Summer 2018

COLUMNS

Chemical and Biomolecular Engineering
A. James Clark School of Engineering
www.chbe.umd.edu

Chair's MESSAGE

Dear Alumni and Friends of the Department of Chemical and Biomolecular Engineering,

I'd like to welcome you to the Summer 2018 edition of our newsletter. We are proud of the continued work we're doing in the department, including cutting-edge research in novel salt water based battery chemistries, more efficient microscopy methods to characterize nanosized aggregates in solution, bioinspired multi-compartment nanocapsules, and other projects where our faculty and students continue to work toward bettering the world through chemical and biomolecular engineering innovation.

As you may have already heard, our campus has launched its $1.5 billion campaign, Fearless Ideas: The Campaign for Maryland. The fundraising campaign — our most ambitious to-date — will focus on elevating and expanding our mission of service, enhancing our academic distinction, and bolstering leading-edge research.

The realities of academia and shrinking department budgets require that we now must bring a majority of funding through individual and corporate philanthropy. To be competitive and to continue to evolve, the Department of Chemical & Biomolecular Engineering will focus on advancing the student experience and expanding research by:

- Supporting undergraduate and graduate student scholarships, allowing every student to have an opportunity to earn a prestigious chemical engineering B.S. or Ph.D. degree from the Clark School.
- Improving our educational infrastructure by improving the computer laboratory, teaching assistant facility and AIChE lounge, enabling our students to have an energizing and productive space for networking, advancing their professional skills and building community.
- Enhancing our Unit Operations Lab, a fundamental course that every chemical and biomolecular student must take, bringing experiments to scale and providing an experience that fully prepares students for the workforce.
- Bolstering faculty and fellowship positions to advance research that will tackle society's grand engineering challenges.

As engineers, we believe that education has the power to improve the life of every person on earth. With your support, we can do just that.

If you are interested in supporting the initiatives outlined above, please visit http://chbe.umd.edu/giving or reach out to me directly at kofinas@umd.edu or (301) 405-7335. Thank you for your gifts, both big and small that make a tremendous impact to the department, our faculty and students. I invite you to visit the department, see our facilities and visit our faculty and students.

Sincerely,

Peter Kofinas
Professor and Chair

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ON THE COVER:

Nina Uchida, a research assistant in the Woehl Research Group, models a sensor, which tests pharmaceuticals for nano-sized aggregates. Photo credit: Alan Santos (UMD).

Woehl Lab Offers Innovative Microscopy Techniques

Microscopy, the ability to see things otherwise invisible to the naked eye, enriches our lives in many ways. Doctors use microscopy to diagnose illness; forensic experts use it to solve crimes; and engineers to inspect infrastructure and ensure buildings, bridges and dams, for example, are safe.

The goal of the Woehl Research Group, led by ChBE Assistant Professor **Taylor Woehl**, is to develop novel microscopy techniques, enabling direct observation of previously obscure phenomena at the nanoscale, leading to the development of new, dynamic materials and a stronger fundamental understanding of nanoscale processes in living systems.

Primarily, the group utilizes transmission electron microscopy (TEM) and advanced optical microscopy techniques to investigate materials at the atomic and nanometer scale. "In a typical TEM experiment, samples are dried on a surface, which inherently changes the structure and freezes the dynamics of nanoscale materials like proteins and synthetic nanoparticles," said Woehl. "Using a TEM, we can visualize nanoscale particles in liquids, enabling us to study chemical engineering processes such as transport phenomena and kinetics, at the nanoscale."

Visualizing nanoscale particles in liquid has practical applications in the study of protein-based drugs, or biopharmaceuticals, and how they're affected during manufacturing and transport. According to Woehl, "Protein-based drugs are analogues of proteins found in our body, so they're less stable outside the bloodstream. This reduces their inherent stability to stresses like increased temperature or agitation, diminishing their shelf-life. When you put artificial antibodies, like those developed by pharmaceutical companies, on a truck and drive them across country, you've no idea how those antibodies might be affected – this destabilization process is a chemical engineering problem."

Woehl's team analyzes how drugs lose their stability using reaction kinetics. "Typically, they form aggregates in solution and we watch them over time," said Woehl. "We do controlled experiments that mimic the temperature increases and agitation the antibodies may experience during manufacturing or transport."

Nina Uchida (pictured below), ChBE research associate in the Woehl lab, is developing a method, using optical interferometry, for rapidly detecting nanosized aggregates in biopharmaceuticals on the manufacturing line, or at the point of patient care. In this method, a drug sample is placed on a sensor (*see cover photo*) and microscopy images of the sensor reveal the amount and size of protein aggregates in the drug, which determine if it is safe to administer.

"There is mounting evidence that the presence of aggregates in pharmaceuticals inherently cause immune responses - this could simply be swelling at the point of injection, or a full-body allergic response," said Woehl.

Nanosized aggregates in bio-pharmaceuticals are not regulated by the Food and Drug Administration (FDA) *because* no detection method is available, a fact that motivated this study. "If we can show the FDA there is a viable technique for detecting nanosized aggregates in solution, we may be able improve current regulations," Woehl said.

For more information visit: **woehl.umd.edu.**

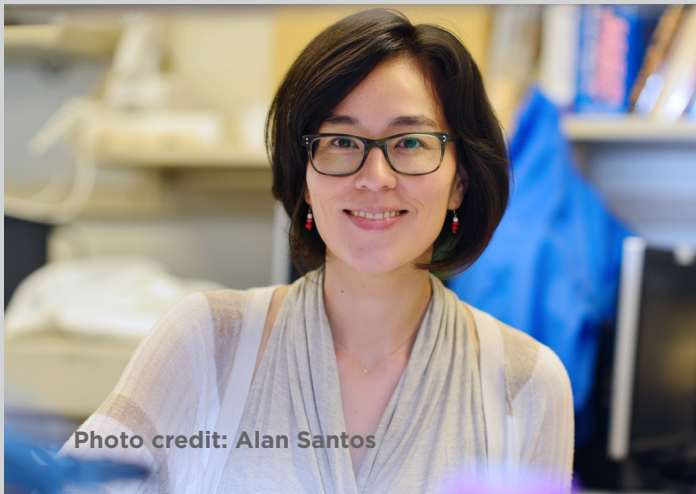


Photo credit: Alan Santos

ChBE/ARL Team Develops Stable, Robust Li-ion Battery Chemistry

Researchers at the University of Maryland (UMD) – partnered with the John Hopkins Applied Physics Laboratory (APL) and the Army Research Lab (ARL) – have been working to develop an enhanced lithium (Li) -ion battery, able to maintain its mechanical integrity under adverse conditions including bending, cutting and even liquid submersion.

This work is a follow-up to past UMD/ARL collaborations focusing on salt-water-based battery chemistry. A 2017 study published in *Joule* revealed the creation of a 4.0-volt aqueous Li-ion battery, based on a water-in-salt concept, capable of powering household electronics.

"UMD and ARL have explored several anode and cathode combinations that can be used within the stability window of our electrolyte," said **Chunsheng Wang**, professor of Chemical and Biomolecular Engineering (ChBE). "By collaborating with APL, we're transitioning this technology into novel battery architectures and demonstrating its true potential."

In their most recent work - "Flexible Aqueous Li-ion Battery with High Energy and Power Densities" - the team inserted a salt water electrolyte in polyvinyl alcohol solution to create a gel polymer electrolyte (GPE). This GPE was then combined with a material called lithium vanadium fluorophosphates, or LiVPO4F, which was utilized as both the anode and cathode, to create an incredibly stable and flexible battery. Over the last few years, LiVPO4F has been frequently used as a Li-ion cathode, but this is the first time it's been used symmetrically.

"What makes LiVPO4F attractive for us is that it can be used as both anode and cathode within the stability window of the water-in-salt GPE, or alternatively, it can be matched with other high-voltage cathodes to achieve high energy density," said **Chongyin Yang**, a ChBE assistant research scientist and first author of the paper.

The most amazing attribute of this newfound technology is its robustness. "The cell can withstand cutting and continue to operate in an open cell condition without malfunction," the team stated in their report. "To the best of our knowledge, this feature has not been previously reported for battery chemistries. The stability of the [water-in-salt] electrolyte in the air was also confirmed by monitoring the weight retention of [water-in-salt] GPE when exposing the electrolyte to air at room temperature for 20 days."

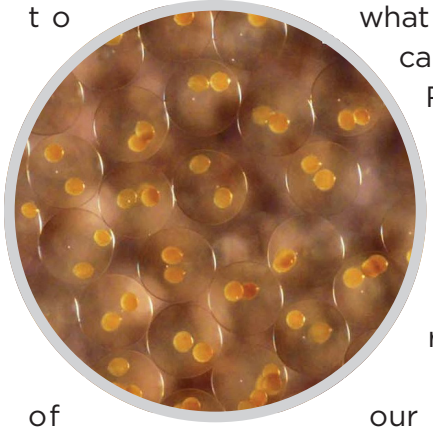
This study was recently published in the journal *Advanced Materials*. For additional information:
Yang, C., Ji, X., Fan, X., Gao, T., Suo, L., Wang, F., Sun, W., Chen, J., Chen, L., Han, F., Miao, L., Xu, K., Gerasopoulos, K., Wang, C. "Flexible Aqueous Li-Ion Battery with High Energy and Power Densities," Joule, 2017. **DOI: 0.1002/adma.201701972.**

Photo provided by ARL.

Raghavan's Multi-Compartment Capsule May Help Explain the Origins of Life, Invention of the Year Nominee

A UMD research group, led by Chemical and Biomolecular Engineering (ChBE) professor **Srinivasa Raghavan**, has invented a new method for synthesizing multi-compartment capsules (MCC) with distinct components in each internal compartment.

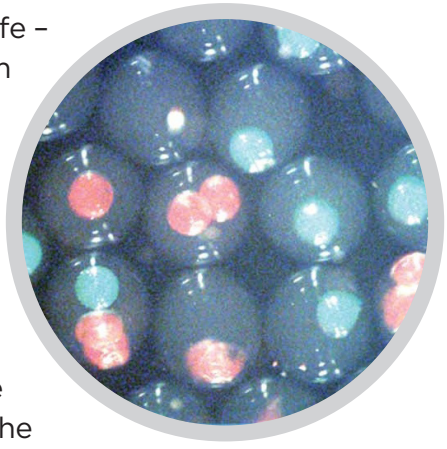
The study was inspired by the structure of biological cells to build capsules with smaller capsules inside that can hold any biological substance, including nanoparticles, drugs, proteins, enzymes, microbial organisms and mammalian cells. Current MCC manufacturing is time-consuming and there are limits to what can be put in the capsules. The method Raghavan and his team developed only takes an hour from start to finish and uses chemicals that are readily available.



"The simplicity of our method to make MCCs is what makes our invention unique," said Dr. Raghavan. "The fact that we can mix and match many different compartments within the same MCC makes it much more versatile as well."

These MCCs can be used in various applications, e.g., drug delivery and experimentation; however, the potential to understand how nature evolves from non-living chemicals to living cells is perhaps the most impactful element of the invention.

"Our MCCs are a platform through which we can ask and answer profound questions about the nature of life," said Raghavan. "By putting different kinds of biological materials in the capsules, we can experiment with creating hybrid forms of life – creating life from the bottom up."



This discovery was nominated for the University of Maryland 2018 Invention of the Year award in the life sciences category.

This study was published in *Chemical Science*. For additional information (see below):

Xi Lu, A., Oh, H., Terrell, J., Bentley, W., Raghavan, S. "A new design for an artificial cell: polymer microcapsules with addressable inner compartments that can harbor biomolecules, colloids or microbial species," Chemical Science, 2018. DOI: 10.1039/C7SC01335C.

Photo credit: John T. Consoli

Zachariah Research Published in Science, Receives MURI Award

A multi-institutional research team is the first to create nanoscale particles composed of eight distinct elements generally known to be incapable of mixing together. The blending of multiple, unmixable elements into a high entropy alloy nanoparticle greatly expands the landscape of nanomaterials and what can be done with them.

The collaborative team of engineers – including Chemical and Biomolecular Engineering (ChBE) Professor **Michael Zachariah** and ChBE graduate students, **Rohit Jacob and Miles Rehwoldt** – responsible for this study published a peer-reviewed paper, entitled, "Carbothermal shock synthesis of high-entropy-alloy nanoparticles," that was featured on the cover of *Science* (**DOI: 10.1126/science.aan5412**).

According to the study, this advance in nanoscience opens vast opportunities for a wide range of applications that includes catalysis, energy storage and bio/plasmonic imaging.

To create the high entropy alloy nanoparticles, the researchers employed a two-step method of flash heating followed by flash cooling. Metallic elements such as platinum, nickel, iron, cobalt, gold and copper were exposed to a rapid thermal shock of 3,000 degrees F., roughly half the temperature of the sun, for 0.055 seconds, resulting in uniform mixtures of the multiple elements. The rapid cooling (more than 100,000 degrees Fahrenheit per second) stabilized the newly mixed elements into uniform nanomaterial.

To demonstrate one potential use of the nanoparticles, the research team used them as advanced catalysts for ammonia oxidation - a key step in the production of nitric acid. They were able to achieve 100 percent oxidation of ammonia and 99 percent selectivity toward desired products with the high entropy alloy nanoparticles, proving to be highly efficient catalysts.

This collaborative study included researchers from Michael Zachariah's group; Liangbing Hu's group (UMD); Reza Shahbazian-Yassar's group (University of Illinois, Chicago); Ju Li's group at MIT and Chao Wang's group at John Hopkins University.

Zachariah (pictured left) is also the recipient of the 2018 Multidisciplinary University Research Initiative (MURI) Award offered by the U.S. Department of Defense. His team will research piezoelectric energetics (PEs) and their potential for a new generation of smart propellants and pyrotechnics with multifunctional capabilities that can be actively controlled via external stimuli. By coupling piezoelectric behavior and nanoenergetics, the team envisions the creation of truly smart and switchable materials that can be controlled and altered by external stimuli including stress, temperature, or electromagnetic fields, while enabling integrated in situ sensing.

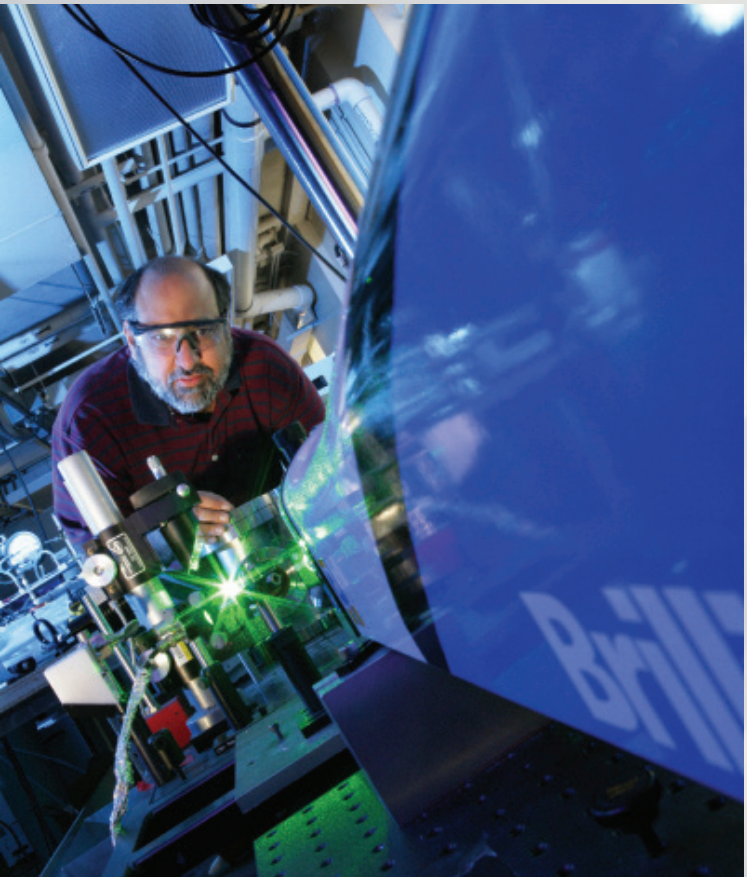


Photo credit: John T. Consoli

ChBE Alumni Looks Back Fondly on Tenure at UMD

Vineet Agrawal (B.S. '98) - a graduate of the Chemical and Biomolecular Engineering (ChBE) Department at the University of Maryland (UMD) – tried three other majors on for size before concluding that chemical engineering was the best fit. He credits his experience at UMD for laying the foundation for a successful career in the field of biomedical engineering.

Born and raised in New Delhi, India, Vineet and his family moved to Montgomery County when he was in high school. UMD, he said, felt like a natural choice for college because of its location and strong STEM programs.

"I started out as a physics major because I was good at math, but at the time, you couldn't do much with a bachelor's in physics, so I switched to engineering," he said. "ChBE made most sense because it was the most applicable for hands-on work."

After completing his studies at Maryland, Vineet wanted to apply his knowledge and opted for a career focusing on medical field applications. He took a position at Merck & Co. in Pennsylvania, in their technical operations department focusing on new products.

"My first project was the development of a brand new type of antibiotic," he said. "Much of what I learned in Prof [Richard] Calabrese's transport class came into play, as did Prof [William] Bentley's biochemical processes classes and the ultimate design project. Those courses prepared me for my role at Merck, which ultimately paved the way for Northwestern University's MBA program – my goal was to leverage my engineering background into managing a product-driven healthcare business."

Vineet went on to work for Baxter Healthcare near Chicago, and then Guidant in Indianapolis. After working for these larger companies, he accepted a position with Micrus Endovascular Corporation in Silicon Valley, California.

Currently, Vineet is the head of international business and marketing at Penumbra, Inc.; a fourteen-year old firm that designs, develops, manufactures and markets innovative, biomedical devices for a range of medical conditions, but specializing in embolization and thrombectomy procedures for treatment of stroke and peripheral artery disease.

"In the last five years, I've visited more than 60 countries," he said. "I'm part of a team that aids in the delivery of lifesaving therapies, and building businesses around the world, designed to provide people with innovative medical care they wouldn't otherwise receive. This was my goal from the very beginning, when I first set foot on the UMD campus - to make a meaningful contribution with my career."

Vineet looks fondly back on time spent at UMD. "You've got to find a university that works for you. I needed a workhorse that gave me lots of opportunity to explore, and to me, that's Maryland," he said. "In terms of personal growth, the five years I spent on campus were the best years of my life. College is the time for exploration, and it's important to learn as much as possible. UMD gives you broad opportunity to be whatever you want to be."

Vineet continued, "I've lived in lots of places, but here in California, when I see other UMD grads, it feels good - I'm glad to see other alumni who have journeyed across the country to see what they can contribute to society."

To current and future majors, Vineet encourages them to take every opportunity to get hands-on training. "Internships and co-ops provide fantastic opportunity to apply theoretical concepts to real world scenarios," he said. "There is a wealth of opportunity available to students on campus! Get to know the faculty - work as a TA or an RA - those applied skills combined with a degree will provide you with a strong base for your future career, and you never know where they might take you."

Pfendner and Hurm Encourage Colleauges to Get Moving

Tanner Pfendner and **Joey Hurm**, both ChBE seniors, founded the campus Calisthenics Club last fall.

"Stress is often overwhelming for many of my fellow engineering peers – it's extremely valuable to take a break and exercise to regain some calm-mindedness," said Hurm. "Tanner and I want to help, so in addition to founding the Calisthenics Club, we started organizing fitness 'workshops' around campus."

Last fall, the duo led a group of roughly 40 people – including ChBE faculty members **Peter Kofinas, Deborah Goldberg, Ganesh Sriram, Amy Karlsson** and **Akua Asa-Awuku** – through an exercise routine on LaPlata Beach near the Eppley Recreation Center.

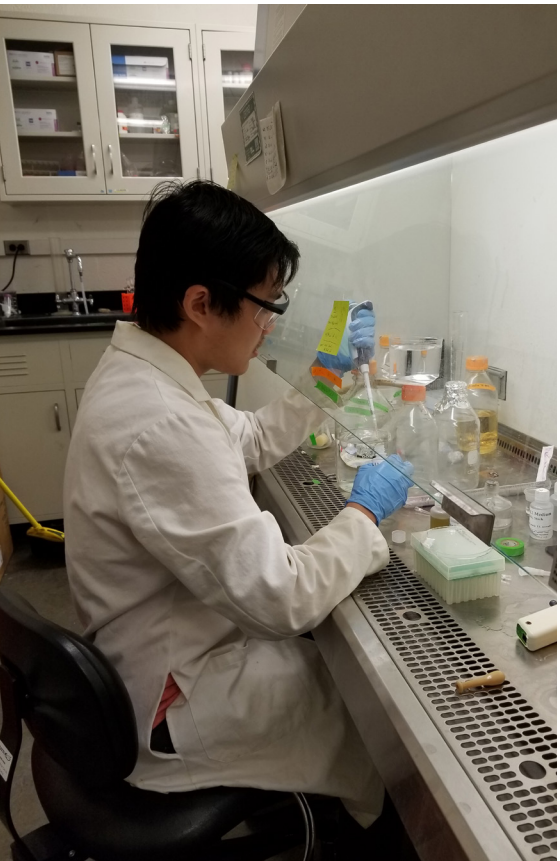
After a full-body warm-up, participants performed a series of movements – push-ups, lunges, squats, flutter kicks and Russian twists, to name a few – in addition to stretching.

"We had an excellent turnout and I hope everyone appreciated the message concerning the importance of fitness, especially while striving to receive such a demanding degree," added Hurm. "We'd also like to thank the UMD AIChE chapter, who sponsored the workshop, for their support!"

The group holds frequent exercise sessions, which everyone is welcome to attend. Weekly exercise routines are posted on Facebook, too. For additional information, contact Joey Hurm at jmhurm@umd.edu or visit the Calistehnics Club Facebook page - **https://www.facebook.com/groups/1044740562298571/**

Dat Huynh Wins HHMI Fellowship

Dat Huynh, a junior in the Chemical and Biomolecular Engineering (ChBE) department received a Howard Hughes Medical Institute (HHMI) Undergraduate Research Fellowship. The award funds his study of an algal-bacterial co-culture consisting of the alga Phaeodactylum tricornutum (Pt) and a bacterium - studies show that both organisms affect each other's physiology and metabolism. Curious about their symbiotic relationship, Huynh is using his HHMI fellowship to investigate the possibility of altered metabolism in both algae and bacteria when they are co-cultured, studying the flow of carbon through chemical reactions in both organisms.



Huynh, originally from Vietnam, has always had a knack for science and mathematics. "Initially, I wanted to become a medical doctor, but soon learned that it was not the right path for me," said Huynh. "Despite this, I still wanted to do work that involved helping the ill. Engineers... create and design products and structures that can help millions of people. With this in mind, I want to work in the medical industry as an engineer, creating products to help people in need."

Huynh, advised by ChBE associate professor **Ganesh Sriram**, conducts his research in Sriram's Metabolic Engineering Laboratory.

Students Benefit from Co-Op Experience

Co-operative education opportunities provide students with valuable, hands-on experience in their field of study and provide employers with access to new recruits. **Priyanka Hiriyanna, Nhi Thao Le, Gerry Ma, Hartej Singh, James Stephen, Lauren Van Exter, Sulin Wu** and **Jessica Young** participated in the 2016/2017 cohort.

Lauren Van Exter (below, right) co-oped at Exxon Mobil in Texas and at Johnson & Johnson in New Jersey. "I was hesitant about graduating a year late to do these co-ops, but it was definitely the best decision I have ever made," Van Exter said. "At Exxon, I gained hands on manufacturing experience, while at Johnson & Johnson, I gained an appreciation for the supply chain system." Now that Van Exter has established her passion for manufacturing, she knows precisely how to kick off her career. "It's significantly easier to talk to recruiters, since I have over a year of engineering experience - I urge everyone to co-op if possible!"

Priyanka Hiriyanna agrees with the assessment. She also co-oped at Johnson & Johnson for six months. "Co-oping is an excellent experience," said Hiriyanna. "It's a productive break from the rigor of the engineering curriculum. I was struggling in the major and the co-op provided a break that was really valuable in terms of my professional and personal development."

Fusi and Colvin Recognized for Their Service and Leadership

Two ChBE students received Dean's Awards this year: **Soliver Fusi** accepted the Kim Borsavage and Pamela J. Stone Student Award for Outstanding Service; **Kenya Colvin**, the A. James Clark School of Engineering Leadership Award.

Fusi, a chemical engineering major, served as President of the Chem-E-Car Team, was a Clark School Ambassador, Academic Excellence Chair for the National Society of Black Engineers and served as the Vice President of the Chemical Engineering Honors Society. She graduated in May and will begin her Ph.D. studies at the University of California, Berkeley, this fall.

Colvin is a member of the Honors College and serves as an ambassador there, and for the Clark School. Colvin is a Ronald McNair Scholar, whose current research is focused on designing an automated point-of-care diagnostic tool powered by the chemical temperature control of phase change materials. Calvin will complete her studies this fall.

Kyu Yong Choi Receives Poole & Kent Teaching Award

Kyu Yong Choi, a professor in the Department of Chemical and Biomolecular Engineering (ChBE) at the University of Maryland (UMD), is the 2018 recipient of the Poole and Kent Teaching Award, granted by the A. James Clark School of Engineering to senior faculty members for excellence in teaching.

Choi received his Ph.D. in chemical engineering from the University of Wisconsin prior to joining the UMD faculty in 1984. He primarily teaches ChBE 442: System Analysis, a math-intensive course that is often difficult for students to manage. Choi is profusely credited by his students for his good humor and ability to connect mathematical concepts to current or historical events.

Photo: Dean Darryll Pines, Prof Kyu Yong Choi and Donald Campbell (Poole & Kent Corp). Photo credit: Alan Santos (UMD)

Said ChBE undergraduate, Wei-Lee Wu, "Dr. Choi's approach to teaching is very unique. He starts each semester by explaining the importance of system analysis to ensure student motivation before diving into the curriculum. For each lecture, he always made our class laugh, which made such a hard math class enjoyable. He emphasizes active learning, and provides discussion periods for students to work out math problems. Dr. Choi is very deserving of this award as I enjoyed every lecture in his class."

Sandra Greer Publishes Book on Ethics

Sandra Greer, professor emerita in the Department of Chemical and Biomolecular Engineering (ChBE) at the University of Maryland, has recently published a book, *Elements of Ethics for Physical Scientists* (MIT Press, 2017).

The book, based on a course that she developed and taught in ChBE from 1995 - 2008, focuses on the daily decisions about right and wrong faced by scientists during research, interaction with colleagues, and how their work affects society. Dr. Greer aims to bolster readers' ethical intelligence so that they can identify an ethical issue when confronted with one, and offers an approach to managing these issues.

Said Dr. Greer, "It's important for students to think about ethical issues, and remember that engineering is not just about academics. It's also about character building, and knowing who and what you stand for."

Greer is currently working on another book - *Chemistry for Cooks* - a general education textbook for undergraduates who are new to science curriculum.

Deborah Goldberg Honored by Clark School for Outstanding Service

Deborah Goldberg, a lecturer in the Department of Chemical and Biomolecular Engineering (ChBE) and ChBE alumna (B.S., '06), was the 2017 recipient of the Outstanding Faculty Service Award bestowed by the A. James Clark School of Engineering. This award recognizes faculty members who have given outstanding service to their Department, the School and the University.

Goldberg consistently receives high teaching evaluation scores, even for the most difficult courses. "She is effusively praised for her clear lectures, fairness, concern for students and responsiveness to feedback," said **Peter Kofinas**, ChBE professor and chair. "Her contributions to students, both in the personal and professional domain, have been incredibly valuable."

In addition to teaching, Goldberg also proposed and developed ChBE 100, a new freshman seminar designed to help students discover which career options are available to ChBE students, available resources that help them succeed in the major, and how to get involved in extracurricular activities. She also developed and implemented a peer-mentoring program specifically designed to ease new student transition into the ChBE curriculum, in addition to providing upper-class students with leadership experience. The pilot program commenced during the summer of 2017, and continues to be successful.

Outside of the classroom, Goldberg devotes much of her time to advising students on how to be academically successful, and preparing them for job interviews and the professional work environment after graduation.

Liu and Ponce Promoted, Associate Prof and Sr Lecturer

Dongxia Liu, a faculty member in the University of Maryland (UMD) Department of Chemical and Biomolecular Engineering (ChBE), was promoted to associate professor with tenure this semester. Liu earned her Ph.D. in chemical engineering from the University of Rochester in 2009 before coming to UMD in 2012.

In addition to teaching both undergraduate and graduate level courses, Liu and her team are currently focused on developing new processes for synthesis of 2-dimensional zeolite materials, and exploring their catalytic properties. "We are also working on novel metal/metal oxide catalysts and reactors for C1 (methane and carbon dioxide) catalysis," she said. "We aim to utilize these two low cost and abundant 'greenhouse gases' as feed-stocks to produce value-added fuels and chemicals using our synthesized catalysts, reactors and catalytic processes. By doing so, we will reduce greenhouse emissions and create energy and chemical supplies for the society.

Aldo Ponce, a faculty member serving both ChBE and Materials Science and Engineering, was promoted to senior lecturer. Ponce received his Ph.D. in chemistry from Kansas State University and joined the UMD faculty in 2013. Since then, his research interests have included materials science, inorganic chemistry, catalysis, surface science, life science and nano-chemistry. Ponce teaches various courses including ENMA 312, ENMA 362 and ChBE 437. He also manages the Department unit ops lab, aiding faculty and students with their characterization needs – the lab is currently being upgraded to include the implementation of a fully instrumented vapor compression refrigerator with belt driven compressor, electrically heated evaporator, thermostatic expansion valve, and water-cooled condenser.

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