CHEMICAL ENGINEERING | UNIVERSITY *of* WASHINGTON

Catalyst

2020

Light at the End of the Tunnel

How ChemE will emerge from 2020 with new inspiration and ingenuity

The 5th Annual Science & Engineering as Art Competition

ON THE COVER

First Place

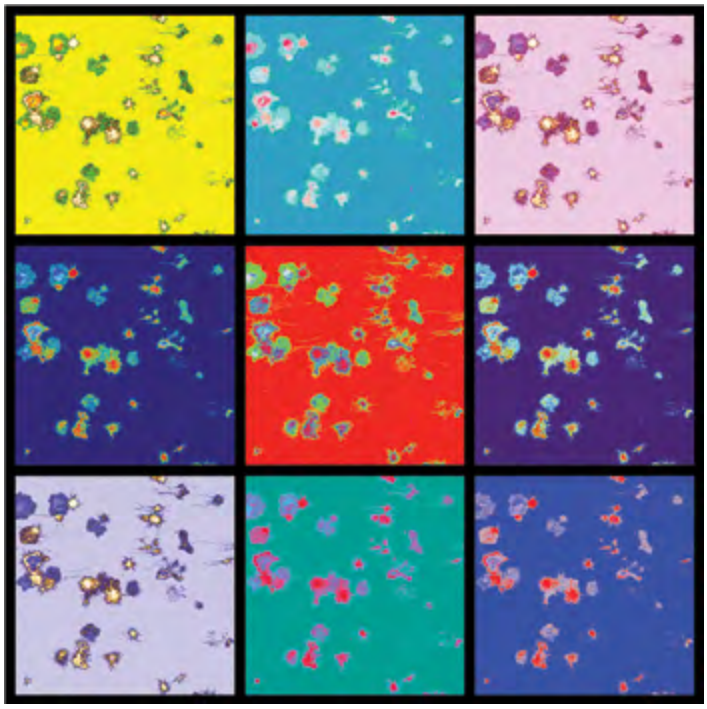
Light at the End of the Tunnel | By Jonathan Witt

A mass spectrometer and ionization gauge light inside of a high vacuum chamber in the darkness of the Benson basement. The mass spectrometer is half of a novel in situ electrochemical impedance and gas phase measurement apparatus.

Second place

Warhol's Glia | By Mike McKenna

An Andy Warhol-themed rendering that provides viewers a unique look at the morphological complexity of microglia, the brain's resident immune cells. The original image was acquired via fluorescence microscopy but was later passed through a series of spectral transformations.



Third place

Paisley Proteins | By Julia Boese

A colored-manipulated SEM image of protein-bound silica nanoparticles in an interesting drying pattern.

FROM THE **CHAIR**

There are no two ways about it — this year has been challenging beyond anyone's imagination. An ongoing global pandemic, racial injustice, natural disasters, political and economic turbulence... it's been a rough ride.

Fortunately we are a community of innovators, and ChemE's specialize in finding optimal solutions to highly constrained problems. This spring, we quickly set about learning how to carry on with our teaching and research in a new reality.

As you'll see highlighted in this year's *Catalyst*, the faculty, staff and students of ChemE have sought out new opportunities and employed their diverse skill sets to make the best of this truly unprecedented situation.

To be sure, the drastic changes to day-to-day life have been hard on everyone, and something is lost when we're not all together on campus. But I believe we will emerge from 2020 as a stronger, more cohesive community. We see a glimmer of light at the end of the tunnel.

Jim Pfaendtner
Rogel Endowed Professor
and Department Chair

ChemE welcomes two alumni back to the department

David Bergsman

Assistant Professor

David returned to UW to join the faculty this fall, bringing expertise in atomic and molecular layer deposition, membrane design, and materials for carbon-free energy and other sustainable technologies. A 2012 graduate of UW ChemE, he earned a Ph.D. in chemical engineering at Stanford and completed a postdoc at MIT. There, he developed a low-cost method for making conductive water filtration membranes.

David says he was thrilled when the offer came to join the department. "It's a fantastic research fit, and I already knew I liked the faculty," he says. Indeed, his interests align with existing research strengths in the department, and his experience with vapor deposition tools and membrane design can enhance ChemE's work in clean energy, medicine, and nanotechnology.

In any project he pursues, David says tech transfer is a key consideration — research that's scientifically interesting but impractical in the real world doesn't rise to the top. "I think it's important to work on technologies that can fit right into manufacturing processes," he says.

On the teaching front, David is of course starting out in the 100% remote environment; this fall he's teaching thermodynamics. He recognizes the distanced setup is stressful for students, but is heartened that they're appreciative of his efforts to facilitate learning challenging material. David knows what it's like to walk in the shoes of a ChemE undergraduate — as it happens, he took the first class Hugh Hillhouse taught at the UW.

David is beginning to set up his lab with an eye toward high-throughput machining. Building a system that can quickly screen materials flips the traditional research script. Instead of a drawn-out process of testing a single material, one can identify suites of promising material candidates for membranes, catalysts, solar cells, and batteries for further development. He can even imagine developing a course involving instrumentation and robotics that encompasses these concepts.

Despite the strange nature of fall quarter this year, David is enthusiastic about his new role in the UW ChemE community. "I love the scope of research that the department is working on," he says. "We're growing stronger, bolder, more impactful, and more diverse every year."

Kyle Caldwell

John C. Berg Endowed Lecturer

Kyle joined ChemE in March as the Berg Endowed Lecturer. After receiving his Ph.D. from the UW, Kyle worked as a senior scientist at Innovative Organics, where he managed a team developing a range of environmentally-friendly chemicals for HDD, IC, LED, automotive, and aerospace markets. His research interests center on nanoparticles and particular composites.

In addition to developing and teaching courses in a remote setting, Kyle is taking the lead on managing the department's shared instrumentation facility and labs. Though the pandemic has slowed activity in these spaces, Kyle aims to strengthen ties with startups and industry partners who might utilize the equipment. Further, he will seek out funding opportunities to acquire new instruments.

Meet the new faculty

Awards

Sam Jenekhe received the 2021 **Polymer Physics Prize** from the American Physical Society. He is recognized for his influential work on semiconducting polymers for electronic and photovoltaic applications.

Buddy Ratner received the 2021 **Bioelastomer Award** from the American Chemical Society Rubber Division.

Cole DeForest celebrates winning the College of Engineering's **Junior Faculty Award** at home, à la 2020

PROMOTIONS & NEW APPOINTMENTS

Cole DeForest has been appointed as Weyerhaeuser Endowed Professor in Chemical Engineering and Associate Chair for Graduate Studies in ChemE

Elizabeth Nance has been appointed as Jagjeet and Janice Bindra Endowed Career Development Professor in Chemical Engineering and Associate Chair for Undergraduate Studies in ChemE

Lilo Pozzo has been appointed as Boeing-Roundhill Professor for Excellence in Engineering and Associate Chair for Research and Infrastructure in ChemE

Neda Bagheri
&
Cole DeForest
were promoted to
Associate Professor

Right: Graham Allan, lecturing in 2004

Below: Brad Holt, in his teaching element

RETIREMENTS & DEPARTURES

The department wishes **Graham Allan** and **Brad Holt** all the best in their retirements.

Graham, an expert in fiber composites and polymer science, held faculty appointments in both the School of Environmental and Forest Sciences and in ChemE. In recent years, he became known for his strong pedagogy and advocacy for creativity in science and engineering, having taught generations of students how to develop and apply their own creativity.

Brad joined the UW ChemE faculty in 1984, and in his 36 years became a popular professor among students and a frequent choice for commencement speaker. Brad served as Associate Chair starting in 2013 and was an invaluable source of knowledge and experience.

Congratulations to **Shaoyi Jiang** on his new position as professor of biomedical engineering at Cornell University, and to **Qiuming Yu** on her new position as professor of chemical and biomolecular engineering at Cornell University.

KNOWLEDGE TRANSFER

ChemE faculty share their views and expertise on technology trends and issues in academia

James Carothers contributed to the article, "What needs to change in academia to increase the number of Black scientists and engineers?" published in *Cell Systems.* He wrote:

Many more Black people could thrive as academics.

Here are three changes faculty could make that would really help:

- Use better ways to evaluate impact. Research shows that typical measures for evaluating teaching (student evaluations) and research (citation counts, speaking invitations) are imprecise and routinely undervalue women and minorities.
- Make diversifying science and engineering everyone's job. It's an old saw, but the task too often falls to already-overburdened women and minorities.
- Senior researchers should hold institutions, journals, and funding agencies accountable. Recently, my Ph.D. advisor joined 14 others in resigning from the board of *Angewandte Chemie* to protest an anti-diversity screed it published. Imagine if everyone showed this kind of conviction!

AAAS
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Mary Lidstrom spoke at February's AAAS meeting on a town hall panel:

Balancing Science with Concerns about National Security

As UW's Vice Provost for Research, Mary is working on how best to guard against foreign government influence in research while still supporting international collaborations.

Writing the perfect recommendation letter

Elizabeth Nance shared her approach in a Career Column published in *Nature*.

> In every recommendation I write, I aim to comment on the individual's traits beyond the classroom or laboratory when I can do so meaningfully. For example, students who organize events demonstrate abilities in project management and troubleshooting that go beyond the prescriptive nature of most classroom assignments. I think these aspects of a student's life are important to capture, and should be treated similarly to highlighting academic and technical achievements.

Dan Schwartz appeared on the December 20, 2019 episode of the public radio program *Science Friday,* "Forecasting the Technology of Tomorrow."

SCI FRI

"Sulfur is one of those chemicals that's going from naughty to nice.

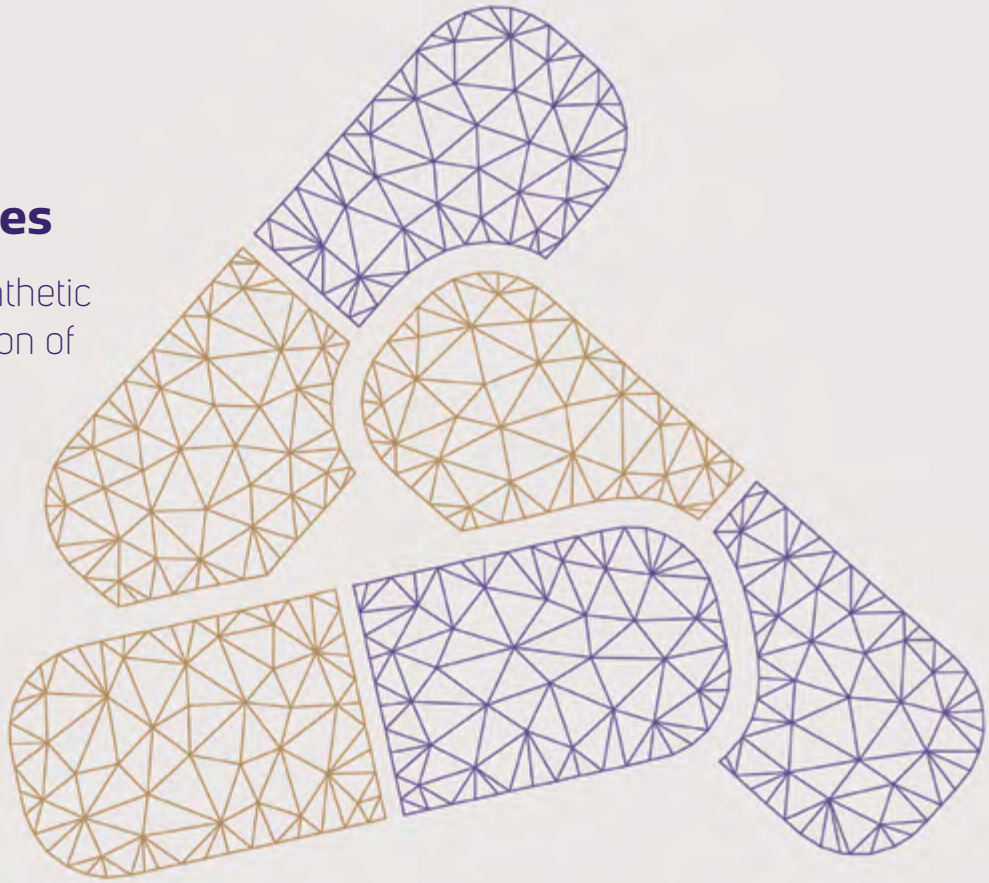
We used to work so hard to get sulfur out of fossil fuels — low-sulfur coal, ultra-low-sulfur diesel fuel. Sulfur is a super light element, super abundant and cheap. And there's so many ways you can add electrons to it or take them out. That's the basis of future energy storage technologies: cheap, lightweight, energetic. And so I'm pretty bullish about sulfur batteries."

DISTRIBUTED MANUFACTURING

Networked pharmacies

Researchers are harnessing synthetic biology for small-scale production of high-value products

By Lindsey Doermann



An interdisciplinary research team that includes Lilo Pozzo and James Carothers is embarking on a project to create plug-and-play synthetic biology modules that can produce valuable products within existing fermentation equipment. Their vision is for fermentation facilities to serve as a network of chemical manufacturers with the flexibility to produce high-value molecules in response to market forces or societal needs. One example: pharmaceuticals or their precursors in a public health emergency. With colleagues from UW Chemistry, UW Human Centered Design & Engineering, and the University of Texas, Austin, they received a multi-year NSF grant to develop the technology and prototype the modules.

Many of our drugs or drug precursors derive from plants. Aspirin originally came from tree bark, opiates have been farmed from poppy flowers, and the anti-cancer agent Taxol was derived from the bark of the Pacific Yew tree. But when it comes to pharmaceutical production, Pozzo points out, "plants are inefficient, because the component you want to isolate may exist in very, very small quantities." Using synthetic biology (SynBio), researchers can hack this process by genetically modifying bacteria and yeast cells to overproduce desired chemicals. Think of it as a sophisticated form of brewing beer.

To create the modules, the researchers will build off of a key innovation by team members Alshakim Nelson and Hal Alper. They recently discovered how to embed genetically-modified microbial "factories" within a 3D-printed hydrogel. In this configuration, they can constrain chemical production to within the gel (as opposed to dispersed in a large fermenter), run reactions continuously, and even grow more than one microbe within a bioreactor.

Now, the ChemE's will focus on developing new materials that optimize the transport of nutrients into the system and chemical products out. Extracting the end product efficiently has long plagued this technology. But with the hydrogel framework and chemical engineers at the ready to solve transport problems, it has new potential.

For student involvement, Pozzo is developing design projects for ChemE undergraduates that look at the economics of different products that could be made by the SynBio systems. Students could consider not only chemical production aspects — e.g. how hard is it to make a given molecule? — but also the market forces. The researchers view the modules as a flexible platform, and Pozzo thinks the students can help reveal just how flexible it can be.

In fact, she thinks pharmaceutical materials are only the beginning. If you can make plant-derived drugs this way, why not other plant or even animal-based products? In the burgeoning field of cellular agriculture, biofactories stand in for traditional farming operations to produce our food. Animals are essentially inefficient bioreactors that produce meat, milk, and eggs. But cells in SynBio systems are capable of producing the same things in a climate-friendlier manner, bypassing animals altogether.

A factory is traditionally designed to make one product, and reconfiguring it to make another is a big undertaking. But think: if your factory is a cell, then reconfigurations occur on the micro scale. "You wouldn't need to have large-scale manufacturing if you could design a cartridge, for example, that you could plug into existing fermentation equipment," says Pozzo. It turns out that a big idea for a new way of manufacturing may actually be microscopic.

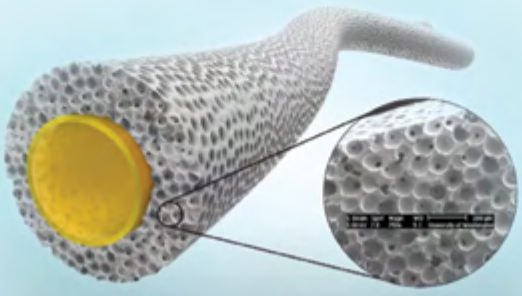
A pair of tissue engineering innovations

Kidney-dialysis team earns acclaim for porous synthetic graft

UW's Center for Dialysis Innovation (CDI), directed by ChemE's Buddy Ratner and UW Medicine's Jonathan Himmelfarb, won a $500,000 KidneyX prize to further develop an arteriovenous, or AV, graft that can make dialysis safer and more reliable. KidneyX is a joint effort of the U.S. Department of Health and Human Services and the American Society for Nephrology. Through a series of cash competitions, it seeks to speed drug and device development to combat the meteoric growth of kidney disease, now estimated to afflict 850 million people worldwide.

Dialysis technicians need to access a patient's blood repeatedly without permanently damaging blood vessels. One option for achieving this is an AV graft, which is a surgically implanted prosthetic tube that connects an artery and vein in a patient's arm. Current AV grafts are FDA-approved, but they are prone to clotting and infection, Ratner said, and their failure requires a major reoperation for the patient.

The CDI team hypothesized that the AV grafts' Achilles heel is their composition: an inert material thought to be biocompatible but which, in many patients, is interpreted by cell macrophages as a foreign object. This brings repeated volleys of inflammation that encapsulate the graft with scar tissue and eventually lead to a blocked blood vessel. "What's needed is a synthetic tube that heals more reliably and more like a living blood vessel," Ratner said.



Fortuitously, in the 1990s, Ratner's bioengineering team invented a biomaterial that had interconnected pores 40 microns in diameter — about half the width of a human hair. It had been successfully integrated with other human tissues such as skin and bone. "What if we put this in as a blood vessel?" Ratner posited.

Le Zhen (Ph.D. '20) developed a stretchy polyurethane tube of the porous material. Month-long animal-model implants of the resulting prosthetic graft, led by UW Medicine vascular surgeon Elina Quiroga, had decidedly better results than the comparable Teflon implants. "The test graft integrated so well into the (carotid) artery that it was nearly indistinguishable from original tissue," Ratner said. With a much lower failure rate, he added, AV grafts could be "transformational" for dialysis patients.

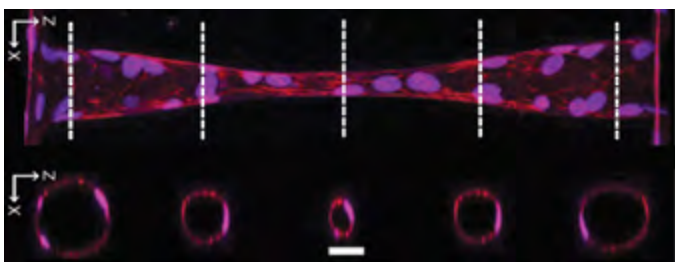
This story has been adapted from an article by Brian Donohue, UW Medicine Newsroom.

Engineered capillaries propel malaria research

Cole DeForest was part of a multidisciplinary team from UW's Institute for Stem Cell and Regenerative Medicine that made great strides toward understanding vascular system diseases. Using laser-based "subtractive manufacturing" techniques developed in the DeForest lab, the researchers were able to carve out capillary-sized vessels within collagen gels, effectively creating synthetic microvasculature. Tissue engineers had previously been unable to create vascular models at this small of scale.

The synthetic capillaries will allow scientists to better model blood flow dynamics that occur in diseases such as malaria and sickle cell anemia, in which red blood cells become deformed or swollen.

Source: Arakawa, C. et al. Biophysical and biomolecular interactions of malaria-infected erythrocytes in engineered human capillaries. *Science Advances*, 2020.



Multiphoton fluorescence microscopic image of capillary vessel at sub 10 um diameter shown in both projected and cross-sectional views. Credit: Caitlin Howard

GRADUATE STUDENT SUPPORT

ChemE launches the Berg Endowed Fellowship

By Lindsey Doermann

It was Ryan Gharios's first year of grad school, and his motivation was waning after long hours studying for a final. That is, until one morning when he woke up early to find an email from department chair Jim Pfaendtner informing him he'd been awarded the John C. Berg Endowed Fellowship. "It was definitely a morale booster," says Gharios.

Gharios is the first recipient of the Berg Fellowship. Longtime ChemE professor and philanthropist John Berg was thrilled to start supporting students in the 2019-2020 academic year, after growing the fellowship fund for several years.

Ryan Gharios with professor John Berg

"The grad student population is the heart and soul of the department," says Berg. However, as the cost of living in Seattle ticked upwards, he saw how students were having a tougher time getting enough support to live and study at the UW. He recognized an opportunity to make a difference for these ChemE trainees — and to provide a consistent source of support that smooths out inevitable peaks and troughs in research funding.

It certainly made an impact for Gharios. A citizen of Lebanon, he has found it particularly difficult to find fellowship support for his UW ChemE education. Many fellowships are available only to U.S. nationals, and that makes others extremely competitive among international students.

With the Berg Fellowship, he can focus more intently on his research in professor Cole DeForest's group, combining his interests in advanced materials and molecular biology. He's designing light-responsive proteins that can reveal basic biological phenomena — how cells communicate, for example. Insights from the research could have applications in tissue engineering.

Gharios views professor Berg as a mentor. After more than 50 years on the ChemE faculty, countless students similarly hold him in this high esteem. As an expert in interfacial and colloid science, Berg has also bolstered the department's research reputation. The endowed fellowship supports a student whose work relates to surface, interfacial, and colloid science. Through his philanthropy, Berg aims to establish a lasting legacy — in the research program he's cultivated over decades, and crucially, in support of students.

Visit **www.cheme.washington.edu/give** to make a gift to the Berg Fellowship and learn about other opportunities to support graduate students.

DYSS turns 10

The department hosted the 10th annual **Distinguished Young Scholars Seminar** in the summer. The program, run by ChemE graduate students, brings in top postdocs and Ph.D. students from around the country to participate in a mock faculty interview and present a research seminar. Traditionally, participants visit the UW and network with students and faculty; this year, the program ran remotely. Learn more at **depts.washington.edu/dyss.**

Two undergraduates and two graduate students represent ChemE in the 2020 Husky 100 cohort

The Husky 100 is a tri-campus award recognizing 100 students who are making the most of their Husky experience

Sarah Alamdari is a Ph.D. student conducting research at the intersection of data science and molecular science in Jim Pfaendtner's group. An NSF Graduate Research Fellow, she uses computer simulations to study the structure, dynamics, and reactivity of biomolecules at interfaces or in extreme environments. Outside the lab, Sarah participates in outreach activities aimed at increasing diversity and access in STEM. She also served as president of the UW Research Computing Club, using the platform to develop outreach activities around virtual reality, supercomputing, and data science.

Andrea Joseph is a Ph.D. student in Elizabeth Nance's lab, where she works on the delivery of nanotherapeutics for treating brain disease. She is a leader in the lab group, having mentored undergraduate and high school students, and in student organizations. Andrea served as Vice President of Women in Chemical Engineering, and revamped ChemE student recruitment as President of the Association of Chemical Engineering Graduate Students. Recently, she's taken a role on the Faculty Council on Women in Academia to provide a graduate student voice for women's issues, such as transparency in promotion and hiring, at the university level.

Hugo Ferreira Pontes, a 2020 graduate, is distinguished in both research and service. In the Nance lab, he studied polymer nanoparticle interaction with the blood-brain barrier, and multiple particle tracking for understanding the brain's extracellular matrix. Hugo is a CoMotion Fellow and a Washington Research Foundation Fellow. He represented Washington state at the Posters on the Hill event in Washington, DC, where he presented research to members of Congress. Hugo joined Lilo Pozzo in installing small-scale solar power systems in rural Puerto Rico following Hurricane Maria so that residents could power medical devices and refrigerate medications.

Georges Motchoffo Simo, a 2020 graduate who double majored in ChemE and biochemistry, is an accomplished researcher who is using his chemical engineering training to pursue a career in medicine. Georges joined the Nance lab at the start of his junior year and conducted research on nanoparticle transport and toxicity in the brain. He participated in the Future Leaders in Chemical Engineering research symposium at North Carolina State University, received a Mary Gates Research Scholarship, and facilitated the Environmental Alternative Spring Break in 2020.

ACTION ON DIVERSITY, EQUITY AND INCLUSION

Throughout the summer, ChemE's Diversity, Equity and Inclusion (DEI) Committee convened a series of town halls for department faculty, students and staff. Participants listened to experiences of individuals from underrepresented groups in STEM and developed action items for improving department culture and access. Learn about existing and planned DEI initiatives in ChemE at **www.cheme.washington.edu/diversity-equity-inclusion**.

Instructions NOT Included

How ChemE adapted to the pandemic

March, as is wont to do, came in like a lion. More and more cases of a disease caused by a novel virus were cropping up in the greater Seattle area. At the UW, Spring Break was just a few weeks away, but on campus, excitement was replaced with trepidation.

When it became clear that we would be facing a shutdown of at least a few weeks, our staff went to work, proactively ordering necessary remote-work gadgets

OFFERED VIA REMOTE LEARNING

After the abrupt shift to online classes in the spring, instructors set about making "virtual" a feature not a bug. Here are some of their strategies.

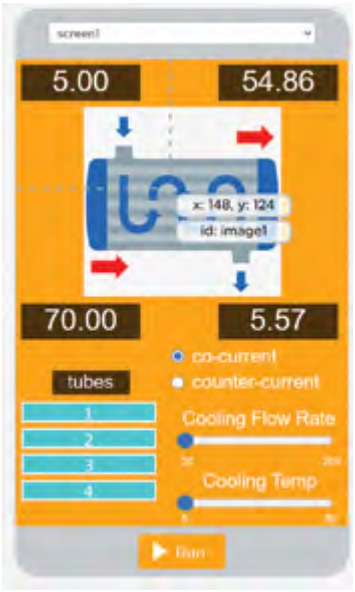
There's more than one way to give a lecture. Faculty use different presentation methods to ward off "PowerPoint fatigue." For example, doc cams simulate writing on a blackboard, and Jupyter Notebooks display code and equations that can be edited in real time.

Keep it interactive. Real-time polls help keep students engaged and give instructors feedback about comprehension. Breakout rooms encourage collaborative problem solving.

Offer avenues for extra help. Through Zoom, students can ask TAs questions via chat during lectures without feeling self-conscious or worrying about interrupting. Maria Politi, a TA in spring quarter, said she provided answers and clarifications in real time, and passed along common questions to the professor to answer for the whole group. Some classes maintain a Slack channel to keep conversations going outside of class.

Many instructors also note higher attendance at virtual office hours than at in-person ones. However, one drawback in the virtual space, professor Brad Holt noted, is that it's harder to help students when you can't see how they're working through a problem on a piece of paper. "You want to see what they were thinking," he said. "Then you can point out what to change, and that helps them learn."

Support students even more. Students are adjusting to new technologies, studying in distracting environments, and missing out on



This heat exchanger simulator is one of several apps that lecturer Chad Curtis developed to demonstrate statistical and design concepts in his remotely-taught courses. He expects to continue using the apps when classes meet in person again.

such as document cameras ("doc cams") and comfortable call-center-style headsets. Faculty, staff, and TAs strove to become instant experts on something called Zoom.

On Friday, March 6, UW president Ana Mari Cauce made the call: starting the following Monday, classes for the rest of winter quarter would be conducted remotely. Labs and classrooms cleared out, and anyone who could work from home did. Depending on public health conditions, Cauce said, we would resume classes on campus in spring quarter.

But it soon became clear that wouldn't be possible. In just two short weeks, ChemE rescheduled several classes, prepared to offer an entire quarter of remote instruction, reconfigured research assignments, and otherwise adjusted in order to keep more than 250 undergraduate and graduate students on track to earn their degrees. The department and university have been operating remotely for the most part ever since.

In the pages that follow, we offer a glimpse into our year of reinvention.

Lilo Pozzo co-taught Kitchen Engineering — remotely — for freshmen in the spring. Here, she takes advantage of balmy weather and a backyard grilling setup to demonstrate the Maillard reaction.

study groups in Benson. The ChemE Advising Team went the extra mile to connect students with valuable resources: the UW Student Technology Loan Program, options for safe study space on campus, and how to get emergency financial aid, to name a few. Advisers moved sessions online and built out a comprehensive, user-friendly resources web page. In class, students felt supported when professors adapted workload and due dates in response to the challenging circumstances. "I think students noticed that the professors cared about them and not just the content of the class," said spring TA Maria Politi.

Don't forget professional development. Internship opportunities are harder to come by, and students are seeking a competitive edge as they prepare to enter a tough job market. Fortunately, guest lectures work quite well in the Zoom setting; professionals in a variety of sectors can easily jump into a virtual classroom to speak with students about their experiences. ChemE will also offer undergraduates three industry-sponsored capstone projects — with Membrion, Sironix, and Talking Rain — in winter and spring quarters (remotely). Senior Ben Sorochuk managed to take advantage of remote learning to complete a co-op with Marathon Petroleum while simultaneously taking classes. Though it's a lot of work, he reclaimed at least two hours each day by not having to commute to campus, and he uses asynchronous learning options so that work and class schedules don't conflict.

Continuously improve. A group of faculty and advisers met regularly over the summer to debrief on virtual courses in the spring and discuss how to improve for the fall. One key recommendation they made for subsequent courses was to offer an asynchronous element (e.g. recorded lectures) for students to reference later. Students stand to benefit, since many face challenges keeping regular schedules, some are in different time zones, and all may like to go back and hear about a concept they missed the first time around.

TRY THIS at home

The Unit Operations and Surface & Colloid Science labs go remote

By Lindsey Doermann

Lab experiences help shape a chemical engineer's education. When COVID-19 forced classes online in the spring, ChemE decided to delay the first unit operations lab course for the Class of 2021 cohort until fall. There was hope that it could be held in person then.

Unfortunately, case numbers rose throughout the summer. While UW would allow a very limited number of courses to be held in person in the fall, ChemE ultimately felt the least bad option would be to conduct all courses 100% virtually.

That meant the department would offer two lab courses in autumn quarter — in custom home-science-kit form. Lecturers Chad Curtis and Kyle Caldwell, with support from ChemE facilities manager Kameron Harmon, worked in earnest to design, assemble, package, and distribute everything students would need to re-create labs at home.

How did they minimize experimental setups, provide safe and inexpensive equipment, and swap out hazardous chemicals for kitchen-friendly ingredients? Like most of us during this pandemic, they had to get creative about what you can accomplish at home.

Labs in a kit

The cavernous unit ops lab space in the Benson basement is memorable for many a ChemE, for better or worse. Could any home or apartment really be a substitute? When Chad Curtis distilled the course to its core, he realized it wasn't such a stretch. He could actually set up very similar experiments to those in Benson; it's just that the equipment would look different.

This first unit operations course is all about heat transfer and fluid dynamics. To adapt it, Curtis created three different kits — at an average cost of about $35 each — that miniaturize the labs done in person. In the first lab, for example, students measure heat transfer through a brass rod. In Benson, the heat source is steam. In the lab kit, it's a coffee cup warmer.

For another home lab, students measure how the viscosity of fluids such as olive oil change with temperature. "Everything we used chemical-wise was something you can buy at a grocery store," he said.

Kyle Caldwell, who is teaching the surfaces and colloids lab, had the advantage of professor John Berg's experience teaching the course. Over the years, Berg has developed upwards of 20 different labs to pick from for each course offering. Caldwell started by going through those tried-and-true options, imagining how each could be adapted to kit form: What could be done on the cheap? Almost everyone has a camera of some sort — could he take advantage of that? Instead of organic solvents, could he use water, cooking oil, and table salt?

"Once I put all those constraints on it, it kind of came together," he said. After some home experimentation of his own, he assembled four lab kits using components mostly bought from Amazon, all for about $60 per student.

Caldwell leveraged the ubiquity of cell phone cameras and incorporated them into three of the labs. After all, he thought, image analysis is becoming more and more routine in the era of big data, and this was a great opportunity for students to bolster those skills.

One of his lab exercises, for example, involves capturing an image of a drop of soapy water and using image processing software to calculate its surface tension. Another has students photographing test tubes of different salt solutions to determine the stability of suspended clay particles, a concept applicable to wastewater treatment.

Learning experiences

Lab work inevitably involves some amount of creative problem solving. It is playing out that way with labs at home, sometimes by design and sometimes not. For example, Caldwell intentionally left it to students to find and properly arrange a light source to create good images.

In unit ops, students learned about data quality issues. They discovered their

Microfluidics @ home: Chad Curtis leveraged department expertise to create bespoke equipment for the microfluidics portion of Unit Ops. He worked with professor Lilo Pozzo to design and fabricate a "dropper" device on the department's 3D printer. The device produces gravity-driven flow, in place of pumps used in Benson.

In one surfaces and colloids lab, students use a series of salt solutions to investigate the minimum concentration required to destabilize a dispersed clay particle, mimicking wastewater treatment.

infrared thermometer guns didn't work well on shiny surfaces, so they sometimes picked up spurious measurements of heat transfer through metal. The workaround: put a piece of tape over the object being measured, or be sure to explain the reason for inconsistencies in the lab report.

The instructors learned, too, from the logistics involved in getting every student up and running. Things like the kits not clearing customs, and some students in Asia, who consequently had to build their own kits, finding that the price of olive oil put them over budget. But both Curtis and Caldwell say such snafus have been few and easy to resolve. (About two-thirds of the students picked up their kits in Benson Hall, and others received theirs in the mail.)

Despite the challenges, the exercise of making labs in kits has expanded the instructors' thinking about designing future courses. ChemE, as a growing department, is facing more demands on its physical space. Shrinking the footprint of experiments may be a smart strategy for easing some of that crunch. Modular, kit-style labs could be part of in-person courses, but they could use more sophisticated tools (e.g. a heat camera instead of a $20 infrared thermometer) and equipment that's safe in a lab setting but not necessarily at home (e.g. a Bunsen burner instead of a coffee cup warmer).

Perhaps more importantly, labs at home may just go to show what's possible with simple, readily available materials. And those low barriers to experimentation could inspire curious engineering students to push themselves further during this time at home.

Lab kits, assembled and ready to be packed up and distributed to students. Unit ops kits include an infrared thermometer gun and materials for heat transfer measurements (top left), and fluids such as motor oil and cooking oil (top right.) A surfaces and colloids kit (bottom) includes equipment for drop formation and solution preparation.

How researchers returned to campus safely amid the pandemic

In late March, after researchers were directed to start working from home, staff and leadership in the UW Office of Research — including ChemE professor and UW vice provost for research Mary Lidstrom — began preparing for the pandemic's impact on the university's rich tapestry of research programs. In May, the office released guidelines for a safe ramp up of in-person, on-campus research activities that had been paused.

Lidstrom spoke with UW News in June to discuss the evolving picture of research at the UW.

Mary Lidstrom, UW vice provost for research, at the Northwest Quantum Nexus summit in 2019. *Andrea Starr/PNNL*

What happened to research at the UW when COVID-19 hit the Seattle region?

ML: Understandably, a lot of research ramped down, but the university also allowed certain essential research to continue, provided strict safety and social distancing requirements were followed. This included all COVID-19 research; biomedical and public health research; long-term experiments; work needed to maintain equipment or for animal care; and research that graduate students needed to complete their degrees by the end of the school year. Many research-related activities continued remotely: data analysis, group meetings, seminars, preparing manuscripts and proposals, online trainings, even remote data collection.

What was the motivation behind the new safety guidelines?

ML: Research is one of the core functions of this university. And in early May, the public health metrics of the COVID-19 pandemic in Washington were looking sufficiently positive that we thought we could start to allow small numbers of individuals to return to campus for research once again. We are recognizing that careers are at stake, and many researchers are eager to resume research.

What are some steps that researchers must take to be able to return to campus?

ML: Every principal investigator must prepare a detailed plan for resuming in-person research. There's quite a lot that must go into this plan: strict limits on the number of people in each room in the research space; moving equipment and staggering schedules to accommodate social distancing; use of personal protective equipment; educating team members about health attestation and safety requirements; and staying home if they come down with symptoms. Then, they must get that plan approved by their department chair, and order and receive all necessary supplies. And that's all before anyone can even show up to campus.

Have UW policies shaped what's happened at other universities?

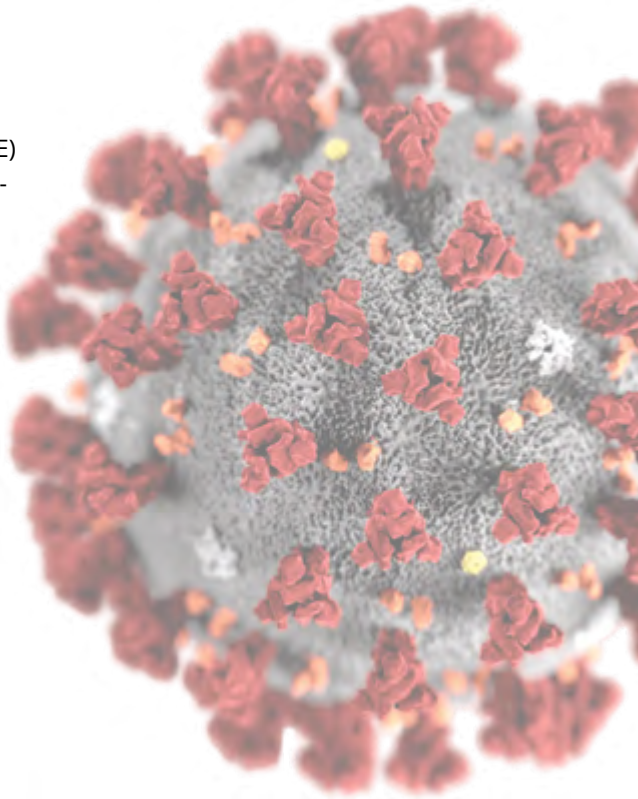
ML: Yes, they have. We were one of the first major research universities to have to deal with COVID-19. We made our initial guidelines public for other institutions to view. They could even use them as templates for their own guidelines. The whole community of research offices has worked together and helped each other. It's just been amazing.

By the end of spring quarter, most ChemE labs that conduct on-campus research had resumed operations with lab-specific guidelines and safety plans in place. They continue to operate in accordance with these COVID-19 guidelines.

This interview is excerpted from a UW News article by James Urton originally published online on June 4, 2020.

Engineering solutions

Developing a first-of-its-kind antibody test



Professors James Carothers and Jesse Zalatan (UW Chemistry and adjunct ChemE) have received an NSF exploratory research award to develop a new type of SARS-CoV-2 antibody test. Rapid, inexpensive, and highly-accurate testing can help public health officials track the spread of COVID-19 and respond to outbreaks.

The researchers' approach is to create a cell-free transcription and translation (TXTL) platform that can measure SARS-CoV-2 antigen-antibody binding. They aim to achieve the precision of commonly used enzyme-linked immunoassays, but with the customizability of a genetically-encoded system.

This platform builds on their previous work creating new CRISPR-Cas tools to activate gene expression (CRISPRa) in bacterial and cell-free systems. The team will now work on engineering a system where CRISPRa activity depends on the presence of coronavirus antibodies in a patient sample and is coupled to visible outputs that can be easily measured. The resulting platform could potentially be used as part of a point-of-care diagnostic.

N95 decontamination for first responders

Photo courtesy of Engineering Innovation in Health

Jonathan Posner and colleagues have developed a box that decontaminates N95 respirator masks using ultraviolet light. First responders use N95 masks to protect themselves from COVID-19 and are concerned about shortages. With this new device, staff are able to decontaminate masks in-house and reuse them. It can disinfect all surfaces of 15 masks at one time using UVC radiation in about a half an hour.

The project, managed by UW's Engineering Innovation in Health program, is building and distributing boxes to first-responder stations across King County, with the goal of distributing at least 100 boxes across Washington.

The Class of 2020 Celebrates

Reaching the summit. Gabriella Tosado sports her regalia atop Mailbox Peak.

Distanced hooding. In lieu of the hooding ceremony typically conducted at graduation, Cole DeForest and Ph.D. recipient Emily Ruskowitz brought out their ski poles and masks to re-create the tradition in the COVID era.

Campus celebrations. Jennifer Ewanich (right) and Wylie Kau (lower right) visit campus to mark the accomplishment of earning a ChemE degree.

COVID-safe commencement. Georges Motchoffo Simo delivered the student address with a theme of resiliency at ChemE's virtual graduation.

2020 R. Wells Moulton Distinguished Alumni Awards

DISTINGUISHED ALUMNUS
IN INDUSTRY

Ray Marzullo
(B.S. '69)

Vice President, Customer Support for the Americas, Boeing Commercial Airplanes (retired)

Ray retired from the Boeing Company in 2010 after serving as VP of Customer Support for the Americas in the commercial airplanes division. Previous roles in his 22 years at Boeing include VP of Flight Services, Director of Flight Training and Director of Service Engineering.

Ray's career was multifaceted; he also applied his ChemE training to the pulp and paper industry and to active military service. After graduating from UW, Ray served in the U.S. Navy as a Naval Aviator for eight years and earned an M.S. in aeronautical systems during that time. From there, he transitioned to serving in the Naval Reserve and took on a more traditional ChemE role as a process engineer with Procter & Gamble. He later accepted a position with the Scott Paper Company. Ray says one of his proudest professional achievements came during his seven years at Scott. In 1985 and 1986, when he was general manager of the Scott plant in Fort Edward, NY, it was named the best managed plant in the company.

When Scott Paper was acquired by Kimberly-Clark, Ray decided to turn back to his passion for aviation. He was hired at Boeing as a flight crew instructor, having kept his piloting skills current in the Reserves. As he moved up in the company to manage more processes, data, and people, he saw the critical importance of soft skills. Further, he could apply analytical thinking from his ChemE training to any role. "You may not be working on a chemical reaction," he says, "but the process of solving problems in most disciplines is the same."

In 2017, Ray and his wife, Kaye, endowed a scholarship for ChemE students. Recognizing the demands placed on military members and their families, the Marzullo Scholarship supports students who are affiliated with the U.S. military, or are children or spouses of military members. "I felt strongly about giving back because I went through college fully financially supported [through ROTC]," Ray says. "I was lucky, and I want to give that opportunity to someone else."

DISTINGUISHED ALUMNUS
IN ACADEMIA

Barry Lutz
(Ph.D. '03)

Associate Professor of Bioengineering, University of Washington

Barry is a nationally recognized leader in microfluidic physics and its applications to point-of-care diagnostics. Among his many innovations in biotechnology is a system that couples a low-cost microfluidic device to a cell phone, such that simple tones from the phone control a lab-on-a-chip device. Also, in collaboration with a pediatric neurologist and a local biotech CEO, he launched the company Aqueduct Neurosciences to engineer a more-reliable pediatric brain drainage shunt for patients with hydrocephalus.

Barry's group in the UW bioengineering department is a key contributor to the Seattle Flu Study, a multi-institution effort to better detect, monitor, and control outbreaks in the city. With the emergence of COVID-19 in the United States in early 2020, the organization spun off the Seattle Coronavirus Assessment Network (SCAN) to apply their expertise to the novel coronavirus and COVID-19. The Lutz group quickly ramped up efforts to produce thousands of test kits. They also began work on a rapid at-home COVID-19 test. The method builds off of the group's work on a simple device originally designed for detecting drug resistance in HIV or diagnosing flu from a nasal swab.

While in UW ChemE, Barry received the D.D. & Sylvia M. Drowley Fellowship and the Jane & Joseph McCarthy Award for Excellence in Graduate Student Teaching. Subsequently, he completed a postdoc at the UW's Microscale Life Sciences Center, investigating the dissimilar behavior of genetically-identical cells. His accolades include the UW Bioengineering Outstanding Faculty Mentor Award, the American Vacuum Society Young Investigator Award, the Pilcher Faculty Fellowship for translational research, and a UW CoMotion Presidential Innovation Fellowship.

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

Diamond Awards

AWARD FOR DISTINGUISHED SERVICE

Scott Roberts (Ph.D. '74)

Retired Vice President, Royal Dutch Shell

Catherine Roberts

Co-founder, Rutherford B.H. Yates Museum

As a Ph.D. student in ChemE, Scott Roberts accepted an opportunity to conduct research at a field station in Turrialba, Costa Rica. He and his wife Catherine drove their infant son 5,000+ miles from UW to Turrialba in a Dodge van full of scientific instruments and materials. As Scott was completing his work testing controlled release pesticides, an earthquake delayed their return for months. That time in Central America spurred a lifelong commitment to service and international relations.

Throughout Scott's 35-year-career with Royal Dutch Shell companies, he led international projects in roles such as EVP of Manufacturing for Shell Chemicals, London, and president of Shell Mexico, Mexico City. He helped nurture a partnership between Shell and the UW that launched the careers of several faculty and provided critical instrumentation for a new national biomaterials research center on campus. Scott served on ChemE's advisory board from 2009 to 2018, and the couple funded a graduate student fellowship endowment in the department.

Catherine, in addition to her involvement with the UW, co-founded the Rutherford B.H. Yates Museum, Inc. The organization has saved six historic structures, built in 1865 by previously enslaved peoples and their descendants, in Houston, Texas. Though Scott and Catherine support diverse organizations, their service is linked by their commitment to the power of education and multiculturalism.

IN MEMORIAM

Dorothy P. Bowers is a 1969 graduate of ChemE and the 2009 R.W. Moulton Distinguished Alumna Award recipient. She supported ChemE philanthropically for over four decades.

Dorothy spent most of her career at Merck & Co., starting in a fledgling Environmental Department. Under her tenure, the organization grew from a two-person office to a diverse team of over 200 staff that oversaw regulatory compliance and pollution standards for Merck manufacturing plants around the world. She retired at age 65 as Vice President of Environmental and Safety Policy.

In retirement, Dorothy chaired the EPA's National Advisory Council on Environmental Policy and Technology. A lifelong learner, she also took on projects such as building the family's television from a kit, rebuilding a Volkswagen engine, and earning her private pilot's license.

In 2013, she established the Dorothy P. Bowers Endowed Fund in Chemical Engineering. The fund has had positive impacts on student support, research, and department culture. It also supports the annual Science & Engineering as Art competition. The winning image from this year's contest appears on the cover of this newsletter.

The Diamond Awards honor outstanding College of Engineering alumni and friends. ChemE is proud to count three members of our community among the eight awards distributed across the College in 2020.

AWARD FOR ENTREPRENEURIAL EXCELLENCE

Greg Newbloom (Ph.D. '14)

Founder and CEO, Membrion, Inc.

At Seattle-based cleantech startup Membrion, Greg leads the technology development of molecular filter membranes that can be used for water purification, flow batteries and other equipment. His innovation — nanoporous ceramic ion exchange membranes — is designed to lower the cost of water purification and energy storage.

Membrion had an exciting year, raising $6 million in Series A funding in March. Then, in light of the COVID-19 pandemic, the company began developing a sprayable coating for cloth masks. The treatment could make masks more protective for the wearer by electrostatically adsorbing virus particles. Membrion received a Small Business Innovative Research grant from NSF for initial product development and testing.

In 2020, Greg was named one of *Puget Sound Business Journal's* Innovators of the Year and received an AIChE 35 Under 35 Award.

Calling members of the Class of 1971!

The College of Engineering is planning a virtual reunion event for June 2021. Join 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.

Chemical Engineering **Leadership Seminar Series**

Now in its 14th year, this series explores the breadth of career paths that can stem from a ChemE degree, and connects students with alumni who are leaders in many industries and sectors. Reflecting upon their careers, speakers offer students valuable insights, lessons learned, and advice for succeeding in today's professional work environment.

2020 SPEAKERS

Linda Cadwell Stancin (B.S. '87)
Director, Emerging Technologies, Collaboration and Innovation, Lockheed Martin

Melanie Drake Curtis (B.S. '11)
Senior Process Engineer, Intel

Kirk Nass (Ph.D. '89)
Technical Team Leader: Dispersants, Inhibitors, and Fuel Additives (ret.), Chevron Oronite Company LLC

Epiphany Wallner-Haas (B.S. '10)
Manager, Business Transformation Consulting, Ernst & Young

Rebeccah Stay
Global Leader of Data Science, Cargill

Enrico Saturay (B.S. '87)
Managing Director, Marsh & McLennan

Lindsey Boles (B.S. '11)
Director of Engineering, Terrapower

Denny Roja (M.S. '89)
Managing Partner, Venture Law Partners; and President, VentureQuest Advisors

Greg Newbloom (Ph.D. '14)
Founder and CEO, Membrion, Inc.

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UW's live mascot Dubs at ChemE's Ph.D. student recruitment weekend in February 2020