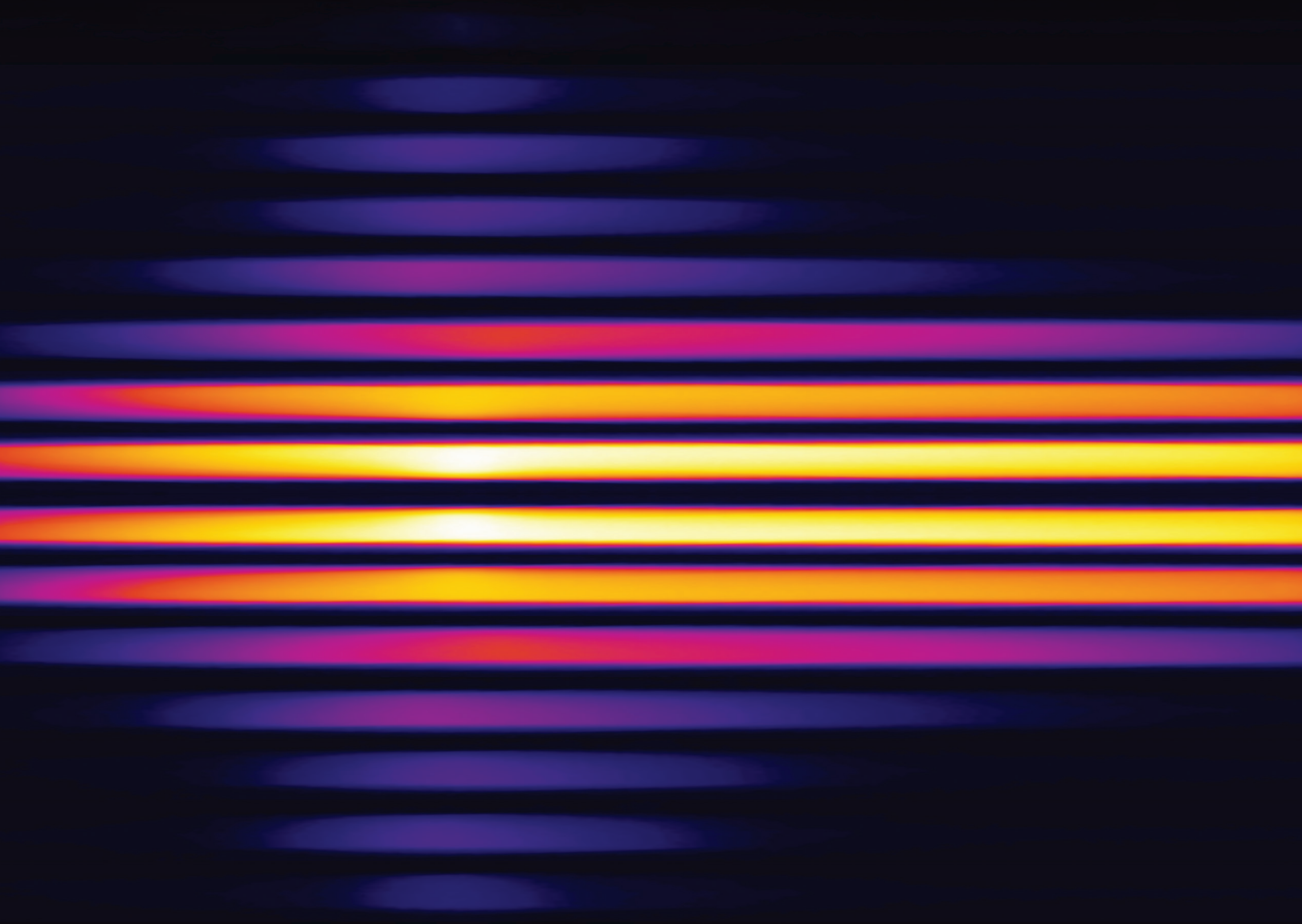
CHEMICAL ENGINEERING | UNIVERSITY *of* WASHINGTON

Catalyst

2019



Carrying the torch

When I became chair of the department at the start of 2019, I recognized the many great elements of our community that I needed to carry on into the future. I am grateful to my predecessor, François Baneyx, who did a tremendous job of cultivating a culture and climate of excellence in the department. I've fully embraced the charge to stay on this course, while finding ways to continue expanding our impact in the world.

My first year has been incredibly exciting. We've added to our faculty, bringing in new expertise in data science, advanced materials and systems biology, as well as an infusion of energy for teaching and mentoring. Recent department accolades include national recognition for some of our junior faculty, and undergraduate student success in campus innovation and entrepreneurship competitions. And we are on track to continue growing the faculty, strategically expand our research portfolio, and forge new partnerships.

Even as we look toward growth, we'd be remiss to lose sight of areas in which we've had a long track record of leadership. Biomaterials is one such field. In this issue, we take a moment to reflect back on the people and projects in the department that have pushed the boundaries of biomaterials — and bring you up to date on the cutting-edge work happening in our department that continues to advance the field.

I hope you enjoy reading about this and other endeavors and achievements from around ChemE in this year's edition of the *Catalyst*.

Jim Pfaendtner
Rogel Professor and Chair

2019 highlights

ACADEMICS

The department awarded **63 bachelor's, 19 master's, and 20 Ph.D. degrees** in the 2018-19 academic year. ChemE celebrated commencement on the Benson patio on June 14 following the ceremony in Kane Hall.

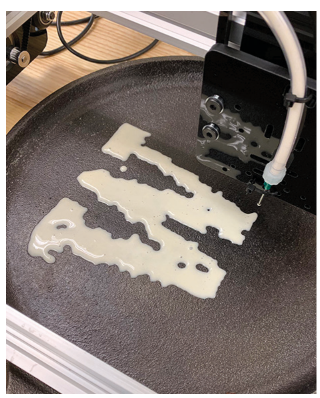
PROFESSIONAL DEVELOPMENT

Jade Hudson (B.S. '87, left) of Boeing and Cynthia Pierre (right) of BP shared career insights at the **Women in Chemical Engineering Fall Industry Event** on November 7.

NEW FUNDING

An interdisciplinary research team led by professor James Carothers received a new **$1 million research grant** from NSF to investigate whether cells can learn, and to develop 'smart' synthetic cell systems.

IN THE CLASSROOM



Lilo Pozzo experimented with pancake-making robots in her **Kitchen Engineering** course.

IN THE LAB

ChemE received a **Top Dawg in Safety Award** from the UW Environmental Health & Safety department.

Keep up with ChemE news

Read online
cheme.washington.edu

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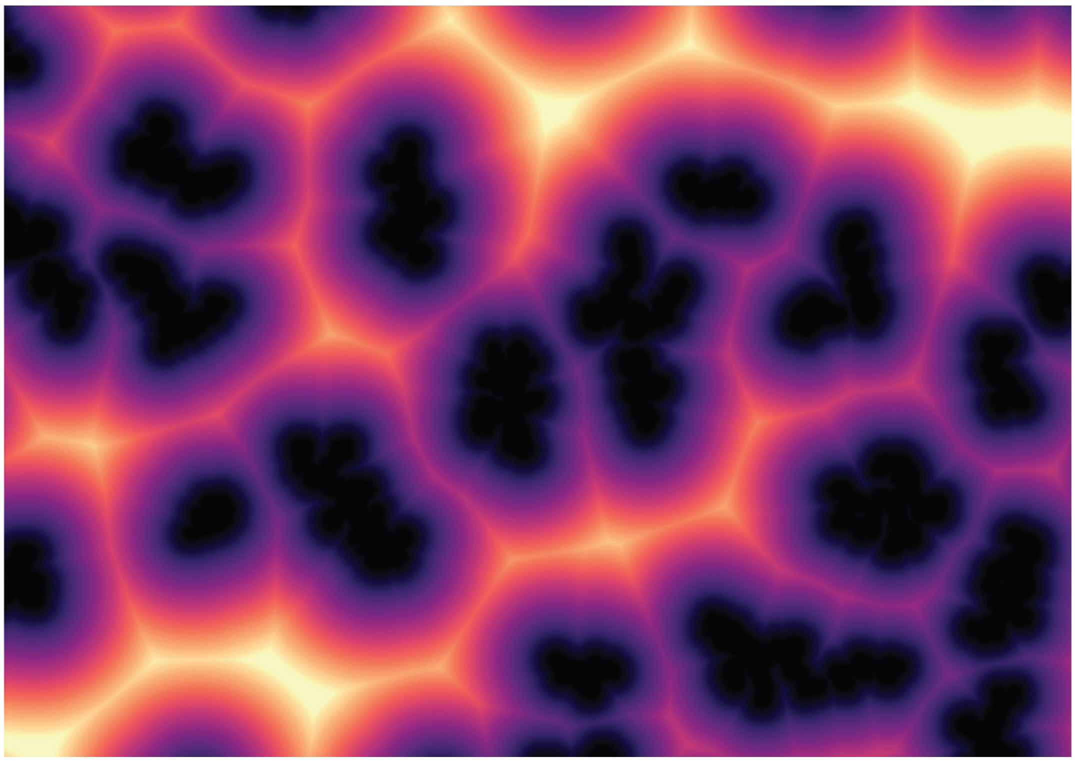
The 4th Annual Science & Engineering as Art Competition

ON THE COVER

First place

A [Bi]t of Light
By Elena Pandres

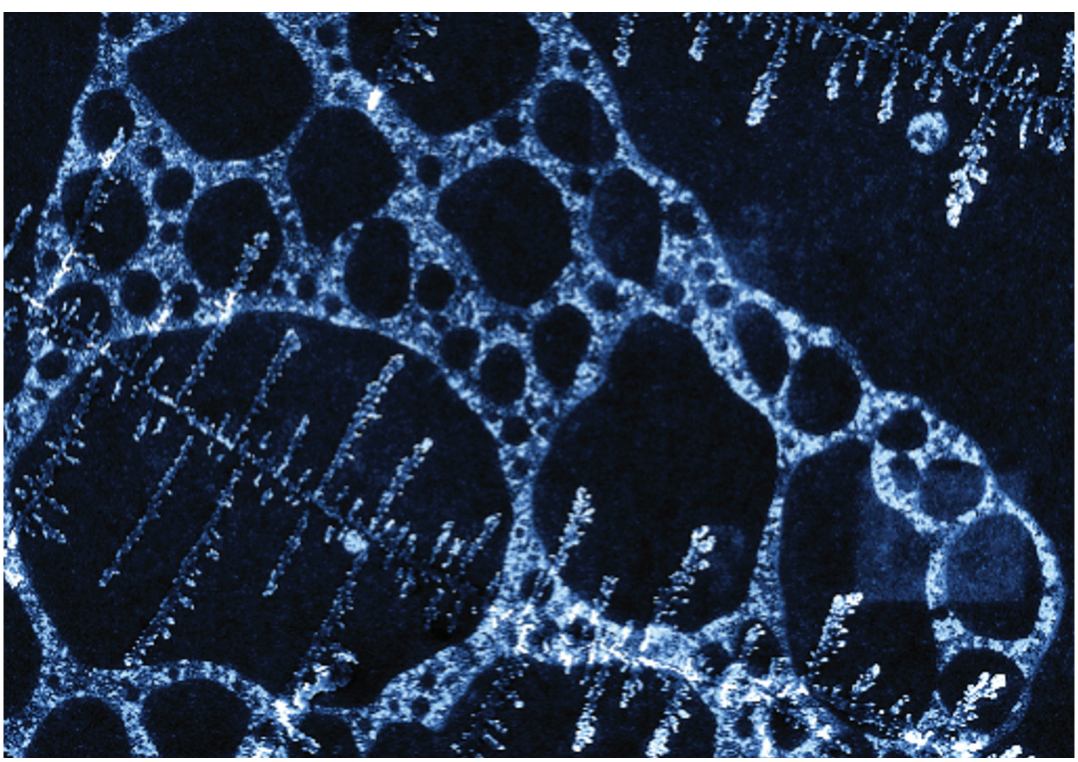
A thermal image time series in which a custom-built, optically-accessible, continuous-flow reactor containing bismuth (Bi) nanoparticles is irradiated with a laser. When irradiated, the Bi nanoparticles generate heat and can be used to drive local chemical reactions in solution.



Second place

Euclidean Brainstorm
By Chad Curtis

A Euclidean distance transform of a confocal microscopy image of microglia cells taken in a rat organotypic brain slice model. The colors are scaled to represent the distance away from a cell surface.



Third place

Diamonds in the Rough
By Julia Boese & Yundi Zhao

A low magnification and colorized SEM image of silica nanoparticles with salt crystals and possible capillary-action-caused patterning.

PIONEERS IN **biomaterials**

How early leaders set the stage for today's innovators

By Lindsey Doermann

The history of the field has seemingly little to do with the life-saving technologies of modern medicine. The origin story of biomaterials involves parachutes, repurposed car parts, and the Atomic Energy Commission. In the present day, the landscape is comprised of molecules called zwitterions, materials governed by Boolean logic, chemical 'light sabers,' and other science fiction-like concepts.

One can't explain how we got from the just-make-do approach to biomaterials — using parachute cloth for blood vessel replacements, for example — to today's precision engineering without talking about some visionary chemical engineers at the University of Washington. UW has had a long history of leadership in biomaterials. And today, ChemE researchers continue to generate new ideas and innovations at the leading edge of the field.

It's tough to pinpoint when the term 'biomaterials' first appeared, says self-made biomaterials historian Buddy Ratner. But the concept has existed as long as physicians have needed substances — be they natural or synthetic, organic or inorganic — and devices that work harmoniously with the body.

An early victory for biocompatibility was the first successful kidney dialysis treatment, post-WWII. With a dialysis machine that utilized cellophane and a water pump from a Ford automobile, Dutch physician Willem Kolff revived a comatose woman, who went on to live for seven more years.

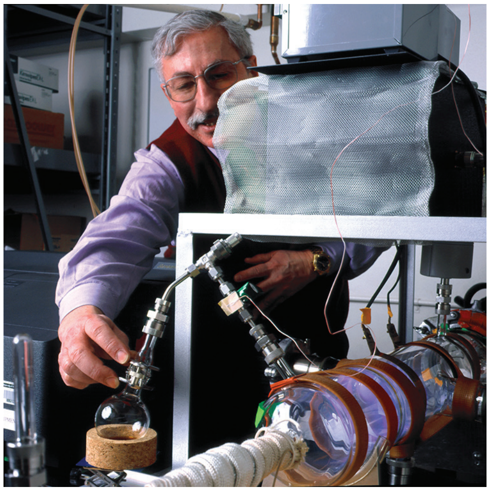
Engineers and physicians at the UW later picked up on this proof of concept. In the early 1960s, nephrologist Belding Scribner was working on hemodialysis as a treatment for acute kidney failure. Wells Moulton connected Scribner with fellow chemical engineer Albert "Les" Babb because of his expertise in mass transfer. Babb, Scribner, and bioengineer Wayne Quinton iterated on devices until they achieved the first portable dialysis machine, thereby ending the era of restrictive, hospital-based treatment.

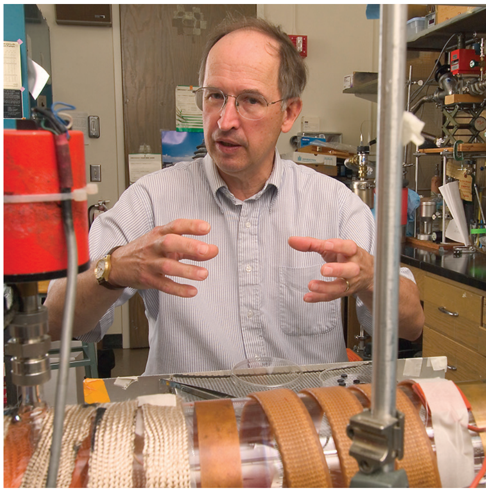
"Those guys made the major breakthrough," says Ratner, a ChemE and bioengineering professor. Though, as Ratner may know better than anyone, they would've been mistaken if they thought the problem was solved. But let's not get ahead of ourselves.

In 1970, chemical engineer Allan Hoffman came to the UW to join the Center for Bioengineering and the Department of Chemical Engineering. Here, he started the first biomaterials group on campus and one of only a handful in the world at the time. (Today, by Ratner's running list, there are upwards of 40 faculty at UW alone that either make or heavily use biomaterials.)

Ratner joined Hoffman's group as a polymer scientist in 1972, fresh from his Ph.D. work on kidney dialysis membranes. He began research on hydrogels, a mainstay in today's field but new at the time. Hoffman also recruited now-Professor Emeritus Tom Horbett to this early group.

In collaboration with physicians, the group moved the needle toward deliberate design of materials for medical devices and drug delivery. "I think we [at the UW] are pioneers in getting engineers and chemists to talk to clinical researchers," says ChemE professor Cole DeForest. It's now common practice, he says, but he attributes the shift in part to people such as Hoffman and Ratner.





Buddy Ratner (left) and Tom Horbett (right), shown here in their labs, worked with Allan Hoffman in UW's first biomaterials group

2019 BIOMATERIALS HIGHLIGHT

A new stealth material

ChemE researchers led by Shaoyi Jiang have discovered a new type of ultralow-fouling biomaterial that's inspired by a zwitterionic compound found in saltwater fish. Zwitterionic materials, which contain an equal number of oppositely charged ions, have emerged as promising materials for nonfouling surfaces because of their superhydrophilic properties; the shell of water molecules they attract prevents biomolecules from attaching. While ultralow-fouling surfaces are critically important for medical devices, only three classes of zwitterionic materials are currently available for this purpose.

To develop the new "stealth" material, the researchers looked to a zwitterionic osmolyte found in fish and derived a new polymer from it. In collaboration with Jim Pfaendtner's group, they used molecular dynamics simulations to help elucidate its nonfouling mechanism: a very short distance between the positively and negatively-charged groups. That feature turns out to be optimal for keeping water molecules attached. Studies showed very little immune response in mice in vivo and low levels of protein adsorption in vitro.

Source: Li, B. et al. Trimethylamine *N*-oxide-derived zwitterionic polymers: A new class of ultralow fouling bioinspired materials. *Science Advances,* 2019.

Over time, it's become clear that applying the chemical engineering mindset to problems in biology and medicine has been key to better materials and devices. With nonfouling surfaces, for example, Hoffman figured out how to graft hydrogels onto surfaces such as tubing (using a radiation grafter borrowed from the fisheries department, as it so happens). Then, with a hematologist and a ChemE graduate student, he studied the kinetics of platelets interacting with those surfaces and found a counterintuitive, yet consequential, relationship between hydrogel water content and platelet destruction.

The group advanced their surface science work in this period with funding from an unlikely source: the Atomic Energy Commission. The AEC fostered peacetime applications of nuclear science (and was abolished in 1974). One such idea was a plutonium 238-powered artificial heart. The AEC funded Westinghouse to develop the device and the UW team to work on the surface materials that would contact blood. Not surprisingly, that particular device didn't gain traction, but the project kept the group moving forward. Ratner has held onto binders of their monthly reports to the agency as relics of an odd era in U.S. government R&D.

The quest for nonfouling surfaces remains central to the field. Shaoyi Jiang, who joined the ChemE faculty in 2000, brought "incredible energy" to this work, says Ratner, and has consistently driven innovation in biocompatible materials.

In what Ratner calls the culmination of 18 years of work, he and Jiang developed and successfully demonstrated an ideal substance that proteins don't stick to — and hence remains invisible to the body. Their findings resulted in a 2014 *Nature Biotechnology* paper.

Current ChemE faculty have advanced other ideas from the original group, such as materials that respond to specific chemical conditions. In 1983, Ratner and Horbett reported the development of a responsive material that delivered a drug based on a stimulus. In this case, it was a hydrogel — call it a "smart" material — that released insulin in response

2019 BIOMATERIALS HIGHLIGHT

Molecular tethers & chemical 'light sabers'

Cole DeForest's group developed a new method of attaching proteins to scaffolds for tissue engineering without destroying protein function. Proteins are key to controlling cell growth and differentiation in tissue engineering. But common chemistries for binding proteins to materials render most of them inactive, requiring researchers to overload scaffolds with proteins in order to get results.

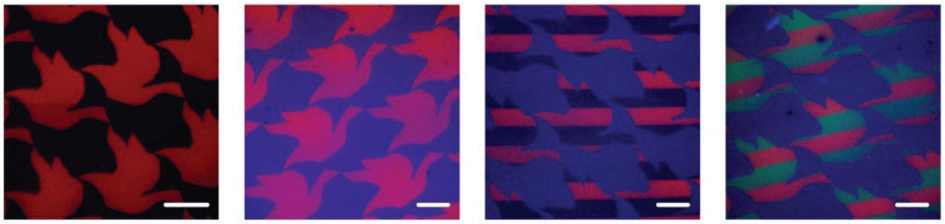
The new approach uses the enzyme sortase to add a short synthetic peptide to each signal protein at the C-terminus, a site present on every protein. The team designed the peptide such that it will tether the signal protein to specific locations within a hydrogel biomaterial. They found that modifying just the C-terminus is much less likely to disrupt protein function.

The proteins can be chemically tethered to the scaffold using laser light — and likewise severed by light (a scientific 'light saber,' if you will). As a result, this method can create evolving patterns of signal proteins throughout a biomaterial scaffold to grow tissues made up of different types of cells.

Scientists may also be able to use this platform for basic cell biology research. For example, they may investigate how protein signals work together to control cell differentiation, heal diseased tissue, and promote human development.

Source: Shadish JA, GM Benuska, and CA DeForest. Bioactive site-specifically modified proteins for 4D patterning of gel biomaterials. *Nature Materials,* 2019.

Figure: Light-controlled release/immobilization of different proteins within a hydrogel biomaterial over time



to glucose. Now, says Ratner, “Cole has come along and made smarter materials.”

Indeed, DeForest is developing materials that respond to well-defined *combinations* of chemical cues, “adding another level of programmability,” he says. His group recently garnered attention when they showed they could control the release of different therapeutics from a hydrogel by applying Boolean logic. They exposed their material to one or two-input combinations of enzymes, reductants, and light, and triggered the release of bioactive proteins through “yes/or/and” control.

Looking ahead in other avenues of research, DeForest is excited about taking a protein engineering approach to biomaterials synthesis, as an alternative to more-common synthetic chemistry methods. He also aims to expand his work on synthetic capillaries, which are not only critical in tissue engineering but can also serve as novel tools for basic research.

Despite such modern developments in the field, it can be hard to fathom that dialysis has remained fundamentally unchanged since its early successes. Quality of life and outcomes for people receiving dialysis treatment remain shockingly poor, with patient life expectancies hovering at 3–5 years.

These factors contributed to Ratner and nephrologist Jonathan Himmelfarb establishing the Center for Dialysis Innovation (CDI) at UW in 2016. Continuing a familiar theme in biomaterials development, the center brings together engineers and medical researchers to develop novel solutions that both improve dialysis therapy and give patients more autonomy.

Its research involves several ChemE faculty who work on the molecular-level and electrochemical aspects of dialysis, including Jiang, Jim Pfaendtner, and Eric Stuve. In one line of inquiry, for example, Pfaendtner is using molecular simulation to understand how toxins besides urea are bound up in the blood — and consequently how dialysis could remove them.

The CDI’s goals are lofty, given the problems with dialysis that have persisted for decades. With how the biomaterials field has advanced on the UW campus, though, there’s good reason to hope that the time and place are right for serious innovation.

ADVANCED MATERIALS

Light-based ‘tractor beam’ assembles materials at the nanoscale

By James Urton, UW News

Modern construction is a precision endeavor. The building industry relies on manufacturers to create reproducible components for secure bridges and sound skyscrapers.

Now imagine construction at the nanoscale — less than $1/100^{th}$ the thickness of a piece of paper. It is the scale at which scientists are working to develop potentially groundbreaking technologies, but one at which traditional fabrication methods simply will not work.

ChemE researchers and colleagues have developed a method that could make reproducible manufacturing at the nanoscale possible. The team adapted a light-based technology known as optical traps or optical tweezers to operate in an environment of carbon-rich organic solvents, thereby enabling new potential applications.

The team reports how the optical tweezers act as a light-based “tractor beam” that can assemble nanoscale semiconductor materials precisely into larger structures. Unlike the tractor beams of science fiction, which grab spaceships, these optical tweezers trap materials that are nearly one billion times shorter than a meter. Vincent Holmberg, ChemE professor and faculty member in the Clean Energy Institute and the Molecular Engineering & Sciences Institute, and Peter Pauzauskie, UW professor of materials science and engineering, are co-senior authors of the study.

To demonstrate the approach, the researchers built a novel nanowire heterostructure — a nanowire consisting of distinct sections comprised of different materials. Their starting materials were “nanorods” of crystalline germanium, each capped with a metallic bismuth nanocrystal.

The researchers used the light-based “tractor beam” to grab and superheat one of the germanium nanorods, melting the bismuth cap. They then guided a second nanorod into the “tractor beam” and soldered the two end-to-end. “We’ve taken to calling this optically oriented assembly process ‘photonic nanosoldering’ — essentially soldering two components together at the nanoscale using light," said Holmberg.

Nanowires that contain junctions between materials — such as the germanium-bismuth junctions the team synthesized — may eventually be a route to creating topological qubits for applications in quantum computing.

To date, optical traps have been used almost exclusively in water- or vacuum-based environments. Holmberg's and Pauzauskie's teams adapted optical trapping to work in the more volatile environment of organic solvents. This allows them to work with components that would otherwise degrade or corrode on contact with water or air, according to Holmberg.

"This is a new approach to nanoscale manufacturing," said Pauzauskie. "All of the components are suspended in solution, and we can control the size and shape of the nanostructure as it is assembled piece by piece. This is the kind of precision needed for reliable, reproducible nanofabrication methods."

Source: Crane MJ et al. Optically oriented attachment of nanoscale metal-semiconductor heterostructures in organic solvents via photonic nanosoldering. *Nature Communications*, 2019.

This story has been adapted from an article that originally appeared in UW News. Read the full story at: *www.washington.edu/news/2019/11/04/light-based-tractor-beam/*

HEALTH TECHNOLOGY

Harnessing the 'ouzo effect' for better ultrasound imaging

By Lindsey Doermann

Postdoctoral researcher David Li and professor Lilo Pozzo have developed a method for synthesizing nanodroplets that could unleash new potential for ultrasound imaging and therapies.

More and more, physicians are using intravenously injected microbubbles to improve contrast in ultrasound images. While these substances work well within blood vessels, they are too large, at >1 µm in diameter, to diffuse through vessel walls and into tissues or tumors. If particles were small enough, they could be used to destroy diseased tissue non-invasively, for example.

To address the issue of size, the team developed an agent that can be injected as a liquid, then vaporized in the body with an acoustic pulse to form bubbles. They made this material by harnessing a phenomenon familiar to bartenders and colloid scientists alike: the "ouzo effect." When water is added to the Greek spirit ouzo, anise oil droplets form spontaneously, turning the drink cloudy.

In the case of ultrasound contrast agents, the researchers found they could dissolve perfluorocarbons (PFCs) in ethanol. When they added a water-based solution, the PFC came out of solution and formed nanodroplets on the order of 100 nm in diameter — small enough to diffuse out of blood vessels.

Creating this sort of material is particularly challenging: it must exist in a liquid form to be injected and diffuse into tissues. But it must also vaporize with sufficiently low-pressure output from a clinical ultrasound scanner to be safe for a patient. That meant the researchers needed to synthesize the nanodroplets without inputting energy, lest the PFC evaporate immediately. The spontaneous nucleation achieved through the ouzo method was ideal for making this unstable material.

The team experimented with several PFC blends to optimize the droplets' stability and activation threshold. Then they tested ouzo-synthesized perfluorobutane droplets in rats, where they were able to successfully image spinal cord tissue.

"The ouzo method is a fast and easy approach to produce nanodroplets with minimal equipment requirements and low costs," Li writes. In addition to better imaging, physicians are exploring how to apply these microbubbles to drug delivery and new therapies.

Source: Li DS et al. Spontaneous nucleation of stable perfluorocarbon emulsions for ultrasound contrast agents. *Nano Letters,* 2019.

Just add

SUNLIGHT, AIR, & WATER

An award-winning senior capstone design produces medical oxygen right where it's needed

By Lindsey Doermann

Oxygen is easy to take for granted. The life-sustaining element surrounds us. And when the need arises, it's readily available in medical facilities in the Western world. But for a child with pneumonia in Ethiopia or a lung disease patient in an area struck by natural disaster, getting oxygen isn't trivial.

It's this seemingly simple problem that ChemE undergraduates took on in a sequence of special design courses. A team of Sophia Nguyen, Harrison Sarsito, and Annalisa Ursino (B.S. '19), and Gabe Lozada (B.S. '20), developed a portable, solar-powered oxygen concentrator for use in regions that are remote or lack reliable electricity. They also developed a business plan for their product, which they call ElectroSolar Oxygen.

The team's year of researching and refining, tinkering and rethinking, paid off. In spring 2019, ElectroSolar Oxygen brought home the $5,000 Clean Energy Prize at the UW Foster School's Environmental Innovation Challenge, and the $5,000 Social Impact Prize at the Dempsey Startup Competition. In addition, the ChemE department selected the team to receive the Ray & Priscilla Bowen Award for Process Design.

The Special Design Program that spawned ElectroSolar Oxygen has become a mainstay in the ChemE curriculum, popular with students who want experience not only with chemical product design but also with tech-based entrepreneurship. The three-course option launched in 2012 as the brainchild of professor Dan Schwartz. Professor Lilo Pozzo now leads the design program as both course instructor and entrepreneurship adviser.

Each year Pozzo selects a different theme for students to develop their technology around. This year, she chose the UN's Sustainable Development Goals. After considering a range of product ideas, the ElectroSolar team focused in on oxygen concentration for medical applications — an idea that stemmed from Pozzo's work on public health and sustainable energy in the aftermath of Hurricane Maria in Puerto Rico.

Current options for supplemental oxygen don't work well in rural areas and disaster-stricken regions. Tanks have to be routinely transported to medical facilities and trucked out when empty. Or facilities can use on-site concentrators called pressure swing absorption (PSA) systems, which require maintenance, a reliable electricity source, and a whole lot of energy.

The team wondered if they could design a system that produced oxygen on location, using only renewable energy sources. And it turns out they could, with a creative use of good old electrolysis. The ElectroSolar Oxygen cell consists of a catalytic membrane sandwiched between an anode and cathode. Electric current from a solar panel splits H_2O molecules into oxygen gas and hydrogen cations (not volatile hydrogen gas). A Nafion membrane transports H^+ ions across the cell where they react with oxygen in the air to form water as a byproduct.

Cells with Nafion membranes are commonly used to produce hydrogen as feedstock for fuel cells. The ChemE team, however, used them to generate medical-grade oxygen gas. The solution wasn't immediately intuitive to professor Stu Adler, a specialist in oxygen concentration and adviser to the team. So he was particularly excited to see the team develop it.

Annalisa Ursino, Sophia Nguyen, Harrison Sarsito, and Gabe Lozada work on the ElectroSolar Oxygen prototype

Each student gravitated toward a part of the project they could specialize in. Nguyen worked on COMSOL simulation of fluid flow through the cell; Ursino took the lead on prototyping and testing; Sarsito went deep into the business aspects; and Lozada, the lone junior on the team, worked across multiple elements, gaining a more holistic view so he could continue working on oxygen-concentrator designs as a senior.

"It's one thing to excel in a classroom, but it's a different type of challenge to apply that knowledge and build a prototype," said Ursino. Reconciling the theory of how something should work and actually creating it, said Sarsito, "was challenging but rewarding." The group had to learn how to use a lot of equipment in order to build something, said Nguyen. And Ursino never thought that, on her way to a ChemE degree, she'd be scouring the plumbing section at Home Depot for the right fittings.

What's more, going into the project, "we didn't know how to navigate the business side," said Sarsito. But finding that aspect intriguing, he took the initiative to learn about business development. He made connections with local entrepreneurs and forged a working relationship with MBA student Shobhit Gupta, who helped the team with their pitch and business plan.

Ultimately, the group thought their competitive edge came from their belief in the technology's potential. Through all of the challenges, said Sarsito, "what helped us is that the end goal of the product is very high-impact."

A national stage for research and a call for change

By Hugo Pontes (B.S. '20)

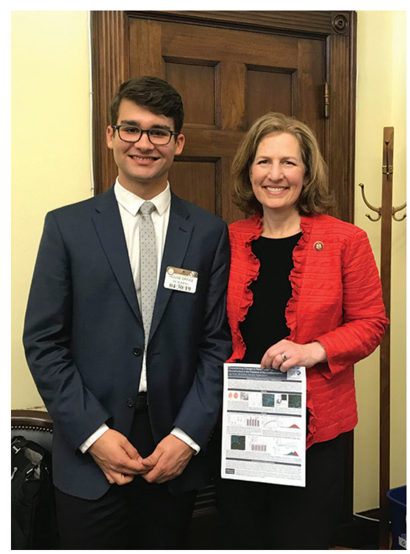
ChemE student Hugo Pontes recently presented his research at the Council on Undergraduate Research's Posters on the Hill Conference in Washington, D.C. Hugo works in Elizabeth Nance's lab, where he studies how nanoparticles move in the diseased brain to reach their desired target.

I arrived in D.C. with my poster tube in one hand, my suitcase in the other, and just enough time to drop my bag at the hotel and hurry to the Hart Senate Office Building. There I had the first of two meetings with my representatives, this one with the staff of Senator Maria Cantwell. I also met with the staff of Congresswoman Kim Schrier (and later got to take a picture with Schrier herself). My goal in these meetings was to show how current policies are not inclusive of all people when it comes to research funding for undergraduate students.

I explained that, as an immigrant, I could only apply for funding and job opportunities that did not have a citizenship requirement. This has greatly limited my options. I'm supporting myself through college, so the scholarships and fellowships I received were not only important for my growth as a researcher, but also a way that I could pay rent every month.

Later that day, at the Rayburn House Office Building, I had the pleasure to share my research with members of Congress, staffers, professors from around the country, and directors of national organizations. It was an amazing mix of people that included everyone from neurobiologists to English professors to institute directors. Having one-on-one conversations with multiple professionals in academia and governmental organizations was motivating.

On the flight back to Seattle, in addition to studying for a midterm I had to take two hours after landing, I reflected on my trip. I started high school without being able to communicate with my classmates because I didn't speak English. Now, seven years later, I presented at the steps of the Congress of the United States.



Hugo with Rep. Kim Schrier

I feel very proud of being able to get here after much hard work, but also very thankful for those that helped me get here. My family has always supported me, and it is along with them that I learned what it means to be a Brazilian immigrant. Professors Nance and Pozzo have also played a crucial role in my development as a researcher, as a student and most importantly, as a compassionate human.

This story has been adapted from an article that appeared on UW's Undergraduate Academic Affairs website. Read the full story: *www.washington.edu/uaa/news/*

FLIPPED CLASSROOM

Lectures at home, homework in class

By Lindsey Doermann

On a Thursday morning this November, ChemE juniors filed into their introductory thermodynamics class. But instead of settling into desks all facing forward, they found their seats at small tables with 4 or 5 classmates; took out notebooks, calculators, and tablet computers; and got to work on their weekly problem set. At the start of the session, professor Stu Adler drew one diagram on the board, told the students that it'd likely be helpful in that day's work, then turned off his microphone.

Welcome to a "flipped" class. Adler is in his third year of teaching thermo this way, and it works like this: Students watch Adler's lectures and demonstrations on video outside of class. Then they spend their class time working on practice problems that in a traditional classroom would be assigned as homework. During class, Adler visits the table groups, reinforcing key concepts and helping students pick up those they may have missed. In the flipped format, all class sessions — not just office hours or recitations — offer opportunities for individualized instruction. It can save students the time and frustration of getting stuck on homework because they missed something in a lecture.

The flipped classroom represents an extreme form of active learning, an educational approach the department is increasingly adding to its curriculum. Adler is a strong proponent, and has data from his flipped classes showing its promise. In short, he's found that more students are mastering more of the concepts. Instead of class grades in a bell-curve distribution, they stack up at the high end. Adler attributes this to the level of descriptive feedback, as opposed to grades, that he's able to provide in this format. TA Brian Gerwe sees it happening, too, finding there to be "a lot more teachable moments" than in a traditional setting.

The success doesn't come easy. Flipping a class comes with a huge upfront cost, says Adler. A lot of time and thought goes into preparing lecture videos, especially since they don't allow for the immediate feedback that's possible in a live lecture setting. "I try to compensate [for the lack of Q&A] by explaining concepts in lots of different ways," he says, and sometimes that's through lab demonstrations. "They can't get that from me standing at a blackboard."

Other ChemE instructors are trying this approach, too. David Beck is using it in the data science curriculum. Chad Curtis (Ph.D. '19, now a lecturer) TA'ed one of Beck's courses, and having been inspired, is planning to flip the Chemical Engineering Computer Skills class. For this type of course, Curtis says, he's seen firsthand the value in freeing up lecture time for discussion and individualized help in the computer lab.

It's often quipped that ChemE's don't let ChemE's do homework alone. In a flipped classroom, they're always in good company.

Professor Stu Adler works with a student in a flipped classroom setting

Meet the new ChemE faculty

Stéphanie Valleau

Assistant Professor of Chemical Engineering

Stéphanie joined the ChemE faculty this fall after having completed a postdoctoral fellowship at Stanford University, sponsored by the Simons Collaboration on the Origins of Life. Stéphanie works at the intersection of chemical engineering, computer science, and biophysics. Her expertise will help advance the department's strategic data science initiative.

Stéphanie has hit the ground running, teaching the reactor design course in fall quarter — revising it to include some Python programming — and beginning to build her research group. At the UW, Stéphanie is looking to leverage computing resources such as the supercomputer Hyak to advance her work. She is excited about starting new collaborations with faculty working on clean energy materials, drug design, and data science methods.

In one line of research, she aims to enable more-rapid reaction design by combining deep learning and computational chemistry approaches. Given the large cost of atomistic simulations, she wants to identify the level of theory needed and the features required to predict kinetics in cycles and networks of reactions using machine learning.

Stéphanie's other big research idea relates to photosynthetic bacteria and builds off her previous work understanding how light-processing structures in those organisms evolved over time. It may be a bit unusual for a chemical engineer to delve into deep time and evolution, but she sees potential applications to the most modern of problems: creating energy for billions of people with minimal harm to the environment. By understanding what genetic mutations were preserved over time that allow the bacteria to process light as they do today, then it should be easier to design artificial photosynthetic complexes for solar fuel production.

Neda Bagheri

Assistant Professor of Chemical Engineering and Biology

Neda comes to UW from Northwestern University, where she was a professor and director of the Modeling Dynamic Life Systems (MoDyLS) Lab. She now splits her time between UW and the Allen Institute for Cell Science. Neda employs machine learning, dynamical systems, and agent-based modeling strategies to explain unique biological observations. Her interdisciplinary projects aim to elucidate, predict, and ultimately control biological response in the context of disease.

In a recent study, for example, she and her team used machine learning to rapidly synthesize, measure, and analyze spherical nucleic acid (SNA) structures. SNAs hold promise as a new class of individualized medicines, as researchers can design the structures to shut off particular genes and cellular activity.

Neda received a National Science Foundation CAREER Award in 2017 and is recognized internationally for her leadership and service in the field of computational and systems biology. She is passionate about outreach and is planning a children's science book series for K–5 students. She also designed a science policy course for engineers to encourage active science citizenship and promote effective science communication.

Chad Curtis

Lecturer of Chemical Engineering

Chad is a newly minted Ph.D. from UW ChemE. His thesis work, in Elizabeth Nance's lab, examined the use of machine learning algorithms in conjunction with nanoparticle diffusion datasets in the design of nanoparticle therapeutics. He is both a passionate engineer and data scientist, and will be teaching courses that help integrate the two — including the DIRECT course series in software engineering and data science.

Jun Liu

Professor of Chemical Engineering and Materials Science & Engineering

Jun's research addresses fundamental challenges of materials synthesis and applications, battery innovation, and energy storage. He previously served as the director of the Energy Processes and Materials Division at PNNL. As director of the Battery500 Consortium, Jun led a team of experts to develop batteries for electric vehicles that are smaller, lighter, and cheaper. He is a fellow of AAAS and the Washington State Academy of Sciences.

FACULTY UPDATES

NATIONAL RECOGNITION

Elizabeth Nance received the Presidential Early Career Award for Scientists and Engineers (PECASE), the U.S. government's highest honor for early career STEM researchers. This year, Nance also received the UW College of Engineering Junior Faculty Award and the UW Undergraduate Research Mentor Award.

Nance and Dr. Kelvin Droegemeier, White House Office of Science and Technology Policy Director

HONORS & PROMOTIONS

Cole DeForest was one of only 100 researchers from around the country selected to attend the National Academy of Engineering "Frontiers of Engineering" meeting

Sam Jenekhe was appointed to the strategic advisory board of the Institute for Molecular Science and Engineering at Imperial College London

Lilo Pozzo received the 2018 Clean Energy Education & Empowerment Award for Education from the U.S. Department of Energy

James Carothers was promoted to Associate Professor

Jim Pfaendtner and **Lilo Pozzo** were promoted to Professor

LEADING IN INNOVATION

François Baneyx was named the new director of UW CoMotion and Interim Vice Provost of Innovation. CoMotion is the UW's collaborative innovation hub dedicated to expanding the economic and societal impact of the UW community. Baneyx also directs the Center for the Science of Synthesis Across Scales, a multi-institution Energy Frontier Research Center funded by the U.S. Department of Energy.

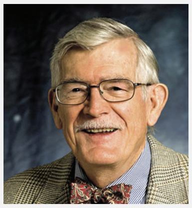
GONE FISHIN'

The department celebrated the retirement of professor and noted angler **Dave Castner** in June with an honorary symposium and barbecue dinner. Professor Emeritus Tom Horbett served as emcee of the symposium, which included talks by Horbett, Buddy Ratner, and Castner's thesis adviser Gabor Somorjai.

Ratner (left) gives a toast, laden with fish puns, to Castner

ChemE congratulates **Venkat Subramanian** on his new position on the mechanical engineering faculty at the University of Texas, Austin

IN MEMORIAM



Professor Emeritus **J. Ray Bowen** served as dean of the College of Engineering from 1981 to 1996. Bowen led the College's advancement in curricular innovation, diversity efforts, enrollment growth, and philanthropy. He also led the formation of the Washington Technology Center. A research specialist in the chemical engineering of combustion, Bowen held leadership roles in professional associations and served as an adviser to the U.S. government.

Gene Woodruff, Professor Emeritus of Chemical Engineering, spent 30 years as a teacher, researcher, and administrator at UW. He was a professor of nuclear engineering, director of the nuclear reactor, and chair of the Department of Nuclear Engineering. He later served for nine years as dean of the Graduate School and Vice Provost for Research.

Chemical Engineering **Leadership Seminar Series**

Now in its 13th year, the Leadership Seminar Series explores the breadth of career paths that can stem from a ChemE degree, and connects students with alumni who are leaders in a wide array of industries and sectors. Reflecting upon their careers, speakers offer students valuable insights, lessons learned, and advice for succeeding in today's professional work environment.

2019 SPEAKERS

Jade Hudson (B.S. '87)

Senior Production Engineering Manager, Boeing

Scott Korthuis (B.S. '82)

Product Manager (retired), Oxbo International;

Mayor of Lynden, Wash.

Zach Sayler (B.S. '13)

Maintenance Planning, Scheduling, and Warehouse Lead, Phillips 66

Christoph Krumm (B.S. '11)

Co-Founder and CEO, Sironix Renewables

Mary Armstrong (B.S. '79)

Vice President of Environment, Health, and Safety (retired), Boeing;

Valley County (MT) Commissioner

Dan Kress (B.S. '08)

Director, Integrated Supply Chain, MicroSurgical Technology

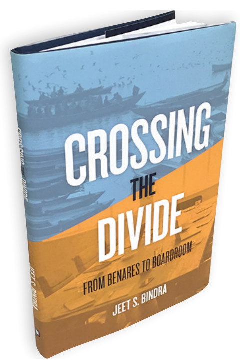
Rick Martin (B.S. '79)

Senior Vice President and Chief Supply Chain Officer, Lamb Weston

STARTUP NEWS

- **Membrion,** a molecular materials company founded by **Greg Newbloom (Ph.D. '14),** won $150,000 from the Department of Energy's Small Business Innovation Research program. They'll work on developing nanoporous ceramic membranes for non-aqueous redox flow batteries at the Washington Clean Energy Testbeds. This year, Newbloom was also named one of *Puget Sound Business Journal's* "40 under 40" and featured as a "Geek of the Week" on *GeekWire*.

- **Sironix Renewables,** founded by **Christoph Krumm (B.S. '11),** won the 2019 Imagine Chemistry collaborative innovation challenge, sponsored by Dutch chemical company Nouryon. They were awarded a joint development agreement with Nouryon and Unilever for their technology to make plant-based surfactants.



Crossing the Divide: From Benares to Boardroom

By Jeet S. Bindra

ChemE distinguished alumnus Jeet Bindra (M.S. '70) has published a book that recounts his journey from humble beginnings in Benares (now Varanasi), India, to his student days at UW, to becoming president of global manufacturing at Chevron. He writes genuinely about tensions between religion and career, diversity issues, and mentoring, offering thoughtful perspective and advice from his 32-year career.

> I hope that, someday, the word "diversity" won't refer to skin color, religion, gender, race, or any of the other superficial markers of difference. For now, we use these faulty identifiers as a kind of shorthand for new thoughts and ideas, via the people whom we judge based on accent or headdress. It is my belief that eventually we will recognize how ridiculous these categorizations are and move on to the phase where we truly judge one another by the contents of our character and intellect, our capacity for hard work, and our desire to learn. We will seek out difference and celebrate it, welcome it into classrooms and boardrooms, and understand it for the boon that it is.
>
> — **Jeet Bindra, in *Crossing the Divide***

Industry Capstone Sponsorship

Do you have an engineering challenge you've had to put on the back burner? Let our bright, creative students help you solve it.

We're looking for sponsors for our industry capstone program, which allows companies to propose and sponsor a project for a team of engineering students. It's a great opportunity for sponsoring companies to connect long-term with ChemE seniors and master's students as they complete high-quality work. Projects kick off in January 2020.

To learn more, visit *www.engr.washington.edu/industry/capstone* and message ChemE chair Jim Pfaendtner at *chechair@uw.edu*.

2019 R. Wells Moulton Distinguished Alumni Awards

DISTINGUISHED ALUMNUS IN INDUSTRY

Dan Dahlgren

(B.S. '82)

Vice President – Strategy and Planning, The Clorox Company

DISTINGUISHED ALUMNUS IN ACADEMIA

Ashutosh Chilkoti

(Ph.D. '91)

Alan L. Kaganov Professor of Biomedical Engineering and Chair of the Department of Biomedical Engineering at Duke University

As Vice President – Strategy and Planning at The Clorox Company, Dan Dahlgren leads the executive team and general managers in developing and implementing winning corporate strategies. Dahlgren's multifaceted career at Clorox spans back to 1989, when he began as an associate marketing manager and progressed through marketing positions in the company's cat litter, household cleaning, laundry, food, and auto-care businesses. Most recently, as Vice President – General Manager, Auto Care, he was responsible for the manufacturing and marketing of Armor All and STP products.

Before joining Clorox, Dahlgren spent five years at Procter & Gamble, first as a process engineer, then as manufacturing team leader and distribution center manager at the company's Sacramento manufacturing facility.

Dahlgren is also active in his local community. He has worked for ten years — including four as Chair of the Board — with the Northern Light School, an independent institution in Oakland, Calif., whose mission is to offer a superior education to students whose families would not otherwise be able to afford it. He also served for three years as Committee Chair for a Boy Scout troop in which his son was a member and earned his Eagle Scout rank.

A native of Bellingham, Wash., Dahlgren earned a bachelor's degree in chemical engineering from UW in 1982 and an MBA from Harvard Business School in 1989.

Ashutosh 'Tosh' Chilkoti is one of the world's leading biomolecular engineering researchers focused on clinical diagnostics and drug delivery. His expertise in protein bioengineering and molecular manipulation of biomaterials for these applications has pioneered therapeutics and devices for patients and doctors worldwide.

At Duke University, Chilkoti leads one of the top biomedical departments in the country. His research program has received more than $18.5 million in funding from the NIH; he has written more than 260 publications in top-tier journals; and he has graduated close to 50 doctoral students.

Chilkoti's many achievements include groundbreaking research discoveries that have defined his field of work: biointerfacial surface analysis methods, nonfouling synthetic polymer brushes for biomedical devices, recombinant elastin-like peptides for drug delivery, and nanoparticle applications for diagnostic assays. He holds more than 50 patents and has founded five startup companies to develop drug delivery systems for clinical use.

Chilkoti accepted his Moulton Award at ChemE's annual Awards Day ceremony in May. In his remarks to the department, he shared select moments of kindness, and of terror, from his ChemE journey. He urged students, when they feel they're struggling, to remember that life is long, life is non-linear, and life is not a spreadsheet. The key to success, he found, is to "be smart enough — and truly passionate."

Since 1993, the Moulton Awards have recognized UW chemical engineering alumni who have made exceptional contributions in industry, academia, government, or public service

DONOR SPOTLIGHT

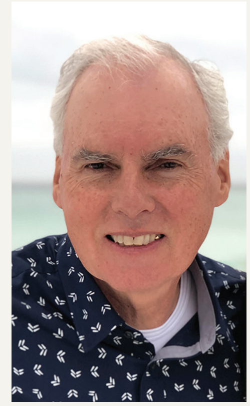
Mark Jones

(B.S. Chemistry '74, B.S. ChemE '76)

By Kaitlin Colleary

Mark Jones has been a donor to the chemical engineering department for 40 consecutive years. An alumnus of both chemistry and chemical engineering, Mark has been thoughtful to split his philanthropy between both units. He is not only generous, but also a savvy philanthropic investor. Mark has spent his career at ExxonMobil, where he has been able to amplify the impact of his giving through the company's matching gift program. In 2013, he leveraged his ExxonMobil match, as well as a university match sponsored by the ARCS Foundation that year, to endow a new fellowship in chemistry. The matching dollars effectively quadrupled the impact of his initial investment.

This year, Mark connected with chemical engineering chair Jim Pfaendtner and learned of the department's goal to bolster support for Ph.D. students. Although Mark did not do graduate work in the department, he wanted to give back to ChemE in a meaningful way, as he did with chemistry. "My UW education has provided me the opportunity to live and work all over the world," he said. "I've worked with brilliant people, made wonderful professional and personal friends, and worked on some of the most challenging and technically advanced aspects of oil and gas production and development."



Through the support of a new university-wide matching program to aid graduate student recruitment and retention, Mark once again leveraged a double match to establish a term fellowship in ChemE that will support 1-2 Ph.D. students per year. The department will be thrilled to introduce Mark to the first Jones Fellow in the next academic year.

"My UW experience challenged me to never stop learning," he said. Now, he's committed to helping others to meet their educational goals, as well.

If you are interested in learning about the university's current matching initiative for gifts to support Ph.D. students, please contact Kaitlin Colleary, Associate Director of Advancement, at 206-685-6192 or *kaitcoll@uw.edu*.

50TH REUNION

ChemE Class of 1969 Gathers in Benson Hall

ChemE department chair Jim Pfaendtner, professor John Berg, and Professors Emeriti Bruce Finlayson and Charles Sleicher welcomed alumni from the Class of 1969 back to Benson Hall in June. The occasion held special meaning for Finlayson, as these were the first students he taught. The group shared stories about their time in Benson Hall and had a laugh about mishaps in the lab. Gene Fioretti showed off some artifacts, including a slide rule, from his ChemE days. Pfaendtner recognized the attendees at the department commencement ceremony that followed.

Left to right: Gene Fioretti, Juanita Neitling, Mark Dassel, Mark McCrary, Mike Roberts, and Jim Pfaendtner

Calling all members of the Class of 1970!

We hope you will join us for your 50th reunion, celebrated in June along with the 2020 ChemE graduation. Come back to campus to reconnect with classmates and visit with current and emeritus faculty. An official invitation with all of the details will be mailed in early spring, but please contact Chloe DeWolf-Domingo, Assistant Director of Advancement, at *cdewolf@uw.edu* or 206-616-8310 with immediate inquiries.

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Department Chair and
Rogel Endowed Professor

Lindsey Doermann
ChemE Communications Manager,
Catalyst editor and designer

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Associate Director,
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