler Distinguished Professor Eric Shusta. The award supports undergraduates and their faculty advisors for collaborative projects with substantial intellectual contributions from student researchers. Snyder received a $3,000 unrestricted stipend and $1,000 went to Shusta to offset research costs associated with the project.

Students **Joshua Olson** and **Aagney** took home third and second place, respectively, in the 2019 competition for the Steuber Prize for Excellence in Writing. Established in 1992, the contest encourages undergraduates to stretch their communication skills beyond the technical style found in most classroom reports—wordsmiths may submit all styles of writing, ranging from expressive to informative or persuasive narratives. Aagney's piece was titled "Grandmother," and Olson authored "The Watering Hole."

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www.engr.wisc.edu/cbe

Department of Chemical & Biological Engineering
1415 Engineering Drive, Madison, WI 53706

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CBE STARTUP ON A GROWTH TRAJECTORY

Kevin Barnett

Pyran, a spinoff from the lab of Richard L. Antoine Professor George Huber, continues to earn recognition for its promising technology and well-thought-out business plan. Co-founded by Kevin Barnett, who completed his PhD in Huber's lab, Pyran's low-cost reaction technology produces a chemical currently used to make everyday paints and plastics, 1,5-pentanediol, from renewable wood and crop wastes. In the past year, Pyran received $225,000 from the National Science Foundation's Small Business Innovation Research program as well as funding from UW-Madison's Discovery to Product (D2P) unit as part of Wisconsin's State Economic Engagement and Development Research Program. Additionally, Pyran was one of the startup competition winners at the 2019 BIO World Congress on Industrial Biotechnology. The prize money and publicity will help Pyran find new partners and continue to work on scaling up the process to industry-ready levels.

Students and alum meet up in Hong Kong

Students in the Hong Kong cohort of the upper-level process design course, lovingly known as Summer Lab, had the chance to meet distinguished achievement awardee Sunny Lo during their time overseas.