SPRING 2017

CHEMICAL AND BIOLOGICAL ENGINEERING

UNIVERSITY OF WISCONSIN-MADISON

A NEW APPROACH TO COMBATTING BACTERIAL INFECTIONS

GREETINGS FROM MADISON

Manos Mavrikakis

It has been a very busy semester here in Madison. The department has been very actively looking to add new, world-class faculty in key areas of expertise within chemical and biological engineering, commensurate with our strategic plan by taking advantage of opportunities for hiring directly through the department and through the Grainger Institute for Engineering. We hope that we will be able to report good news on that front in the near future.

In the most recent edition of the *U.S. News and World Report's* "Best Graduate School" rankings, our department is ranked 6th. Our goal is to further improve that ranking in the next few years. With your continued help and support, we are confident in reaching that goal.

Among faculty news, Ive Hermans, professor of chemistry and affiliate professor of CBE, has recently reported in *Science* some very exciting work on the selective oxidative dehydrogenation of propane to propene using boron nitride catalysts, thereby opening new directions for activating plentiful hydrocarbons in shale gas natural resources toward more sustainable plastics production.

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Additionally, Victor Zavala, the Richard H. Soit assistant professor, and his team are studying the management of organic waste generated by the dairy industry in Wisconsin. With support from the U.S. Department of Agriculture, the National Science Foundation, the U.S. Environmental Protection Agency, and Dane County in Wisconsin, Victor is developing decision-making frameworks that government and industry can use to identify optimal strategies to tackle these important environmental problems. You can read more details about this potentially high-impact project along with other faculty news in this newsletter.

Earlier this year, we've had some excellent opportunities to visit and reconnect with our CBE alumni family. In particular, alumni and friends gathered at the Space Center Houston, where we also celebrated Thejas Wesley, a CBE undergraduate who received a prestigious scholarship from the Astronaut Scholarship Foundation. It was a great opportunity to visit with our Houston-area alumni and learn about their experiences as students in the department, and the latest from their impactful careers.

Further, this year's Founders Lecture was presented by John Church (BSChE '88). John is the executive vice president, supply chain, of General Mills Inc. At the lecture, students learned about John's experience as a summer lab student and how this played a significant role throughout his career. John's presentation, "Reflections of a UW chemical engineer: The real world is a lot like summer lab," gave students a new way of thinking about the training they receive in summer lab and how this translates into real-world experiences that students encounter in their careers. This message is very timely as current students are preparing for their summer lab experience in June and

IN FEBRUARY, THE COLLEGE OF ENGINEERING HOSTED AN ALUMNI EVENT AT THE SPACE CENTER HOUSTON, AND THE GROUP INCLUDED MANY CBE ALUMNI.

Pictured *(from left)*:
Lars Grabow, Jon Konen, Eric Lewandowski, Braden Sprecher-Reinke, CBE Professor and Chair Manos Mavrikakis, Joe Zimny, Steve Ward, Cheryl Salmonson, Brett DuCharme, CBE senior Thejas Wesley, Jim Hillier, Joseph Spence, Wade Wallinger, Ben Radtke, and Eric Hubatch.

July. You can learn more about John's distinguished career in this newsletter.

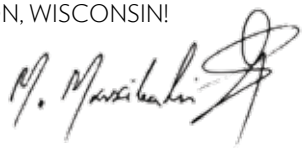
More recently, Professor Julia Kornfield of California Institute of Technology presented the annual BSL Lecture, including some unique highlights on the impact Bird, Stewart and Lightfoot had in chemical engineering education. At the time this letter is being written, we are looking forward to the annual Hougen Lectures by Professor Ignacio Grossman of Carnegie Mellon University.

In this newsletter, you can also read about the 40-year distinguished career of Gordon Brunner (BSChE '61) at Procter & Gamble. Among others, Gordon contributed greatly to the success of popular product brands that include Crest, Tide and Dawn, and currently serves as the chairman of the Wisconsin Alumni Research Foundation (WARF) commercialization committee to help commercialize UW-Madison inventions.

Our students continue to distinguish themselves through their scholarly activities. Most recently, three of them were awarded a very competitive and prestigious National Science Foundation (NSF) graduate fellowship: Kimberly Dinh (BS '15), currently pursuing her PhD at MIT; and Daniel Vigil and Thejas Wesley, who are both about to head to graduate school for their PhD studies.

We are always interested in hearing about you. Tell us about the great things that are happening with your lives and careers. If you have news you would like us to consider including in our future newsletters, please email your news to us at che@che.wisc.edu.

ON, WISCONSIN!



Manos Mavrikakis
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Ann Leahy

ALL WAYS FORWARD

The Department of Chemical and Biological Engineering long has stood as one of the top-ranked programs in the world, thanks to groundbreaking contributions to our research and teaching missions and the generosity of our loyal alumni. Your philanthropic support makes a tremendous difference in our ability to continue to provide an exceptional education for the next generation of chemical and biological engineers, while pursuing cutting-edge research. On behalf of the department, thank you for your loyal and generous support over the years—particularly throughout the university's ongoing comprehensive campaign, All Ways Forward.

One of the easiest ways to leave a lasting legacy in the department—and contribute to the All Ways Forward campaign—is to include a gift to the University of Wisconsin Foundation for the department in your will. This is the most common avenue that our donors take in making an investment in UW-Madison through their estate. Charitable gifts made through a will are 100-percent tax deductible; no federal estate tax or state inheritance tax applies to such gifts. This means you can be sure the full value of your gift goes for the purpose you intend.

Bequests have made a tremendous impact on the department and are a crucial pillar of support for us. These gifts have provided support for faculty members to pursue new frontiers of research and teaching methodologies, as well as flexible resources that enable the department chair to address our most pressing priorities, maintaining and enhancing the program's excellence.

For instance, in 1995, we were very fortunate to receive a generous gift from the Paul A. Elfers Trust (CBE '26), which created two professorships in his name. Christos Maravelias and Manos Mavrikakis both hold a Paul A. Elfers Professorship. This gift has been transformative to their careers, allowing them to create many key initiatives in research and teaching. It has also provided these faculty with the resources to expand student research opportunities—an area of emphasis in the department and the college—to better prepare our students for challenging careers and to build stronger ties among our students and the faculty. Recently, another alumnus and his wife made a generous pledge through their estate to create a future chemical and biological engineering graduate fellowship—a top area of need for the department.

If you're interested in discussing the idea of a bequest, please feel free to contact me. My colleagues in the office of gift planning at the UW Foundation also are available to answer specific questions about a variety of planned giving strategies.

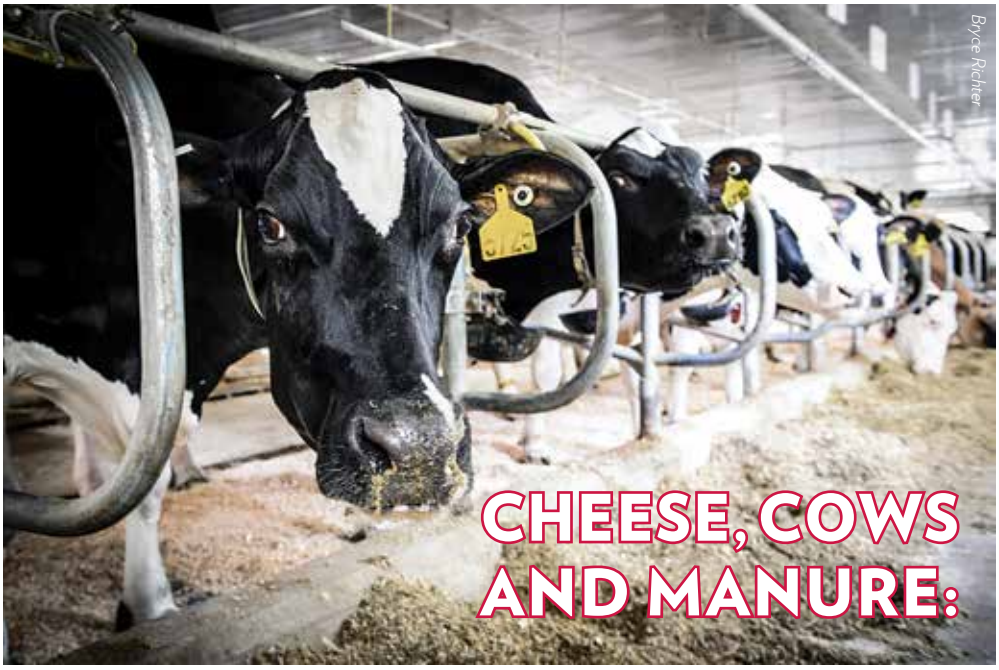
If you've already included us in your estate plans—thank you! We encourage you to include the language in the box on the right in your will provision or estate plan, and work with UW Foundation to create a memorandum of agreement to assist the UW Foundation in following your wishes for the use of your gift. You can update the agreement at any time, allowing for future flexibility, if needed.

After you inform the UW Foundation that you are including the department in your estate plans and in recognition of your generosity, you will become a member of the Wisconsin Legacy Society.

If you have included us in your will provision or estate plan, we encourage you to include this language:

"I hereby give, devise and bequeath to the University of Wisconsin Foundation, a non-profit, non-stock Wisconsin corporation with its principal offices in Madison, Wisconsin, the sum of _____dollars ($_____) to be used for the Department of Chemical and Biological Engineering at UW-Madison. It is understood and agreed that should the purpose for which this bequest is instituted cease to exist, then the Foundation may devote said bequest for such other uses and purposes as it determines to be in accordance with my original intent in making this gift."

Ann Leahy is the associate vice president and managing director of development for the College of Engineering. She collaborates closely with department chair Manos Mavrikakis and Dean Ian Robertson on raising financial resources to support the department's highest priority initiatives. Contact her: ann.leahy@supportuw.org or (608) 316-5874.



CHEESE, COWS AND MANURE:

For all stakeholders, systems approach makes tough decisions easier to digest

Wisconsin is known as America's dairyland— more than one third of all the cows in America live on some-3,000 farms in the state. Those bovine residents contribute to a thriving dairy industry, but milk is not the only thing that they produce in prodigious quantities. That many cows inevitably leads to a significant amount of manure, and managing that organic waste is an important problem for everyone living in the state.

"It is a horribly complex problem, and we all contribute to it and are affected by it," says Victor Zavala *(pictured, pointing)*, the Richard H. Soit Assistant Professor. "Farms generate the manure and we are all affected by its environmental impacts. But manure production is driven by strong economic forces originating from urban areas that demand dairy products."

Phosphorus runoff from manure causes algal blooms in water bodies. Manure also releases pathogenic bacteria and methane gas. Technologies do exist to process organic waste, while at the same time recovering valuable products such as biogas and struvite for fertilizer; but these technologies are expensive and affordable only for large farms.

Yet, deciding on a suitable solution involves much more than technology cost alone: Where to locate manure processing plants, how to transport the waste, and who should pay for the equipment are all challenging questions. With so many competing interests, no single individual can realistically keep track of all the costs, benefits, and constraints. "This problem is too complex. You need to find simpler and more direct ways to explain the interactions between social, economic and technology aspects to people making decisions," says Zavala.

Conflicting stakeholder interests complicate the problem further; most of the time such conflicts arise unnecessarily because of a lack of data about technology and logistical constraints.

A decision-making framework can help people to better grasp the large number of factors that need to be considered and to narrow down the options to a few potential solutions—and Zavala and his colleagues are developing such a framework to help people reach agreements in complex and potentially controversial decisions such as manure management. By systematically quantifying costs, environmental impacts, and people's opinions and priorities, these tools can help lead to compromise solutions that maximize collective stakeholder satisfaction.

"We are hoping that with this framework, we can have a more informed negotiation process. Instead of just telling stakeholders what they should do, we want to provide better frameworks for people to negotiate on what the manure management infrastructure would do," says Zavala, who is leading the effort along with Rebecca Larson, an assistant professor of biological and systems engineering at UW-Madison. "The framework can also be used to inform stakeholders on how their opinions influence (or not) the final decision. That is a powerful piece of information."

In related research, Zavala and colleagues recently completed a project on organic waste management in Dane County, Wisconsin. That team included UW-Madison/UW Extension collaborators from the Departments of Biological Systems Engineering, Chemical and Biological Engineering, Soil Science, and Water Resources Management. Funding for the project was provided by Dane County. The team's analysis of the livestock in the Upper Yahara Watershed study area indicates an excess of up to nearly double the manure phosphorus in comparison to crop uptake. The level of excess indicates a need to redistribute the manure outside the study area.

The U.S. Department of Agriculture, the National Science Foundation, the U.S. Environmental Protection Agency, and Dane County in Wisconsin are supporting the research.

A new approach to combatting bacterial infections:

DISRUPTING THEIR COMMUNICATION

We call them "superbugs"—and antibiotic-resistant bacteria are literally an evolving threat. Doomsday prophets and other pessimists foresee a future where superbugs run amok, overwhelming doctors' efforts to rid once easily treatable bacterial infections. Even optimists recognize the problem of antibiotic resistance as a serious public health threat. That's why researchers around the world are looking for novel approaches to control bacterial infections, and one promising approach is taking shape in labs at UW-Madison.

Collaborators David Lynn, the Duane H. and Dorothy M. Bluemke professor and Vilas Distinguished Achievement professor, and Helen Blackwell, a professor of chemistry at UW-Madison, approach the control of bacterial infections not by blasting them with toxic antibiotics, but instead by inhibiting the ability of bacteria to become infectious in the first place.

Many common species of bacteria, including those that cause dangerous infections, are actually fairly harmless at certain stages in their lifecycle. These bacteria become infectious—or virulent—only when they sense that their numbers have crossed a certain threshold. Once that threshold is crossed, a message travels through the colony, which signals that it's time to go on the offense and infect their host. This communication process is called quorum sensing, and it's a potential weak spot for bacteria.

That's because researchers are beginning to understand the mechanisms behind quorum sensing so well that they've been able to produce molecules that inhibit the process. It's a potential breakthrough not only in preventing new infections, but also in potentially slowing the pace of antibiotic resistance. Quorum sensing inhibitors don't kill bacteria—they simply render them impotent, allowing a host's immune system to zap them before they become infectious.

Antibiotic resistance is the product of the selective pressure of toxic drugs that kill most bacteria, leaving behind only those with resistant traits—however, quorum sensing inhibitors don't kill bacteria and therefore should not create the selective pressure that leads to anti-

David Lynn and Helen Blackwell

biotic resistance. Blackwell's lab has successfully produced many different types of quorum sensing inhibitor molecules.

Meanwhile, Lynn's lab is developing novel methods for delivering these quorum sensing inhibitors to the body. New research published in the journal *ACS Infectious Diseases* describes their latest approach, using a technique called electrospinning that produces tiny nanofibers that contain the inhibitor molecules. "The technique involves passing a polymer solution through a needle," says Lynn. "That needle has a large electrical potential, resulting in basically a jet of wildly fluctuating polymer solution from the tip of that needle. The dimensions of that jet just happen to be on the nanoscale."

The solvent then evaporates and leaves behind fibers with diameters on the order of several hundred nanometers. These fibers, which contain the inhibitor molecules can be collected as non-woven 'mats' or coatings on the surfaces of many kinds of materials, including common mesh-like wound dressings.

Perhaps what makes the nanofiber delivery method most exciting is that the nanofibers control the release of the inhibitor molecules as they degrade.

This timed release is a key goal of Lynn's research as quorum sensing inhibitors aren't much use if they don't stick around long. The nanofibers in this current research have controlled release of the inhibitor for about two weeks, but some of Lynn's other approaches have controlled release up to eight months.

In addition to wound dressing applications, Lynn sees potential for the approach to be used in medical implant devices and both on its own or in concert with conventional antibiotics. He continues to work on other quorum sensing inhibitor delivery methods, and he and Blackwell are teaming up with researchers in the veterinary medicine and microbiology programs at UW-Madison to begin testing in mouse models.

Still, Lynn cautions that it will be some time before quorum sensing inhibitors are part of doctors' antibacterial armament. "This anti-virulence approach is brand new and there's a lot of science that still needs to be understood," Lynn says. "There's a lot of work to do yet."

Photos: Stephanie Precourt

David Lynn *(center)* and his students are developing methods to deliver molecules to the body that render certain bacteria impotent.

Left: George Huber. Above: Graduate student Kevin Barnett takes a liquid sample from a continuous flow reactor in Engineering Hall to analyze its composition, including the presence of 1,5-pentanediol.

RENEWABLE PLASTIC PRECURSOR COULD GROW CELLULOSIC BIOFUEL INDUSTRY

A team of UW-Madison chemical and biological engineers has found a way to produce from biomass a valuable compound used in plastic production that they estimate could lower the cost of ethanol produced from plant material by more than $2 per gallon.

The development is the latest in an ongoing effort at UW-Madison to create commodity chemicals currently derived from petroleum out of biomass. These bio-derived chemicals could serve as high value co-products of the biofuels manufacturing process, improving the economics of cellulosic bio-refineries.

"This breakthrough shows how biomass-derived commodity chemicals can economically be used to replace petroleum-derived products," says George Huber, Harvey D. Spangler Professor. "It also shows how we might improve the rural economies in which biomass grows."

In their paper published recently by the journal *ChemSusChem*, Huber and collaborators report a new chemical pathway used to produce 1,5-pentanediol, a plastic precursor primarily used to make polyurethanes and polyester plastics. The group's highly efficient approach is six times cheaper than a previously reported method and represents the first economically viable way of producing 1,5-pentanediol from biomass.

Plant biomass is typically about 40 percent oxygen by weight, while petroleum oil is less than 0.1 percent oxygen.

"In our approach, we use the oxygen already inherent in the biomass to produce high-value oxygenated commodity chemicals that can be used to make performance polymer materials like polyurethanes and polyesters," says Huber.

The study's foundational discovery, its new pathway for chemical production, also provides fundamental chemistry that could be applicable to a wide cross-section of products. For instance, the same pathway could be used to produce two other plastic precursors—1,4-butanediol and 1,6-hexanediol—currently derived from petroleum and which together represent an annual market of a more than $6 billion.

In the days ahead, the team will continue to refine its work, collecting the data needed to scale up the process to pilot plant testing. The Wisconsin Alumni Research Foundation (WARF) is licensing the technology.

"We've had companies asking more about this exciting way to economically produce a valuable chemical from sustainable sources," says Leigh Cagan, WARF's chief technology commercialization officer. "Professor Huber's published work will bring us closer to engaging with industrial partners to commercialize this technology."

Huber was joined in the collaborative study by Professors James Dumesic and Christos Maravelias, experts in a catalysis and techno-economic modeling, respectively, graduate students Zachary Bentzel and Kevin Barnett, and postdoctoral researcher Kefeng Huang.

FAMILY, FOOTBALL & FAVORITE SUBJECTS

CONVERGE ON CHEMICAL ENGINEERING MAJOR

When high school senior Rachel Maguire joined her two older sisters—and scores of other red-clad Badger fans in Camp Randall's student section—to watch a football game in fall 2013, she said to herself, "I could get used to this!"

Three-plus years and many new friends and experiences later, her career plans have changed a bit, but watching a Badger game is still her favorite pastime on campus. As the youngest of three sisters hailing from Wausau, Wisconsin, to enroll at the UW-Madison, it was easy enough to follow their footsteps and even choose the same major—chemical and biological engineering—as her middle sister, Shaenah.

Rachel Maguire *(left)* with her older sisters Chelsie and Shaenah at a Badger football game in 2013. Shaenah (BS '16) works at IM Flash in Utah. Chelsie received a BS in medical microbiology and immunology in 2013 and an MS in May 2017 from the physician assistant program at UW-Madison.

But Maguire's enduring interests don't end with football games. She fell in love with chemistry in 2011, thanks to a chemistry-focused science outreach project run by one of her favorite high school teachers, Bill Heeren, and the Milwaukee School of Engineering. Since she had always been good at math, chemical engineering seemed like a perfect fit.

Maguire also became fascinated by stem cell research at a young age, partly because she toured Anita Bhattacharyya's lab at the UW-Madison Waisman Center, where her oldest sister, Chelsie, worked in 2010. Today, Maguire works in a similar lab directed by Surgery Professor Jon Odorico. While she didn't have a fully developed set of biomedical lab skills when she started, her engineering classes came in handy for troubleshooting experiments.

"When research projects don't work out as you expect them to, which is the majority of the time, you have to be able to break down the process and figure out what's helping or hurting," Maguire says.

Beyond classes and hands-on research, UW-Madison provided another formative experience. The summer after her freshman year, Maguire went to Tanzania with the student organization Medicine, Education and Development for Low-Income Families Everywhere, helping local physicians triage patients and set up mobile clinic equipment.

"In Tanzania, I realized that you can treat people individually, but ultimately, the infrastructure plays such a big role in why they fall ill," Maguire says.

Having initially considered medical school, she says her time in Africa convinced her to go "lower" in the process, working to prevent people from getting sick instead of just treating them.

In 2016, that change in perspective led her to reach out to Symbiont, a Milwaukee-based consulting firm of engineers and scientists, for a summer internship focused on wastewater treatment. "Wastewater isn't glamorous, but it's important," Maguire says, remembering how often polluted rivers in Tanzania contributed to the illnesses she witnessed.

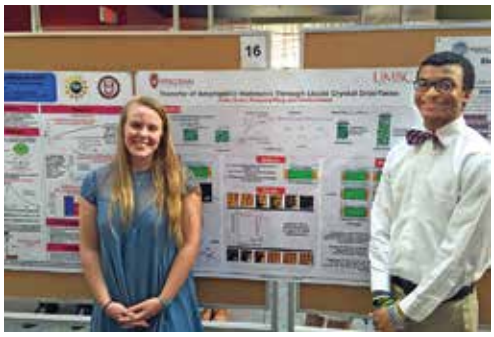
She decided to return to Symbiont in summer 2017 for two other reasons: the company's small size—typical of many engineering consulting firms—that allows for personal connections between employees and executives, and the variety of projects consultants get to work on.

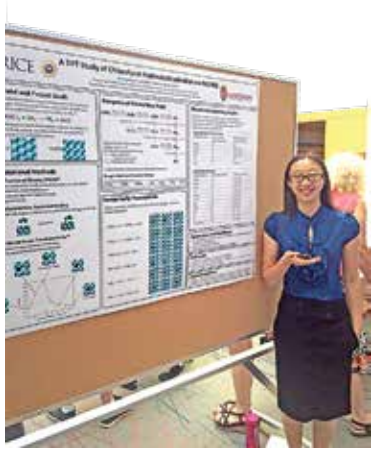
After graduating in spring 2018, Maguire plans to enter the workforce, but could see herself pursuing graduate school down the road. Before completing her degree, she hopes to have a little more time to enjoy UW-Madison's beautiful campus and the city's lakes and trails during the summer. "One thing I love about Madison is that you have all the amenities of a midsize city, but then you walk to Picnic Point and it feels like you're somewhere else," Maguire says.

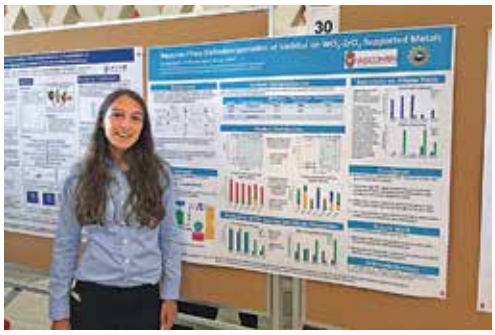
She doesn't regret the decision to follow her sisters' footsteps. "There is so much diversity at UW-Madison, not only in the cultures of the people who study and work here, but also in majors," Maguire says. "You can't go to any other school in Wisconsin and have friends with any kind of major you can think of. I've really enjoyed that."

Below: Maguire *(fourth from left)* on a 2015 trip to Tanzania.

Photos courtesy of Rachel Maguire.







FOR UNDERGRADS, PROGRAM PROVIDES UNPARALLELED RESEARCH OPPORTUNITIES

For undergraduate students who may not have research opportunities at their own institutions, the Research Experience for Undergraduates in Chemistry and Chemical and Biological Engineering at UW-Madison offers an unparalleled opportunity to conduct research under some of the world's most accomplished faculty members.

A program offered through the chemistry, chemical and biological engineering, and materials science and engineering departments at UW-Madison, the REU brings students from across the country to the university for 10 weeks in summer to do research guided by UW-Madison faculty and graduate students.

The program began with a five-student cohort in 2006, with funding from the National Science Foundation through the Nanoscale Science & Engineering Center at UW-Madison. The success of that initiative inspired program director Andrew Greenberg and collaborators to keep it going. In 2010, they applied for and received an NSF grant to support further development of the REU program, which has since been renewed in 2012 and in 2017. Now nationally acclaimed, the program receives 500 to 700 applications to fill 35 to 40 slots each year.

The REU program also provides infrastructure for other summer research experiences at UW-Madison, supporting a larger community of scholars and creating a rich and educational community that benefits all involved.

"Students are immersed socially as well as professionally," says Greenberg, a distinguished faculty associate in CBE. "They're integrated into a program where they can have the full experience."

Successful REU applicants are placed in the labs of participating faculty mentors who foster growth in the applicants' areas of interest.

According to Andrew Greenberg, 10 to 20 percent of students who go through the program ultimately return to UW-Madison as graduate students.

In chemical and biological engineering, past REU alumni have researched stem cells under Milton J. and A. Maude Shoemaker Professor Sean Palecek, biofuels in the labs of Ernest Micek Distinguished Chair James Dumesic and Harvey D. Spangler Professor George Huber, and liquid crystalline materials under John T. and Magdalen L. Sobota Professor and Hilldale Professor Nicholas Abbott, to name a few. Working closely with faculty and graduate students in these labs, students attend weekly faculty-led seminars, participate in professional development opportunities, and present their research in a poster session at the end of the summer.

One aspect of professional development the program offers is improvisation workshops, which encourage students to be creative and think on their feet. The idea for these workshops came from science and engineering communication workshops at the Museum of Science in Boston. Now Anne Lynn Gillian-Daniel, education director of the Materials Research Science and Engineering Center at UW-Madison and affiliate with the Madison-based improvisation studio Atlas Improv, coordinates the workshops for the REU and has helped to incorporate them into UW-Madison's curriculum. According to Greenberg, 10 to 20 percent of students who go through the program ultimately return to UW-Madison as graduate students.

Greenberg enjoys seeing students, particularly those from community and technical colleges, come to UW-Madison for the summer and discover that graduate school is an attainable goal—that they actually can conduct innovative research at a top university. "Seeing students grow over the summer and seeing the program convince students that they have what it takes to compete with anybody and launch their careers—that's really rewarding for me," Greenberg says.

"Engineering doesn't teach you what to do; it teaches you how to think," says John Church, executive vice president of supply chain at General Mills.

Church, who was born in Boston, lived in Jacksonville, Florida, and attended high school in De Pere, Wisconsin, earned his bachelor's degree in chemical engineering from UW-Madison in 1988.

He has worked for General Mills ever since. Over nearly 30 years with the company, his work as an engineer has morphed into a career as an international businessman and corporate executive.

The skills he learned as a chemical engineer have followed him to this day. Even so, for Church, the most crucial part of the infamous chemical engineering summer lab was learning how to effectively make a point.

"The lab reports matter," he says. "They teach you how to communicate. In the business world, everyone assumes *they're* right. You have to be able to convince other people that you're right. In summer lab, that was worth doing—convincing people that *your* answer was the right answer."

Church began working for General Mills with a clear idea of what he wanted from his career. Accustomed to the world of science and the jargon of engineers, he liked the idea of representing a product—something that existed outside of the laboratory.

Like a ubiquitous breakfast cereal, for instance.

"The idea of being in consumer products—where people can see and relate to your work—was important," he says. "Because when I was a chemical engineering student, no one knew what we were talking about."

The adaptive nature of the industry—a marketplace that follows the ever-changing desires of the consumer—appealed to him. And opportunities for growth seemed limitless and diverse. For example, even though he worked for General Mills in research and development as a product developer and plant manager, he also gained exposure to the legal and marketing sides of the business. "General Mills never let me get bored," he says. "I always had something exciting to do."

In 1991, just a few years out of college, he led the development of Multigrain Cheerios, the fourth type of Cheerios in the world. A new product requires new plants, new suppliers, and new technology to make and distribute it. Church was at the forefront of these developments.

A few years later, he relocated from Georgia back to Minneapolis when General Mills acquired Pillsbury. His role was to lead the supply chain integration of Pillsbury and General Mills in North America. Coincidently, Church had interned at Pillsbury in research and development during the summer before his senior year of college.

Over time, Church continued to take leadership roles with increasing responsibility, working as vice president of engineering, adding procurement and logistics to his responsibilities and now, as the leader of the global supply chain, a position that he's held for nine years.

In this role on the General Mills senior management team, he is accountable for more than half the company's employees. Many mornings he wakes up early to call Europe or Asia, discussing challenges or aligning on strategy. If he's not on the phone or traveling, he's in meetings or coaching sessions, ensuring that his employees have the tools to make the right decisions and breaking down any barriers to their success.

"My job is to make sure that I can take what our business strategies and company strategies are and translate them into a technical and operations agenda for my team around the world," Church says.

To this day, Church fondly remembers his time as a UW-Madison student: tailgate parties in his front yard for every UW-Madison football game, study breaks for Babcock ice cream, and walks down State Street. And he says he still draws on his valuable chemical engineering training, which allows him to adapt and react when the need arises.

> "Engineering is about problem-solving, input and output, losses. All of those things apply to every situation there ever was," he says. "Whether it's a business process or chemical process, there are things I need to do to catalyze that reaction. The world is like a laboratory."

Through our prestigious Founders Lectureship, Church returned to UW-Madison in January 2017 to give the talk, "Reflections of a UW chemical engineer: The real world is a lot like 'summer lab.'"

In career at Procter & Gamble, alum GORDON BRUNNER developed products that improve people's lives

Did you brush your teeth with Crest toothpaste this morning? Are you wearing clothes washed with Tide laundry detergent? Did you eat your breakfast with tableware washed with Dawn dishwashing liquid?

If so, Gordon Brunner has had an impact on your life today. Crest, Tide and Dawn are just three examples of the many Procter & Gamble brands that alumnus Gordon Brunner (BS '61) contributed to in his 40-year career at P&G.

In the late 1950s, when the fields of biochemistry and chemical engineering were rapidly evolving and interacting, Brunner came to Madison to study fluid flow and energy transfer under R. Byron Bird, Warren Stewart and Edwin Lightfoot, professors who spearheaded the field of transport phenomena.

At that time, Brunner recalls having to learn from Bird, Stewart and Lightfoot's rough notes because there was no comprehensive book until the trio completed its seminal textbook, *Transport Phenomena,* in 1960. Brunner says the opportunity to learn from professors as they were innovating was priceless. "I felt like I was at the best chemical engineering school in the world," recalls Brunner. "The timing was just perfect."

After graduating from UW-Madison in 1961, Brunner earned an MBA from Xavier University at night while beginning work at P&G in Cincinnati. He worked in research and development his entire career, starting with food and detergent product development before assuming management leadership positions later in his career.

At P&G, Brunner was drawn to the challenge of developing consumer-preferred products with the goal of solving tough everyday problems. "The products may seem mundane, but the technology behind them is actually very sophisticated," he says.

As an illustration of that sophistication, P&G received the U.S. Medal of Technology in 1995—an award normally given to individual outstanding scientists, but uniquely presented to P&G for its innovation. Brunner accepted the award from then-U.S. President Bill Clinton on the company's behalf.

One of Brunner's favorite brands to work with was the Pantene line of hair products. Before the 1980s, hair products were utilitarian and lacked unique functional benefits. Shampoos cleansed, but also removed desirable hair softness and manageability. Conditioners were marginal in adding benefits, and required a separate step. The notion of a 2-in-1 product that combined shampoo and conditioner functionality was revolutionary and very difficult to achieve technically. For example, when shampoo and conditioners are combined, they interact chemically, resulting in a product that doesn't clean or condition. But Brunner and his colleagues discovered how to solve this conundrum. The result was the new brand Pantene, which became the world's largest hair care brand during the late 1990s.

After developing products in Cincinnati for more than a decade, Brunner became P&G's European director of research and development operations from 1976 to 1983. He became vice president in 1985, senior vice president in 1987, and chief technology officer in 1999. He was also elected to P&G's board of directors in 1991 and served until his retirement in 2001.

Aside from seeing five new multi-billion-dollar global brands—Tide Liquid, Pantene, Swiffer, Febreze, and Actonel osteoporosis drug—launched during his tenure as CTO, he is also proud of restructuring the company's technical career system.

These days, Brunner still is active professionally. He serves on several boards, does consulting work, gives talks, and serves as the chairman of the Wisconsin Alumni Research Foundation commercialization committee to help commercialize UW-Madison inventions.

Brunner is a longtime golf enthusiast; in fact, having caddied through high school, he attended UW-Madison on an Evans Scholarship, which supports deserving caddies. These days, he applies his engineering acumen in the golfing arena as chairman of the Equipment Standards Committee for the PGA Tour. In this capacity, his committee interacts with the U.S. and International Golf Associations to study golf science and develop global standards for golf balls and equipment.

Brunner's passion to create things fuels his leisure time as well. "My desire as a youngster was to make and fix things—I was always a tinkerer," he says.

While working at P&G, Brunner spent at least an hour in his home workshop almost every evening to decompress from the day's work, crafting items such as baby cribs, high chairs and rocking horses for his eight grandchildren. An avid gardener and longtime member of the American Hosta Society, Brunner also experiments with unique hybrids, and caters his gardening repertoire to the different climate zones in Florida, Michigan and Ohio. "I'm not the kind of guy who sits around a lot," he says.

Alumnus Paul Hansen's ingenuity spawned successful 3M products

Behind every innovation, from Scotch Tape to Post-It Notes to medical masks, there is a creative thinker, a team, and a company pushing for success. In the case of these products, 3M is that company, and Paul E. Hansen, a 1954 graduate of CBE, was one of those creative thinkers.

Since it was founded in 1902, 3M has created a wide variety of products that solve everyday problems, as well as supported the teams of creative people who dreamed them up. Hansen began working at 3M at a time of high innovation for the company, inventing many original products in his time, and acquiring multiple patents.

In 3M's early days, the focus was strictly on abrasives—and in particular, sandpaper. Some of the company's most active customers were auto shop workers, who added these abrasives to the arsenal of products they used to paint cars. These paint jobs weren't always easy—and auto workers themselves had to get creative in completing their jobs.

A man by the name of Dick Drew, a scrappy 3M lab-assistant-turned-engineer, took note of these challenges and decided to find a solution. After Drew's first huge success, a patent on masking tape, the company started to expand and to see the immense value in inventiveness.

Drew was a risk-taker. A college dropout from the University of Minnesota, he was not a conventional engineer. To facilitate his inventions, he had to work creatively. 3M took note of his methods, as well as his successes, and decided to give him the room he needed to run with his ideas. 3M's Product Fabrication Lab was born.

Housed in an old dairy building away from 3M's regular campus, the Pro-Fab Lab was the playground of many engineers. Drew filled it with innovative people, regardless of their education levels, and gave them total freedom to create under his mentoring. This is the environment into which Paul Hansen was hired. A young engineer, fresh out of UW-Madison, Hansen was in his element.

3M, centered in St. Paul, Minnesota, was hiring heavily at a time of high innovation, and Hansen made himself the type of asset that Drew was looking for. And Drew was exactly the type of mentor that a young engineer like Hansen needed. "He was very creative and helped people always," says Hansen.

Encouraged to work with their own ideas, Hansen and his team began the creative inventing work that would come to be the trademark of the Pro-Fab Lab.

Upon his hiring, Hansen began working with nonwoven fabrics. The company's newly acquired Rando Webber, a machine that formed a special kind of nonwoven fabric, fell under his control, and his first task was figuring out all the potential the brand-new machine held. "I was full of energy and kind of acted as a missionary to the other labs and to 3M, showing them what we could do with this new machine," says Hansen.

By this time in 3M's history, the company had a very good grip on adhesives, and the state-of-the-art pressure-sensitive tape pioneered by Drew was already turning a good profit for the company. But this tape had adhesive backings that were far from ideal for medical applications. Micropore tape, one of the first big successes for Hansen's team, replaced older medical tapes that irritated the skin and were painful to remove.

Several other medical tape products followed the success of Micropore, and by this time, 3M had developed a small medical products division, of which Hansen became a lab manager. And the innovation continued with increasingly efficient medical tapes and later, surgical masks. At the time, surgical masks were nothing but cheesecloth tied over the nose and mouth. But the medical division saw opportunity and began working on a molded polyester that had many potential applications.

"Actually, the first patent we got on that was for bra cups, of all things," says Hansen.

Some of the products created under Hansen drew on 3M's early emphasis on abrasives, but with a new spin, thanks to the Rando Webber. For example, a unique scrubbing pad called Scotch-Brite pads; a kitchen cleaning staple to this day, they were perfect at the time for scrubbing linoleum floors that would have been damaged by the less-than-ideal steel wool they replaced.

"Actually, the first patent we got on that was for bra cups, of all things," says Hansen.

Hansen applied his ingenuity to many other products, including Petrifilms, a film coated with adhesive and nutrients and used to easily culture various microorganisms; and Coban, a stretchy band used for medical applications. Today, it's popular as the material placed around the arm after giving blood. Tegaderm, another member of the medical products line, was and remains popular in the medical field. A transparent film through which wounds can be observed while they heal, it was yet another big success.

In 1979, Hansen was inducted into the 3M Carlton Society. This honor, named after 3M's fifth president Richard P. Carlton, is the company's highest recognition, given to scientists who have made extraordinary contributions.

With the freedom to be a problem-solver, as well as having the influence of a phenomenal mentor and a supportive company, Hansen was able to engineer products that are essential to our daily lives. As Drew puts it, Hansen "took the blinders off" to produce profitable products and, most importantly, improve global lives and health by endlessly thinking outside the box.

Lifetime loyal Badgers return to Madison, bearing estate gift for CBE Department


Harriette and Jack Burkhalter

Harriette and Jack Burkhalter graduated from UW-Madison in 1957—Harriette with a BS in chemistry and Jack with a BS in chemical engineering. Recently, after years of living in Minnesota in the summer and Arizona in the winter, the couple—who met as undergraduate students—finally moved back to the home of their alma mater. They accompanied their move with an estate gift to the department annual fund.


The 1956 CBE summer lab. Jack is sitting in the middle of the fourth row.

The annual fund is discretionary—it gives the department the opportunity and flexibility to support initiatives for which funding is not immediately available. The estate gift itself is a "planned gift," which means it is integrated into the giver's will *(learn more about making estate gifts on page 3)*. "We were motivated to donate by our respect for the university—what it has done for us and our life, and out of respect for the department," Jack says. "Certainly, I got a very good education there, and it did well for us, and we wanted to give something in return."

He and Harriette first met in a freshman chemistry course at UW-Madison. Although 60 years have passed since their time as undergraduate students, the two still have vivid and fond memories of their times at the university. Jack, for one, still remembers the difficulty of the chemical engineering summer lab. "It was probably the hardest I've ever worked in my life," he says. "It was almost 40 hours of class and 40 hours of homework a week, and a very difficult thing to get through."

Harriette, who grew up in Chicago, decided to attend UW-Madison after a family friend made a recommendation that stuck with her: "It doesn't matter what you study at UW-Madison; you will get a good education."

Jack and Harriette attended the university at a uniquely fortuitous time for both of them. Harriette recalls being one of the few females in the chemistry department at the time, and being lucky to learn under high-quality faculty who, she says, cared about their students and challenged them. Jack had the opportunity to learn chemical engineering under R. Byron Bird, Warren Stewart and Edwin Lightfoot.

After graduating, the two moved to Minnesota, where Harriette worked as a research associate for 3M, and Jack was an operations engineer with Cargill, in food processing plant operations. He continued to work for Cargill until his retirement in 1997.

The two—even after 60 years of living away from Wisconsin—are loyal Badgers. "I grew up in Madison, and I've been going to football and basketball games since I was old enough to take the bus to campus," says Jack, who also attended the UW-Madison high school before it closed in 1964.

He and Harriette continue to cherish their connection with the university and with Madison as a whole. "We really liked the idea of coming back to Madison; it's a great place to live, and in retirement, we have more time on our hands to enjoy it," says Jack.

ALUMNI NEWS

David Griffith (PhD '77) wrote to tell us that he published a book, *Basic Principles and Calculations in Process Technology*, for process operators who work under process (chemical) engineers. He also developed an eLearning course about statistical control charts for AIChE. Offered in October 2016, the course applies to all engineering disciplines, as well as many other non-engineering activities.

Roger Harrison (MS '69, PhD '75) was inducted as a fellow of the American Institute for Medical and Biological Engineering. Fellows are a select group of the top 2 percent of medical and biological engineering professionals and represent the most accomplished and distinguished medical and biological engineers responsible for innovation and discovery.

Jim Hillier (BSChE '00, BS Biochem '00 and BS Molecular Biology '00) is the new site manager at the LyondellBasell Clinton Complex, one of the largest chemical plants in Iowa. Hillier's return to Clinton is a homecoming of sorts, as he previously worked in the city as an engineer from 2004 to 2007.

Jensen family fellowship will help CBE attract top grad students

Mike and Mary Jensen, longtime Bascom Hill Society members, are adding to their history of giving to UW-Madison with the Jensen Family Chemical and Biological Engineering Graduate Fellowship.

Alum Mike, and Mary, a University of Nebraska chemical engineering alumnus, met through their work at the consumer goods giant Procter & Gamble. As a result, they approach giving with a consumer mindset. "We want to uncover what would be the most impactful," says Mary.

Mike and Mary Jensen

So they ask: What would make things better?

To address diversity, they created the Jensen Family Engineering Diversity Scholarship in 2006 for women of color studying engineering. "A more diverse work group means better solutions; better solutions help make the world better," says Mike.

The Jensens created the Jeannie and Jinny Undergraduate Grant Scholarship for women pursuing careers in nursing and education in 2015. They matched funds from the Nicholas match, a one-to-one gift match established by Ab and Nancy Johnson Nicholas to inspire other donors to fund undergraduate and athletic scholarships and graduate fellowships for UW-Madison students.

The Jeannie and Jinny grant honors Mike and Mary's mothers, Ruth Jeannine Ries and Virginia Jensen Balentine, whose self-reliance and perseverance inspired Mike and Mary's lives.

Next, they created the Jensen Family Volleyball Scholarship Fund to provide scholarships to volleyball student athletes in 2016. Mary and all three daughters played volleyball in high school, and the scholarship recognizes the value of athletics in education.

The Jensens' most recent gift also benefited from Nicholas match funds. This time they are funding the Jensen Family Chemical and Biological Engineering Graduate Fellowship. This fellowship addresses the department's desire to remain competitive in attracting top graduate students.

Educational and professional success has laid the foundation for the Jensens' giving. After dabbling in math and astronomy, Mike graduated from UW-Madison in 1973 with a bachelor's degree in chemical engineering. Upon graduation, he considered an array of career paths, including a racetrack photographer, a Peace Corps volunteer, and a consumer goods researcher.

The photographer position would have been lucrative, and the Peace Corps path would have been an opportunity to embody the Wisconsin Idea of public service that education at UW-Madison had instilled in him. In the end, still guided by the Wisconsin Idea, Mike decided on R&D with Procter & Gamble in the consumer goods industry. He saw it as a means to improve many lives in many ways. "It was an opportunity to help a little bit every day—with drier diapers, better feminine care products, tastier coffee, or new-to-the-world products like Febreze and Swiffer," says Mike.

Mike thought he might be at P&G for a few years, but it hooked him. He started there in 1973 right out of college and worked there until retiring in 2008.

These days, Mike helps companies of all sizes innovate with a few consulting projects per year. He also volunteers with the Yahara Lakes Association in Madison and serves on the Chemical Engineering Advisory Board.

Mary's path to engineering and consumer goods was more direct than Mike's. At age 13, Mary decided she wanted to be a chemical engineer based on a survey from a *Weekly Reader* magazine, and the rest was history. In 1974, she became fifth woman ever to graduate from the University of Nebraska with an undergraduate degree in chemical engineering. Like Mike, she went to P&G straight from college and remained there for her entire career, leading research efforts around the globe. Today she's active with JDRF and Impact 100, a women's group that provides one-time transformational gifts to nonprofit organizations.

The Jensens give to UW-Madison because of an affinity for the university that developed over the years. Besides Mike, three of the Jensens' four children attended UW-Madison. "There's a feeling you get when you're on campus," says Mike. "Other universities don't have the same vibrant ambiance," Mary agrees.

And Mary has personally contributed to the UW-Madison vibe in an unexpected way: Babcock Dairy's ice cream flavor "Bec-Key Lime Pie"—all Mary. She submitted the winning name and flavor idea in a contest to develop an ice cream in honor of incoming UW-Madison Chancellor Becky Blank.

Jeff Sprecher (BS '78) had a paper route, went to the Madison public schools, and made his way to UW-Madison as a chemical engineering student. No one, including Sprecher himself, would have ever guessed he would go on to buy the New York Stock Exchange. Hear how UW-Madison helped prepare him for his unusual career path in this first installment of the video series "Big Apple Badgers." **View the video:** www.engr.wisc.edu/big-apple-badgers-jeffrey-sprecher/

HUMBOLDT FELLOW JOINS CATALYSIS GROUP

In April 2017, the department welcomed Thomas Erhard Kropp, a visiting scientist from Germany who is supported by the Humboldt Foundation's Feodor Lynen Research Fellowship. Kropp received his doctoral degree in theoretical chemistry from the Humboldt University of Berlin in 2016 and has worked as an instructor and postdoctoral researcher at the same institution since then. He is studying the catalytic properties of materials derived from cerium, a rare earth metal that can be obtained at relatively low cost. Cerium oxides are of great interest in the development of fuel cells, which convert chemical energy, typically derived from burning hydrogen in the presence of oxygen, into electricity. They operate at higher efficiency than the combustion engines currently used by most cars and power plants and do not generate carbon dioxide emissions or other air pollutants. During his two-year visit, Kropp will work with the computational surface science and catalysis research group directed by Professor Manos Mavrikakis.

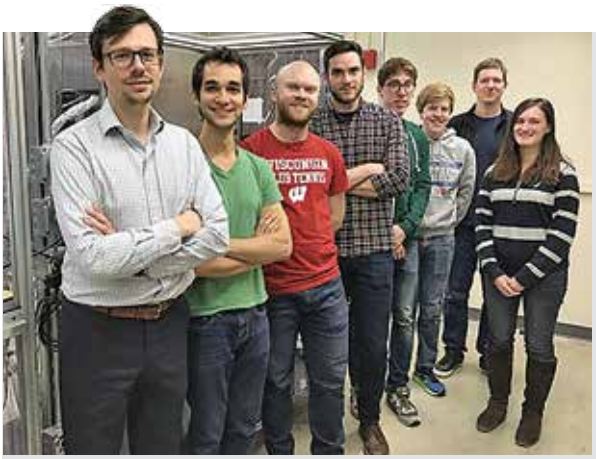


Photo courtesy of the Hermans research group.

A team of UW-Madison chemistry and chemical engineering researchers has discovered a new family of catalysts for converting propane to propene. From left, co-authors Ive Hermans, Juan Venegas, Joseph Grant, William McDermott, Philipp Mueller, Samuel Burt, Florian Goeltl, and Sarah Specht. Not pictured: Carlos Carrero.

Novel catalysts improve path to more sustainable plastics production

To meet demand for propene, a key component of plastics, the chemical industry has been working for decades to produce the compound through a chemical process called "oxidative dehydrogenation of propane" (ODHP). Now, Associate Professor Ive Hermans and his students have discovered a new type of catalyst to drive the ODHP reaction. In a paper published Dec. 1, 2016, in *Science*, a team led by Hermans reports success with hexagonal boron nitride and boron nitride nanotube catalysts in the chemical reaction that converts propane to propene. **More**: www.engr.wisc.edu/novel-catalysts-improve-path-sustainable-plastics-production/

GRAD STUDENT RECOGNIZED FOR OUTSTANDING PRESENTATION

In February 2017, PhD student Travis Arnold learned he gave the best presentation of the session at the annual meeting of the American Institute of Chemical Engineers (AIChE), which was held in November 2016 in San Francisco. The title of Arnold's talk was "Noise covariance estimation for an air separation plant" at the estimation and control of uncertain systems session of the meeting. Arnold's PhD advisor is Professor Jim Rawlings.

Current and former students receive NSF grad research fellowships

In March 2017, the National Science Foundation announced the latest recipients of its prestigious Graduate Research Fellowships, which include 18 UW-Madison students. Among these are two current CBE undergraduate students and an alumna who is now pursuing her PhD at the Massachusetts Institute of Technology.

Undergraduate Thejas Wesley plans to characterize the properties of new materials that can function as electrocatalysts: They modify the rate of a chemical reaction designed to generate electrical power without being consumed in the process. An example of such a reaction takes place in fuel cells, where hydrogen and oxygen are burned to generate electricity. Thejas' work will help discover novel catalysts that may eventually contribute to power generation with renewable sources, such as wind and solar energy.

Undergraduate Daniel Vigil's research also concerns renewable energy. He plans to develop new computational models of the chemical reactions that take place during the production of biofuels. Complementing traditional chemical experiments, computational modeling has become a powerful tool for understanding how to extract the maximum amount of energy from the complex reactions between biological molecules.

Kimberly Dinh, a 2015 CBE graduate who is a doctoral student at MIT, is studying the oxidation of methane, which makes up the majority of natural gas, to methanol. Natural gas has to be compressed in order to be transported. Since this is an expensive process, natural gas obtained as a byproduct in oil drilling is often burned at well sites. If, instead, the methane was converted to methanol, an energy-dense liquid that is easily transported with existing infrastructure, it could be utilized for a variety of downstream applications while reducing the environmental impact of oil drilling.

FACULTY NEWS

Nick Abbott was among 10 UW-Madison recipients of a prestigious WARF named professorship, which honors faculty who have made major contributions to the advancement of knowledge. He chose the name of his professorship: the Paul J Bertics Professor, which honors the memory of noted UW-Madison biomolecular chemistry faculty member Paul Bertics.

In November 2016, Clarivate Analytics (formerly the Intellectual Property and Science business of Thomson Reuters) named Professors **Jim Dumesic** *(left)* and **George Huber** to its 2016 list of highly cited researchers in the natural and social sciences. Researchers named to this list have been most cited by their peers and are considered to be among the world's most highly influential scientific minds.

Among UW-Madison faculty participants of the new U.S. Reducing Embodied-Energy and Decreasing Emissions (REMADE) Institute are Professor **George Huber** *(left)*, who is among the world's leading biofuels researchers; and Assistant Professor **Victor Zavala**, whose expertise centers around developing models for evaluating technological systems. Led by the Rochester Institute of Technology Golisano Institute for Sustainability, the institute is a U.S. Department of Energy Manufacturing USA initiative and is a national coalition of leading universities, national laboratories and industries that will forge new clean-energy initiatives deemed critical in keeping U.S. manufacturing competitive.

To recognize outstanding contributions to atomic-scale materials design, using first-principles electronic structure calculations, and to the fundamentals of chemical reactivity, the Michigan Catalysis Society awarded Professor **Manos Mavrikakis** its 2017 Guiseppe Parravano Memorial Award for Excellence in Catalysis Research.

Associate Professor **Jennie Reed** was among 11 UW-Madison faculty recipients of a Romnes Faculty Fellowship, which recognizes exceptional faculty members who have earned tenure within the last six years.

Victor Zavala was named an associate editor of the *Journal of Process Control*. Covering the application of control theory, operations research, computer science, and engineering principles to solving process-control problems, the journal is among the leading journals in the field of control.

IN MEMORIAM

Robert Ackerman (ChE '51) died in July 2016. After he graduated in 1951, he began working with Eastman Kodak, and over the years, his responsibilities included consulting on emulsion manufacturing in the company's facilities in the United States and in England, France, Mexico, Brazil, Australia and India. He also served at Ft. Belvoir, Virginia, as a first lieutenant in the Corps of Engineers, Engineering Test Unit, in charge of testing guided missile support equipment from 1954 to 1956. He retired from his career as an engineer in 1987 after nine years as director of manufacturing at Kodak Brasiliera. He was a member of the National Society of Professional Engineers, the American Institute of Chemical Engineers, the Photographic Society of America, the Society of American Military Engineers, and the Society of Photographic Scientists and Engineers.

Edward Charles Paulsen, age 94, passed away April 11, 2017. For 38 years, Edward worked as a laboratory engineer in our department. He served the U.S. Air Corps in World War II as a radio communication/Morse Code instructor. He graduated from Iowa Teachers School (University of Northern Iowa). You can make gifts in honor of Edward to our department by following the "Give" link on www.engr.wisc.edu/department/cbe/ and designating your gift to "Edward Paulsen."

Generous support from alum Mike and his wife Sherri Miske has helped Assistant Professor Reid Van Lehn establish his research program as he begins his faculty career in CBE. When the Miske family visited the department, they had the opportunity to meet Reid (right) and learn about his work.

Huber guest edits special journal issue focused on pyrolysis

In recent years, researchers have focused on fuel options that are more environmentally friendly, have lower carbon emissions, and are cheaper, while still viable with existing vehicles.

The journal *Energy Technology* highlights many types of energy research, including the fundamental issue of how to make various technologies commercially viable—and CBE alum John Uhlrich (PhD '09) is its editor.

In January 2017, biofuels expert and Harvey D. Spangler Professor George Huber was one of two guest editors of a special edition of the journal, which compiled articles all focusing on pyrolysis—the process of using heat to decompose a solid. It is a process in the field of biofuel production that currently is a hot research topic. "Pyrolysis is one of the most promising technologies to convert biomass into liquid transportation fuels like gasoline," says Huber.

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Our annual summer Research Experience for Undergraduates program is nationally acclaimed and attracts as many as 700 applicants each year for approximately 40 positions. *(Read more about it on page 8.)*